HILLGROVE RESOURCES

Hillgrove Copper Pty Ltd

Kanmantoo Copper Mine

ML6345, ML6436 and EML6340

Program of Environment Protection and Rehabilitation (PEPR)

APPENDICES

Revision: 9

Date: 11 November 2019

Table Appendices

Appendix A - Mine Closure Native Vegetation Management Plan (Hillgrove, 2019)

Appendix B - Kanmantoo Visual Impact Assessment (JBS&G, 2019)

Appendix C - Further Assessment and Consideration of Management of Seepage Water at the Kanmantoo Copper Mine (JBS&G, 2018)

Appendix D - Independent TSF Raise Design and Closure Review for Hillgrove Resources – Kanmantoo Copper Mine (Williams, 2019)

Appendix E - Kanmantoo Pumped Hydro Energy Storage, Underground Development and Groundwater Recovery Groundwater Impact Assessment Modelling Summary Report for Hillgrove Resources (Mining One 2019a)

Appendix F - Explosives Management Plan (Hillgrove, 2019)

Appendix G - Blue Minerals Consultancy Geochemical Assessment: Stages 1 to 3 (2017)

Appendix H - Stage 8 and 9 Design Report Kanmantoo TSF (PSM, 2019)

Appendix I - TSF Operating Manual (PSM, 2019)

Appendix J - Partial Lease Relinquishment Plan ML6345 Pumped Hydro-electric Scheme

Note Appendix A and B of the PLRP have not been included: Appendix A = PEPR Appendix E and Appendix B = PEPR Appendix K

Appendix K - Giant Pit Abandonment Bund Report (Hillgrove, 2017)

Appendix L - IWL Cover Design Summary Report (Hillgrove, 2019)

Appendix M - Groundwater Management and Monitoring Plan (JBS&G, 2019)

Appendix A - Mine Closure Native Vegetation Management Plan (Hillgrove, 2019)

HILLGROVE
RESOURCES

Hillgrove Copper Pty Ltd

Kanmantoo Copper Mine

ML6345 and ML6436

MINE CLOSURE NATIVE VEGETATION MANAGEMENT PLAN

Revision: **10**

Date: **18 09 2019**

Version No.	Prepared By	Reviewed By	Approved By	Date
1DRAFT	Hillgrove Resources	J. Crocker	C. Davis	18/9/19

(Cover Photograph: Direct seeded *Eucalyptus odorata* woodland community – NW corner of ML6345)

Table of Contents

Table of Tables

Table of Figures

Table of Appendices

1.0 Introduction

1.1 Kanmantoo Copper Mine

Hillgrove Resources Limited (Hillgrove) is an Australian copper-gold producer, listed on the Australian Stock Exchange since 2003. Hillgrove conducted mining operations at Kanmantoo Copper Mine (KCM) from 2011 to May 2019. The KCM is located within Mining Lease 6345 (ML6345) located approximately 44 km southeast of Adelaide in South Australia (SA) (Figure 1-1). The two closest townships to the KCM are Kanmantoo, approximately 1.5 km to the northeast, and Callington, approximately 4 km to the southeast.

Processing operations at the KCM will continue until the ore stockpile is depleted in early 2020, with potential to extend mine life through underground mining. The Mine's operations were approved under the conditions outlined in the KCMs 2016 Program for Environmental Protection and Rehabilitation (PEPR) The Main Report and Executive Summary for this PEPR can be accessed via the following link <Kanmantoo Copper Mine PEPR 2016>.

1.2 Legislative Requirements

Any vegetation removal or disturbance within the KCM Mining Lease (ML) must be compliant with the following legislation and its associated regulations.

- *Native Vegetation Act 1991* (SA) and Native Vegetation Regulations 2017
- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
- *Development Act 1993* (SA) and Development Regulations 2008
- *Natural Resources Management Act 2004* (SA)
- *Aboriginal Heritage Act 1988* (SA)
- *Local Government Act 1999* (SA)
- *Highways Act 1926* (SA)
- *Rail Commissioner Act 2009* (SA)
- *Fire and Emergency Services Act 2005* (SA)

The context by which each legislative instrument is applicable to vegetation clearance is described within the following document:

Vegetation Removal Policy. Standard Operating Procedure under the Native Vegetation Act 1991 (August 2018), SA Department of Planning, Transport and Infrastructure, pages 10 to 14.

This document can be accessed via the DPTI web page via the following link:

https://www.dpti.sa.gov.au/__data/assets/pdf_file/0008/35657/DOCS_AND_FILES-1965602-v36-Environment_-_Technical_Standards_-_Vegetation_-_Vegetation_Removal_Policy.pdf

1.3 Native Vegetation Management Plan

This Mine Closure NVMP supersedes three previous versions of the NVMPs for the KCM, namely:

- The **Original NVMP (2010)** submitted in association with the KCMs first phase of mining operations.
    - Included details of approved native vegetation disturbance and agreed Significant Environmental Benefit – Offset (SEB-offset) obligations for vegetation disturbed by initial mine construction and mining operations.
    - At the time of the Original NVMP approval (December 2010), separate 'controlled action' Federal Government permission was not required for disturbance of native vegetation communities ultimately listed as 'critically endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation Act of 1999* (EPBC Act).
    - All approved vegetation disturbance, required appropriate SEB-offsets which were to be delivered within the ML on rehabilitated mine landforms or other appropriate areas, as detailed by the Original NVMP

- The **Life of Mine Extension NVMP (2014) (LOM NVMP)**. The LOM NVMP appended the Original NVMP and included details of additional disturbance to native vegetation communities for mine expansion, where the disturbed vegetation fell into two broad types;
    - Vegetation communities which had become classified as 'critically endangered' under the EPBC Act required Federal Government approval for disturbance (which was granted as Controlled Action EPBC 2013/6965). The LOM NVMP was required to detail how and where appropriate SEB-offsets would be delivered for approved disturbance of EPBC Act listed vegetation communities.
    - Vegetation communities not listed as critically endangered by the EPBC Act, where the LOM NVMP detailed suitable SEB-offset provision for the approved disturbance of those communities

In both cases, SEB-offsets for disturbance of EPBC-listed vegetation and non-EPBC-listed vegetation were co-located on Hillgrove-owned land directly adjacent to the ML.

- The **Giant Pit Cutback Addendum to the LOM NVMP (2016)**, which included details of approved vegetation disturbance, required for an emergency cut-back of the Main Pit crest (also referred to as 'Giant' Pit) required for geotechnical stability and worker safety purposes.
    - The cut-back occurred in the northeast corner of the Giant Pit, within a mining area referred to as 'Schultze' and did not involve disturbance of an EPBC-listed vegetation community.
    - A SEB-offset for approved disturbance of the vegetation community associated with the Giant Pit 'Schultze' cutback, was co-located with other offset vegetation on Hillgrove-owned land directly adjacent to the ML.

No further disturbance of native vegetation was required to complete mining operations at the KCM through to May 2019.

To date, the three NVMP's listed above are the only approved NVMPs associated with Hillgrove's mining operations within the KCM ML (ML6345).

1.4 Proposed Changes to the KCM NVMP

This revision of the KCM NVMP will be referred to as the **Mine Closure NVMP**.

*The Mine Closure NVMP addresses tasks associated with the mine closure and lease relinquishment phase of the KCM and supersedes all previously approved versions of the KCMs NVMPs, apart from the LOM Extension NVMP which covers EPBC SEB offset (*Appendix C*).*

The Original NVMP was developed with an expectation that a pipeline of additional mine asset developments by Hillgrove would support the progressive establishment of SEB-offsets associated with vegetation disturbance required for the commencement of mining operations, expansion of the historic Main Pit and construction of Nugent and Emily Star Pits.

As the KCM plan progressed, unexpectedly difficult mining conditions associated with the KCM ore-body and its related geotechnical issues presented significant, ongoing operational constraints for the mining operations on site. This restricted funds and prevented further mine asset development by Hillgrove during the operational life of the KCM. As the original NVMP was reliant on proceeds from the KCM to fund the type of long-term SEB-offset and EPBC-vegetation offset establishment and management programs required to achieve the offset objectives, operational constraints slowed progressive rehabilitation and SEB-offset establishment programs during the operating life of the mine. Additionally, the lack of development of additional assets reduced the anticipated mine life of the operation which does not provide sufficient time for the establishment of the SEB-offset and EPBC-vegetation offset areas to the maturity likely required to meet the objectives, without a unrealistically long monitoring and maintenance period post-closure of the KCM.

With the LOM extension completed and following the conclusion of mining at Kanmantoo in May 2019, even with potential short-mine-life underground extensions, further SEB-offset establishment and long-term support of the SEB-offset maintenance objectives described in the previous KCM NVMPs are now unlikely to be achievable by Hillgrove.

This revision of the KCM NVMP will now seek to pay into the South Australian Native Vegetation Fund (NVF) in lieu of the planned SEB-offset establishment program outlined in previous versions of our NVMP for all non-EPBC Act listed vegetation.

Subsequently, this Mine Closure NVMP will focus on the following main areas.

- ***Section 2.0:*** *Background information and provision of details associated with the calculation of Native Vegetation Fund payments required to replace the previous commitments of SEB-offsets for non-EPBC Act listed vegetation disturbance.*
- ***Section 3.0:*** *A description of how the KCM domains will be closed, including details of rehabilitation and how rehabilitation success will be monitored and assessed with the aim of lease relinquishment, i.e., delivery of rehabilitation obligations under the Mining Act.*
- ***Section 4.0:*** *A description of how existing ML vegetation communities and non-EPBC SEB-offsets within the ML will be managed until lease relinquishment of ML 6345 can be achieved.*
- ***Section 5.0:*** *A description of how existing non-EPBC SEB-offsets on Hillgrove-owned land off the ML will be managed.*

Delivery of offsets for EPBC-Act listed vegetation disturbance is not addressed in this NVMP due to inability to engage the Commonwealth government on proposed alternatives at this time. Hence, until such time as alternatives can be agreed, Appendix C provides the Life of Mine (LOM) Extension NVMP (2014) which covers all EPBC SEB-offsets.

Please note that the physical location of proposed EPBC SEB-offsets within allocated Hillgrove-owned land allotments will need to be varied under a future revision of the LOM Extension NVMP (if a revision is required), however, the total area of EPBC SEB-offsets to be delivered by Hillgrove will not vary unless an alternate agreement with the Commonwealth government, such as making payment in lieu of providing EPBC, is agreed.

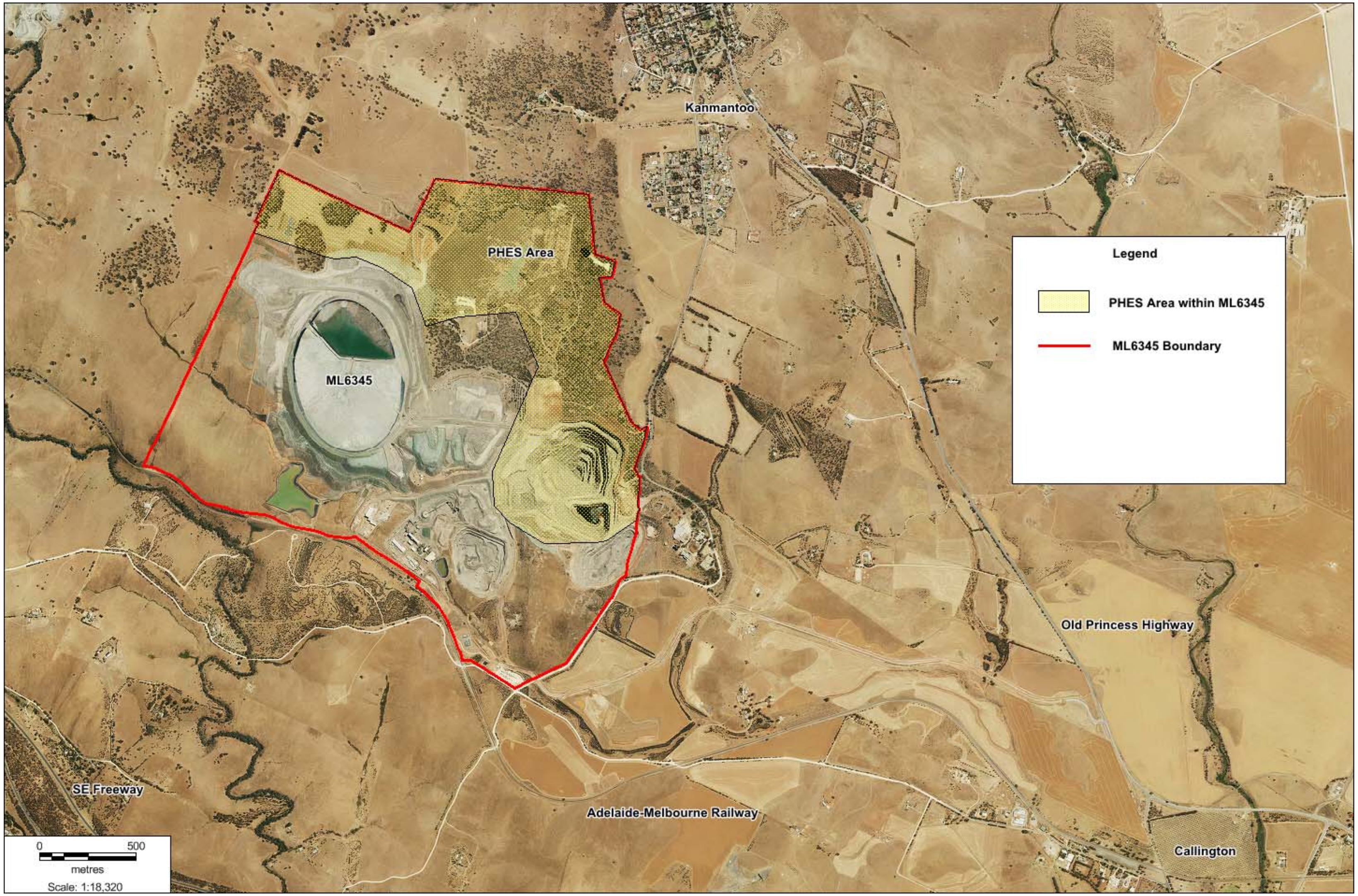

Figure 1-1 - Location of ML6345 and the Kanmantoo Copper Mine and the potential PHES Area

2.0 SEB-offset Obligations and Payment into the NVF

2.1 Proposed Changes to the KCM NVMP

All vegetation disturbance approved under prior versions of the KCM's NVMP has been completed. No further new native vegetation disturbance or SEB-offset assessment is required under this NVMP. As such, the assessment criteria current at the time of the initial vegetation clearance approvals (i.e., 2010, 2014 and 2016 for non-EPBC clearing) have been used in this NVMP as more recently updated criteria cannot be applied to vegetation that has already been removed.

Payment requirements in lieu of SEB-offset establishment for disturbance of non-EPBC Act listed vegetation communities have been calculated in accordance with the SEB-offset guidelines which were current at the time that vegetation disturbance was approved under previous NVMPs, i.e., *Guidelines for a Native Vegetation Significant Environmental Benefit Policy for the Clearance of Native Vegetation Associated with the Minerals and Petroleum Industry*, (DWLBC, September 2005). The use of these guidelines has been agreed with Adam Schutz (meeting of 15th February 2019) of the South Australian Department for Environment and Water (DEW)).

BlackOak Environmental was commissioned by Hillgrove to carry out an independent SEB-offset review and perform a calculation of the sum to be paid into the NVF in lieu of Hillgrove's approved SEB-offset obligations. Matt Launer conducted the work and is listed as an Accredited Consultant by the Native Vegetation Council. He has first-hand experience with the composition and location of the native vegetation that originally existing on the ML area through participation in on-site vegetation surveys. Mr Launer's report: *SEB-offset Review for the Kanmantoo Copper Mine* (BlackOak Environmental, May 2019), has been appended as Appendix A.

There is a need for further consultation with the community to determine the appropriate location for the potential use of NVF grants whose origin would be from Hillgrove's payment into the fund. Hillgrove and the community commit develop project plan(s) within 6 months of PEPR approval for NVF grant consideration. Any application for an NVF grant will be subject to assessment against NVC requirements set out in the council's policy for significant environmental benefit (SEB).

It is important to note that while areas paid into the fund will no longer be SEB they will remain rehabilitated areas with mixed natives and pasture species.

To demonstrate the difference in SEB obligations if KCM pay into the fund see Figure 2-1 and Figure 2-2.

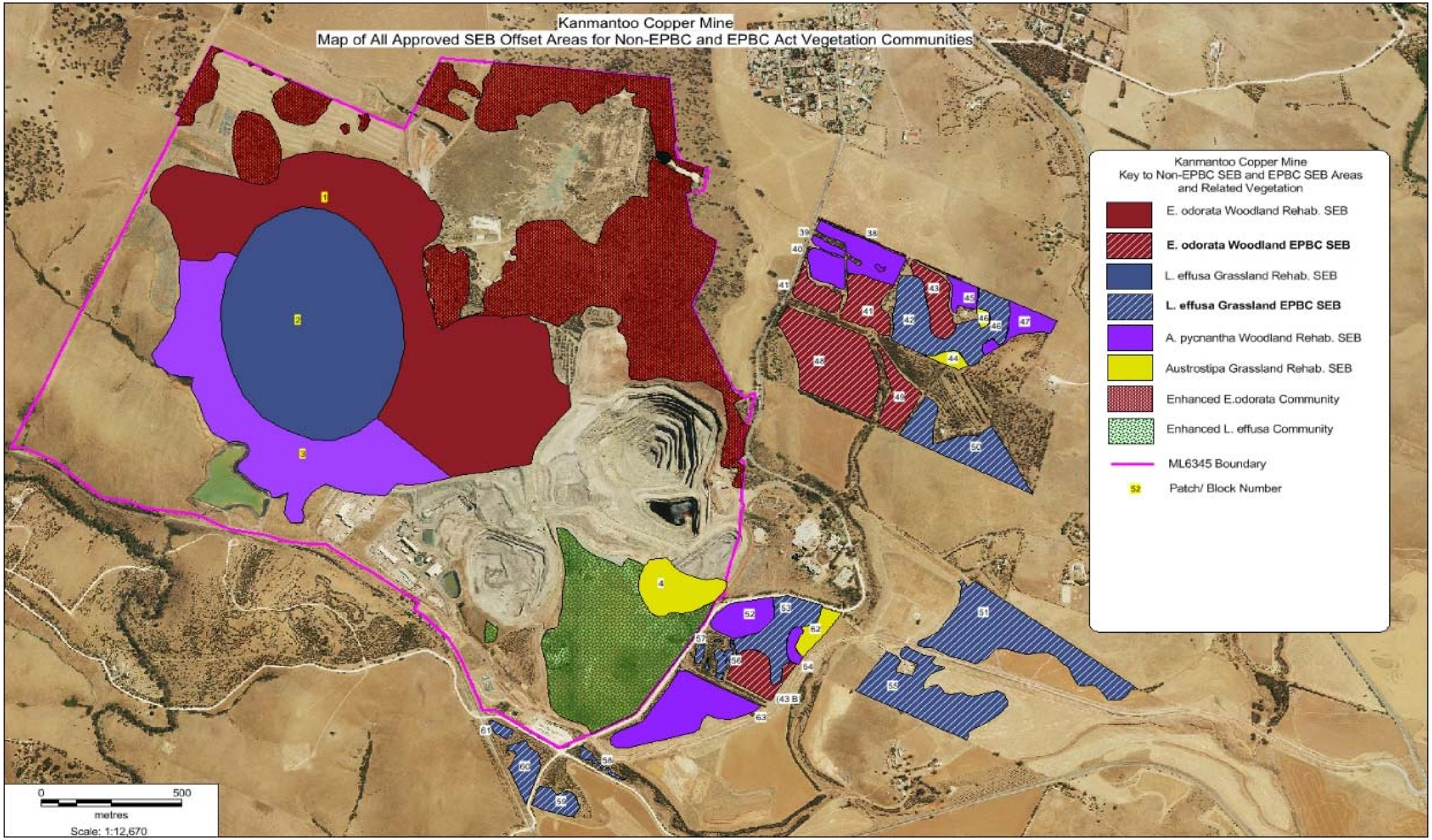

Figure 2-1 – MAP of all approved SEB offset areas before paying into the NVF

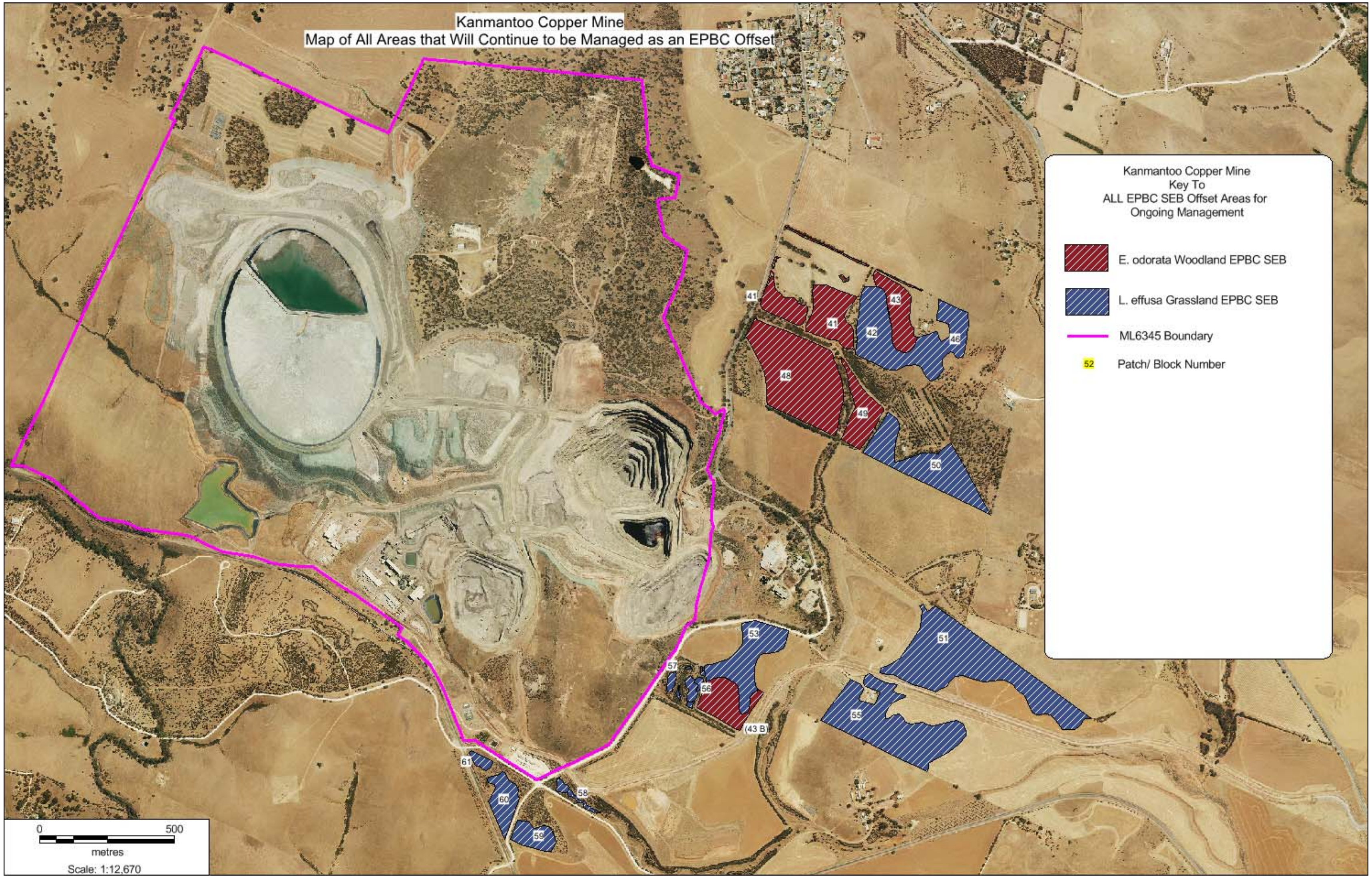

Figure 2-2 – MAP of all approved SEB offset areas after paying into the NVF

Vegetation assessment criteria used at the time of native vegetation disturbance approval
The following tables are extracted from the BlackOak Environmental report (Appendix A).

Table 2-1 provides the vegetation assessment criteria which was current when the KCM's vegetation disturbances were initially approved (ex DWLBC, 2005). Tables 2 to 5 provide a summary of native vegetation areas disturbed, their condition (SEB ratio), the area of SEB-offset required in each case and the calculated fee payable to the NVF if the offset obligation was not delivered by Hillgrove.

Table 2-1 – Applicable SEB assessment guidelines (DWLBC, 2005)

Vegetation condition	Indicators for condition	SEB ratio
Poor: Weed-dominated with only scattered areas or patches of native vegetation.	Vegetation structure no longer intact (e.g., removal of one or more vegetation strata)	2:1
	Scope for regeneration, but not to a state approaching good condition without intensive management	
	Dominated by very aggressive weeds	
	Partial or extensive clearing (greater than 50% of area)	
	Evidence of heavy grazing (tracks, browse lines, species changes, no evidence of solid surface crust)	
Moderate: Native vegetation with considerable disturbance.	Vegetation structure substantially altered (e.g., one or more vegetation strata depleted)	4:1
	Retains basic vegetation structure or the ability to regenerate it	
	Very obvious signs of long-term or severe disturbance	
	Weed dominated with some very aggressive weeds	
	Partial clearing (10 to 50% of area)	
	Evidence of moderate grazing (tracks, browse lines, soil surface crust extensively broken)	
Good: Native vegetation with some disturbance.	Vegetation structure altered	6:1
	Most seed sources available to regenerate original structure	
	Obvious signs of disturbance	
	Minor clearing (less than 10 % of area)	
	Considerable weed infestation with some aggressive weeds	
	Evidence of some grazing (tracks, soil surface crust patchy)	
Very good: Native vegetation with little disturbance.	Vegetation structure intact (e.g., all structure intact)	8:1
	Disturbance minor, only affecting individual species	
	Only non-aggressive weeds present	
	Some litter build-up	
Intact vegetation:	All strata intact and botanical composition close to original	10:1
	Little or no signs of disturbance	
	Little or no weed infestation	
	Soil surface crust intact	
	Substantial litter cover	

Source: BlackOak Environmental (2019) Table 1

The BlackOak Environmental data has been partitioned in this NVMP to differentiate between differing types of previously approved native vegetation disturbance as follows;

- Disturbance of vegetation communities which were not listed by the provisions of the EPBC-Act at the time disturbance approval was granted (non-EPBC SEB); and
- Disturbance of vegetation communities which were listed as 'critically endangered' under the provisions of the EPBC Act at the time approval was granted (EPBC SEB).

Table 2-2 to Table 2-4 present calculation of NVF payment requirements. The KCM is considered to be within the Mt Barker District Council for NVF payment purposes, hence the formula for calculating the SEB-offset payment into the NVF (DLWBC 2005) is:

NVF Payment =

(land value per hectare x required SEB-offset in hectares) +

(management fee per ha x area of clearance in ha)

There is scope to apply to the Native Vegetation Assessment Panel to review the appropriated land value associated with the NVF Payment given the proximity of the impact site to the Council boundaries of Murray Bridge and Alexandrina.

2.2 Original NVMP Native Vegetation Disturbance

When the Original NVMP was approved, none of the vegetation disturbance associated with the initial phase of mining operations triggered EPBC Act provisions. All SEB-offsets resulting from vegetation disturbance were approved by Regulators within South Australia. SEB-offsets and payments due for non-delivery of those offsets listed in the Original NVMP are detailed in Table 2-2.

Table 2-2: Original Mine Disturbance SEB calculations

Vegetation community	SEB condition ratio	Clearance area (ha)	Required SEB-offset (ha)	LGA land value	Management fee	SEB-offset Payment Due
Eucalyptus odorata low woodland	10:1	0.90	9.00	$8,401.00	$800.00	$76,329.00
	10:1	0.30	3.00	$8,401.00	$800.00	$25,443.00
	8:1	0.30	2.40	$8,401.00	$800.00	$20,402.40
	8:1	1.10	8.80	$8,401.00	$800.00	$74,808.80
	8:1	<0.10	0.00	$8,401.00	$800.00	-
	8:1	0.60	4.80	$8,401.00	$800.00	$40,804.80
	4:1	0.30	1.20	$8,401.00	$800.00	$10,321.20
	2:1	0.20	0.40	$8,401.00	$800.00	$3,520.40
	2:1	0.10	0.20	$8,401.00	$800.00	$1,760.20
Lomandra effusa open tussock grassland	10:1	6.80	68.10	$8,401.00	$800.00	$577,548.10
	10:1	0.30	3.00	$8,401.00	$800.00	$25,443.00
	4:1	0.20	0.80	$8,401.00	$800.00	$6,880.80
	4:1	0.10	0.40	$8,401.00	$800.00	$3,440.40
	4:1	0.10	0.40	$8,401.00	$800.00	$3,440.40
	4:1	0.20	0.80	$8,401.00	$800.00	$6,880.80
	4:1	1.00	4.00	$8,401.00	$800.00	$34,404.00
	4:1	0.50	2.00	$8,401.00	$800.00	$17,202.00
	4:1	0.20	0.80	$8,401.00	$800.00	$6,880.80
Austrostipa sp. open tussock grassland	10:1	0.10	1.00	$8,401.00	$800.00	$8,481.00
	10:1	0.10	1.00	$8,401.00	$800.00	$8,481.00
	4:1	0.60	2.40	$8,401.00	$800.00	$20,642.40
Eucalyptus gracilis, +/- *E. oleosa* open mallee	10:1	0.20	2.00	$8,401.00	$800.00	$16,962.00
	10:1	1.60	16.00	$8,401.00	$800.00	$135,696.00
	10:1	0.20	2.00	$8,401.00	$800.00	$16,962.00
Callitris gracilis low woodland	10:1	<0.10	0.00	$8,401.00	$800.00	-
Acacia pycnantha low woodland	8:1	2.10	16.80	$8,401.00	$800.00	$142,816.80
	8:1	0.40	3.20	$8,401.00	$800.00	$27,203.20
	4:1	0.10	0.40	$8,401.00	$800.00	$3,440.40

Vegetation community	SEB condition ratio	Clearance area (ha)	Required SEB-offset (ha)	LGA land value	Management fee	SEB-offset Payment Due
	4:1	0.10	0.40	$8,401.00	$800.00	$3,440.40
	4:1	1.80	7.20	$8,401.00	$800.00	$61,927.20
Sub-total	-	**20.50**	**162.50**	-	-	**$1,381,562.50**
Scattered trees	-	56 trees	17.80	$8,401.00	$800.00	$149,537.80
Total	-	**20.50**	**180.30**	-	-	**$1,531,100.30**

Source: BlackOak Environmental (2019) Table 2

At the time of the Original NVMPs approval, a total of 20.5ha of native vegetation and 56 isolated trees was disturbed, attracting and SEB-offset establishment obligation of 180.3ha. The corresponding fee payable for non-establishment of these SEB-offsets is calculated to be $1,531,100.30.

2.3 LOM Extension NVMP Native Vegetation Disturbance

Table 2-3 details approved native vegetation disturbance for non-EPBC Act listed vegetation approved within the LOM Extension NVMP, the SEB-offsets required for that disturbance, and the corresponding calculation of an appropriate SEB-offset payment for non-delivery of that offset.

At the time of the LOM NVMP approval (2014), disturbance of *Eucalyptus odorata* low woodland communities and *Lomandra effusa* +/- *Helichrysum leucopsideum* open tussock grassland communities were considered to be 'controlled actions' under the EPBC Act. For completeness, Table 2-4 details approved disturbance of EPBC-Act listed vegetation within the LOM NVMP. Delivery of SEB-offsets for disturbance of EPBC Act listed vegetation communities will not be discussed within this NVMP: refer rather to Appendix C.

Table 2-3 – LOM Extension Disturbance SEB calculations (non-EPBC SEB)

Vegetation community	SEB condition ratio	Clearance area (ha)	Required SEB-offset (ha)	LGA land value	Management fee	SEB-offset Payment
Austrostipa sp. open tussock grassland	10:1	0.20	2.00	$8,401.00	$800.00	$16,962.00
Acacia pycnantha low woodland	8:1	1.50	6.00	$8,401.00	$800.00	$51,606.00
	4:1	1.10	4.40	$8,401.00	$800.00	$37,844.40
Total	-	**2.8**	**12.4**	-	-	**$106,412.40**

Source: BlackOak Environmental (2019) extract from Table 3

Table 2-4 - LOM Extension Disturbance SEB calculations (EPBC SEB)

Vegetation community	SEB condition ratio	Clearance area (ha)	Required SEB-offset (ha)	LGA land value	Management fee	SEB-offset Payment Due
Eucalyptus odorata low woodland	10:1	1.80	18.00	-	-	-
Lomandra effusa +/- *Helichrysum leucopsideum* open tussock grassland	10:1	3.40	34.20	-	-	-
	8:1	0.01	0.10	-	-	-
	4:1	1.00	4.10	-	-	-
Total	-	**6.21**	**56.40**	-	-	-

Source: BlackOak Environmental (2019) extract from Table 3

The total area of native vegetation disturbance approved under the LOM NVMP was 9.01ha. Of this, 2.8ha of non-EPBC Act listed vegetation was disturbed, requiring a total of 12.4ha of SEB-offset establishment.

The fee payable to the NVF for not delivering SEB-offsets for non-EPBC Act listed vegetation is $106,412.40

2.4 Giant Pit Cutback NVMP Addendum.

The approved vegetation disturbance required to complete the Schultze cut-back of Giant Pit did not involve EPBC-act listed vegetation communities. The area of disturbance, SEB-offset obligations for disturbance and NVF payment due for non-delivery of the SEB-offset is listed in Table 2-5.

Table 2-5 - Giant Pit Cutback Disturbance SEB calculations

Vegetation community	SEB condition ratio	Clearance area (ha)	Required SEB-offset (ha)	LGA land value	Management fee	SEB-offset Payment Due
Acacia pycnantha low woodland	6:1	0.99	6.0	$8,401.00	$800.00	**$51,198.00**

Source: BlackOak Environmental (2019) Table 4

The Giant Pit cut-back disturbed a total of 0.99ha of non-EPBC Act listed vegetation, requiring provision of 6.0ha of SEB-offset. The payment due to the NVF for non-delivery of this SEB-offset is $51,198.00.

2.5 Summary of SEB Offset Payments

Table 2-6 summarises all vegetation disturbance approved under pervious NVMPs and details the NVF payments due for non-provision of SEB-offsets relating to the disturbance of non-EPBC Act listed vegetation during mining operations.

Table 2-6 - Summary SEB Offsets for KMC Operations

Vegetation community	Clearance area (ha)	Required SEB-offset (ha)	LGA land value	Management fee	SEB-offset Payment Due
Stage 1 Areas (Original NVMP)	20.5	162.5	$8,401.00	$800.00	**$1,381,562.50**
Stage 1 Scattered Trees	56 trees	17.8	$8,401.00	$800.00	**$149,537.80**
Stage 2 Areas Non-EPBC Act Listed Vegetation (LOM-Extension NVMP)	2.8	12.4	$8,401.00	$800.00	**$106,412.40**
Stage 3 Areas (Giant-Pit Cut-Back NVMP)	0.99	6.0	$8,401.00	$800.00	**$51,198.00**
Totals (non-EPBC Act)	**24.29ha + 56 trees**	**198.7**			**$1,688,710.70**
Stage 2 Areas EPBC Act Listed Vegetation (within Controlled Action EPBC 2013/6965)	6.21	56.4	-	-	-
Complete Totals	**30.59 ha + 56 trees**	**255.1**			

In summary, Table 2-6 highlights that a total of 30.59ha of native vegetation and 56 scattered trees were disturbed during Hillgrove's mining operations at KCM.

- At the time that our various NVMPs were approved, 24.29ha of native vegetation disturbance was approved outside of EPBC Act provisions.

- Approved disturbance of vegetation outside of EPBC Act provisions attracted a combined obligation to establish 198.7ha of SEB-offset vegetation.
- Hillgrove's inability to deliver KCM non-EPBC Act SEB-offsets will require a payment to the SA Native Vegetation Fund of $1,688,710.70.

2.6 Location of SEB-offsets

The provision of SEB-offsets has been commenced within the ML on available introduced pasture land and on rehabilitated mine landforms as a component of Hillgrove's progressive rehabilitation program. SEB-offsets have also been established on abandoned farming land within Hillgrove-owned properties directly adjacent to the ML. Figure 22.3 provides a generalised view of where SEB-offset establishment has been commenced between 2010 and 2019.

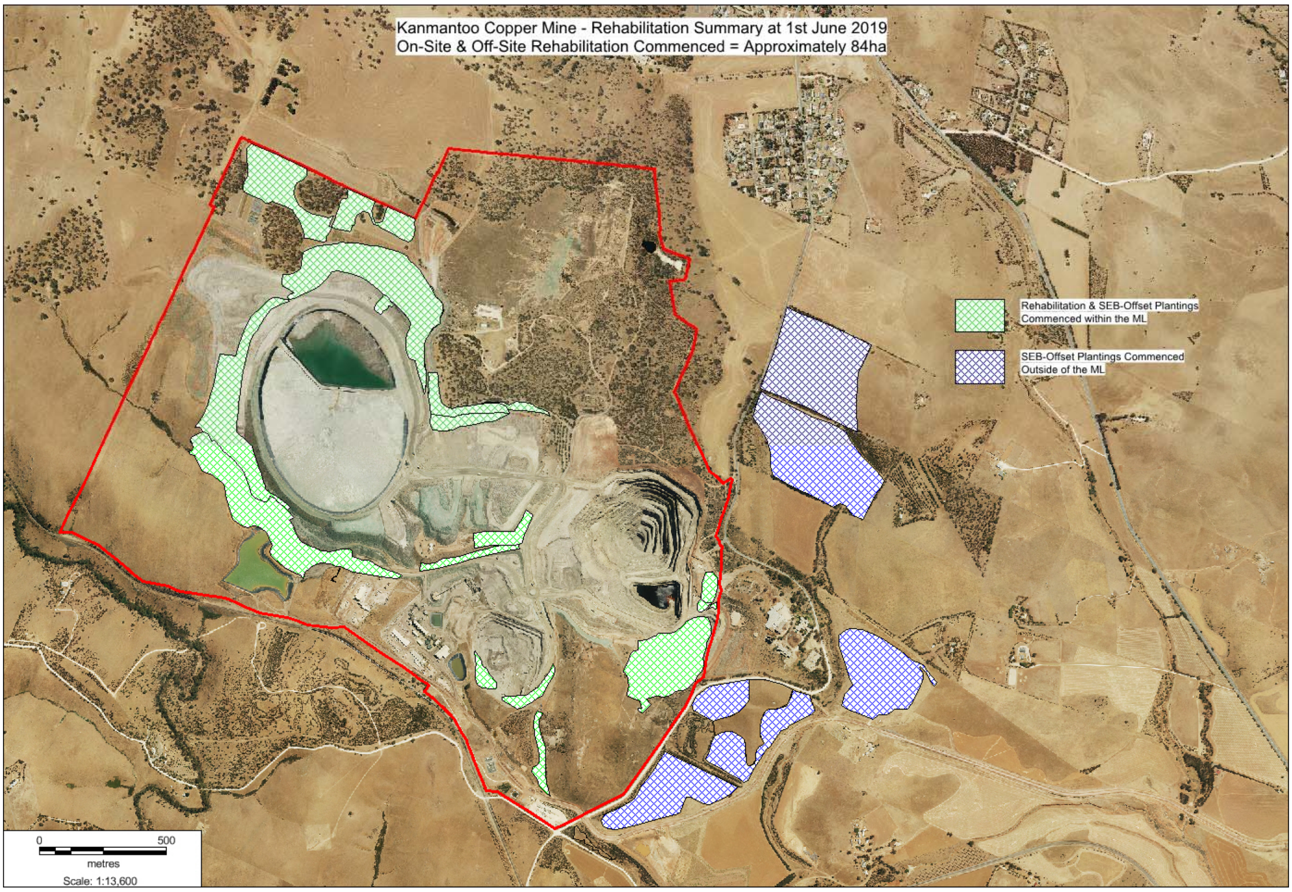

Figure 2.3 - Map of SEB-offset commencement within ML area and off-site on Hillgrove-owned properties (2010 to 2019)

The green SEB areas within the ML area shown above on Figure 23, are associated with offset obligations accrued through the approved disturbance of native vegetation communities not listed by the EPBC Act at the time approval was granted (i.e., within the Original NVMP).

The blue SEB areas off-site on Figure 23 are offset obligations accrued through the approved disturbance of native vegetation communities during the LOM Extension and Main Pit cutback, hence approved under controlled action EPBC 2013/6965. The blue areas also contain SEB-offsets commenced for approved disturbance of non-EPBC Act listed vegetation during the LOM Extension and Main Pit cut-back. The location of SEB-offsets for disturbance of EPBC Act (red) and non-EPBC Act (green) vegetation outside of the ML area is illustrated in Figure 2-4 and listed in Table 2-7.

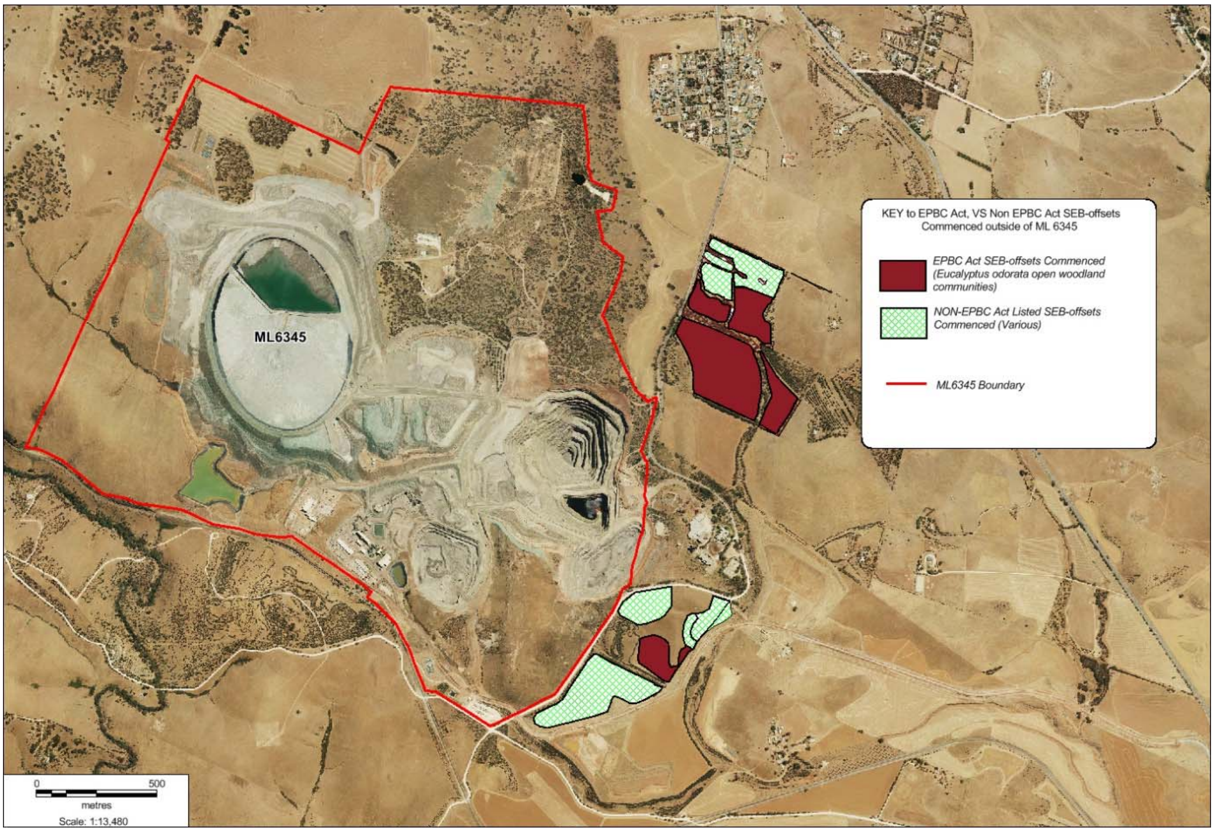

Figure 2-4 - Location of EPBC Act and Non-EPBC Act SEB-offsets commenced outside of the ML

Table 2-7 - List of Hillgrove-owned Properties including ML6345 and EML6340, which currently host non-EPBC SEB offsets and EPBC SEB offsets

Property Name	CT Reference/ Owner	Type of SEB-Offset Community Currently Planted or Proposed
141 Mine Rd 'Storer's'	F160800 A61/ Hillgrove	EPBC (*Eucalyptus odorata*) Non-EPBC (*Acacia pycnantha*)
175 Mine Rd 'Mulawa'	F1636 AL1/ Hillgrove	EPBC (*Eucalyptus odorata*)
319 Mine Rd 'Ferguson's'	D80644 AL21/ Hillgrove	EPBC (*Eucalyptus odorata*) Non-EPBC (*Acacia pycnantha*, *Austrostipa*)
2362 Old Princess Highway 'Borchardt's'	F1636 AL5/Hillgrove	Not yet planted EPBC (*Eucalyptus odorata*) Non-EPBC (*Austrostipa*)
Lot 25 Mine Rd	D60948 AL25 (EML6340)/ Hillgrove	Non-EPBC (*Acacia pycnantha*)

Property Name	CT Reference/ Owner	Type of SEB-Offset Community Currently Planted or Proposed
440 Mine Rd 'ML6345 – South	D80644 AL20/ Hillgrove	Non-EPBC* (*Eucalyptus odorata, Austrostipa*)
236 Mine Rd 'ML6345 - North	D20509 AL59/ Hillgrove	Non-EPBC* (*Eucalyptus odorata, Austrostipa*)

* Non-EPBC offsets commenced for disturbance of these communities within the ML approved prior to them being listed by the EPBC Act.

2.7 Conclusions

Under this revision of the Kanmantoo Copper Mine NVMP, i.e., the Mine Closure NVMP, Hillgrove will pay $1,688,710.70 to the South Australian Native Vegetation Fund (NVF) pending review of the land value calculation as payment in full for disturbance of all non-EPBC Act listed vegetation during the Hillgrove mining operations at the KCM.

The payments will be staged to reflect the potential changes associated with the EPBC offsets (refer to Section 5.3.3)

Hillgrove's payment to the NVF will extinguish further SEB-offset establishment for the disturbance of non-EPBC Act listed vegetation detailed in previous versions of Hillgrove's NVMPs.

Further activities to be conducted on the areas of non-EPBC SEB-offsets which have been established to-date is covered in Section 5.0.

Further investigation of appropriate payments for non-establishment of SEB-offsets for disturbance of EPBC-Act vegetation communities is currently underway with the Federal DoE and may result in a later update to the Mine Closure NVMP. Until such time, the LOM Extension NVMP (as amended) in Appendix C applies to all EPBC Act SEB offsets.

3.0 Delivery of NVMP Obligations Prescribed by the Mining Act 1971

3.1 Background

This section of the Mine Closure NVMP focuses on amending commitments to meet the KCM mine rehabilitation and mine closure obligations under the SA Mining Act 1971, namely those included as lease conditions under ML6345 and ML6436 (applicable to the northeast extension of the Nugent Pit).

The lease condition requirements related to mine rehabilitation are:

> *Schedule 2 – Clause 27. Rehabilitation*
>
> *The Lessee must demonstrate prior to Lease expiry or surrender that the following outcomes will be achieved indefinitely post mine closure to the satisfaction of the Director of Mines:*
>
> - *The external visual amenity of the site is comparable with the surrounding areas and in accordance with the reasonable expectations of relevant stakeholders including removal of all mine related infrastructure (unless otherwise approved by the Director of Mines in consultation with relevant stakeholders);*
> - *The risks to the health and safety of the public and fauna are as low as reasonably practical;*
> - *Ecosystem and landscape function is resilient, self-sustaining and indicating that an ecosystem and landscape function comparable to the surrounding areas will ultimately be achieved;*
> - *The site is physically stable to the extent that vegetation provides an improvement to erosion outcomes long-term*

Relevant to the Mine Closure NVMP is the condition: *Ecosystem and landscape function is resilient, self-sustaining and indicating that an ecosystem and landscape function comparable to the surrounding areas will ultimately be achieved;*

This has been translated to the following mine completion outcome:

Completion Outcome 1

Ecosystem and landscape function is resilient, self-sustaining and indicating that an ecosystem and landscape function comparable to the surrounding areas will ultimately be achieved.

The condition requiring '*The site is physically stable to the extent that vegetation provides an improvement to erosion outcomes long-term'* has been addressed in the PEPR in terms of landform erosion rather than vegetation influence on erosion and as such is not relevant to the Mine Closure NVMP.

The condition; '*The external visual amenity of the site is comparable with the surrounding areas and in accordance with the reasonable expectations of relevant stakeholders including removal of all mine related infrastructure (unless otherwise approved by the Director of Mines in consultation with relevant stakeholders)'* has also been addressed in the PEPR in terms of broad visual amenity. While revegetation is a factor in visual amenity, this input to this requirement will be met through meeting Completion Outcome 1; hence this condition is not discussed further in the Mine Closure NVMP.

Further information on mine completion outcomes is provided in the PEPR.

Additional operational lease conditions that are relevant to this NVMP are:

Fauna: 11. The Lessee must in constructing and operating the Lease ensure that there are no net adverse impacts from the site operations on native fauna abundance and/or diversity within the Lease area and in adjacent areas. **Flora**: 12. The Lessee must, in constructing and operating the

Lease, ensure that all clearance of native vegetation is authorised under appropriate legislation and ensure no permanent loss of abundance or diversity on or off the Lease.

Weeds and Pests: 13. The Lessee must in constructing and operating the Lease ensure no introduction of new weeds, plant pathogens or pests (including feral animals), nor increase in abundance of existing weed or pest species in the Lease area and adjacent areas caused by mining operations.

3.2 Mine Closure at Kanmantoo Copper Mine

3.2.1 Mine Closure Domains

Hillgrove has been conducting progressive closure since mid-2013 across the KCM, waste rock dumps and Integrated Waste Landform as well as implementing the required offset revegetation off-site and enhancing remnant vegetation on site. This has allowed Hillgrove to trial different rehabilitation techniques and determine appropriate and tested closure techniques.

A full description of mine closure and completion commitments are presented in the PEPR.

The ML area has been divided into mine closure domains to allow for the definition of the capability of the area to support proposed post-closure land uses (Figure 3-1). The identified proposed land uses for each domain is presented in Table 3-1, with a preference towards land uses which are complementary with each other and to the surrounding existing land uses.

Table 3-1 - Proposed land uses for each domain on closure

Domain	Proposed land use	Mine Closure NVMP Section
Open pits	Main pit (open pit void with plugged / backfilled underground portal) – pit lake of poor water quality. Backfilled pit areas: modified landform of mixed native and pasture vegetation.	Section 3.3.1
Underground	Underground voids, portal within open pit.	Not addressed – no rehabilitation closure component
Integrated waste landform (IWL)	Modified landform of mixed native and pasture vegetation	Section 3.3.2
Infrastructure	Industrial Park (Should the Industrial Park not be realised, the area will be rehabilitated to mixed native and pasture vegetation)	Section 3.3.3
Surface water structures	Those structures not required for an Industrial Park will progressively become filled with silt. In time, they will revegetate with mixed native and pasture vegetation through natural recruitment	Section 3.3.4
Native woodland	Native woodland habitat	Section 3.3.5
Native grassland	Native grassland habitat	Section 3.3.6
Introduced pasture	Unchanged retained as introduced pasture	Section 3.3.7

Domain	Proposed land use	Mine Closure NVMP Section
Enhanced vegetation areas	Unchanged – enhanced vegetation areas Note – these are areas that have been converted from introduced pasture through planting of native species	Section 3.3.8
Old tailings dam	Unchanged – remains as old tailings dam with incident vegetation cover	Section 3.3.9
ElectraNet Infrastructure	The ElectraNet power substation is located near the main entrance to the ML. It supplies the power requirements of the MLs processing plant and support infrastructure. This substation is the property of ElectraNet and they hold full management responsibility. The substation may continue to be required if the infrastructure domain is retained as an industrial park and will remain the responsibility of ElectraNet. If the substation is no longer required, removal and any remediation and rehabilitation will be the responsibility of ElectraNet. Hillgrove has no current or future responsibility for management of this area.	Not addressed – no Hillgrove rehabilitation closure component
Other disturbed areas	Mixed native and pasture vegetation	Section 3.3.10

The base case for closure of the Kanmantoo Copper Mine ML area is a mixture of remnant native vegetation and rehabilitation consisting of natives and pasture species, similar to the surrounding lands, with the infrastructure domain retained as an Industrial Park. T(see Figure 3-3).

Rezoning activities are currently underway for the Industrial Park and should this option be realised, some of the infrastructure and services may remain and be transferred to third parties for use within the Industrial Estate (refer to Section 3.3.3).

There is also the potential for a pumped hydro-electricity scheme (PHES) to be implemented on the northern portion of the ML. In the event the PHES is implemented, a number of the above domains would be partially impacted (Figure 3-1). This PEPR details the closure assuming PHES does not go ahead. Should the PHES be implemented, the closure applicable to the PHES area is presented in the Partial Lease Relinquishment Plan as an appendix to the PEPR.

3.2.2 Mine Completion Criteria

Mine completion criteria have been established to provide for clear evidence of achievement of the mine completion outcomes as relevant to the lease conditions identified in Section 3.1. of the PEPR.

3.3 Rehabilitation and Vegetation Management Processes for Mine Closure

Progressive rehabilitation and land management programs within ML6345 will continue to proceed within the closure domains highlighted in Figure 3-1 until such time as the lease is partially or fully relinquished.

Rehabilitation processes appropriate for each closure domain are discussed in the following sections.

Point of difference between previous NVMPs and Mine Closure NVMP

The intensive post-hydroseeding follow-up maintenance and tubestock planting required to achieve SEB-offset quality native vegetation will not be conducted.

To meet SEB criteria, this intensive maintenance is required for at least 8 to 10 years, which is now not feasible for Hillgrove (refer to Section 1.4). Under the Mine Closure NVMP, SEB-offset vegetation will not be established on rehabilitated mine landforms, i.e, the IWL, or on other available areas within the ML.

This change is reflected in the differences evident between the post-closure vegetation maps, i.e., Figure 3-2 (the 'original' post-closure vegetation distribution) and Figure 3-3 (the 'revised' post-closure vegetation distribution reflected in this NVMP)

3.3.1 Open Pit Domain

Landform Rehabilitation

Mining operations at the KCM were carried out in a number of open-pit areas, including Main (Giant) Pit, Nugent Pit and Emily Star Pit. Most of the Main (Giant) Pit will remain a void, while Nugent and Emily Star Pits have been backfilled. The Main Pit void may become a water storage for the PHES project.

The backfilled pits are the lighter area in Figure 3-4.

Nugent Pit: These areas were progressively backfilled when mining was completed, with the landform returned to an approximation of the pre-mining hill profile. Nugent Pit has been hydroseeded and the landform blends into the adjacent terrain and approximates the pre-mining form of this hillside.

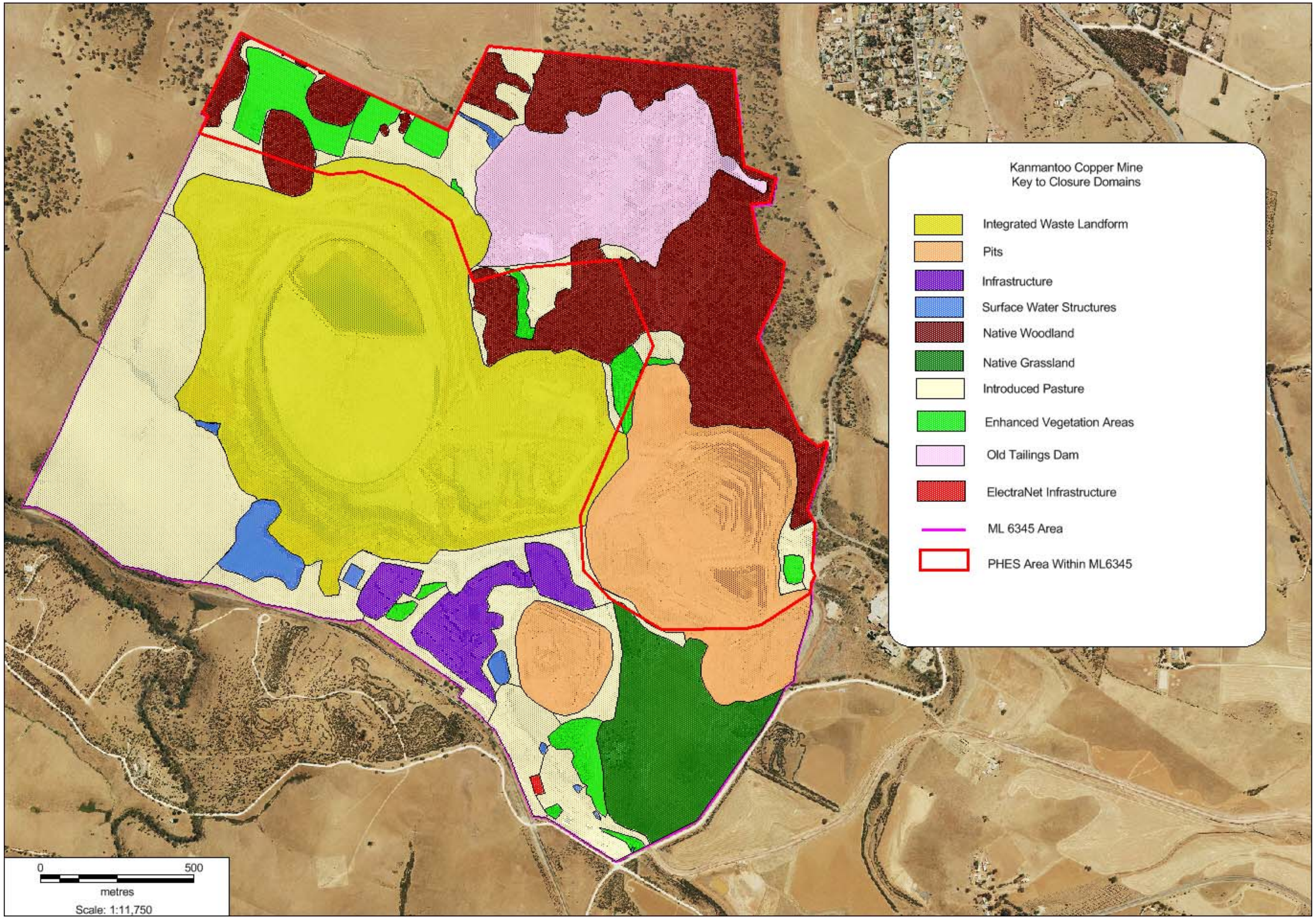

Figure 3-1 – Kanmantoo Copper Mine Closure domains

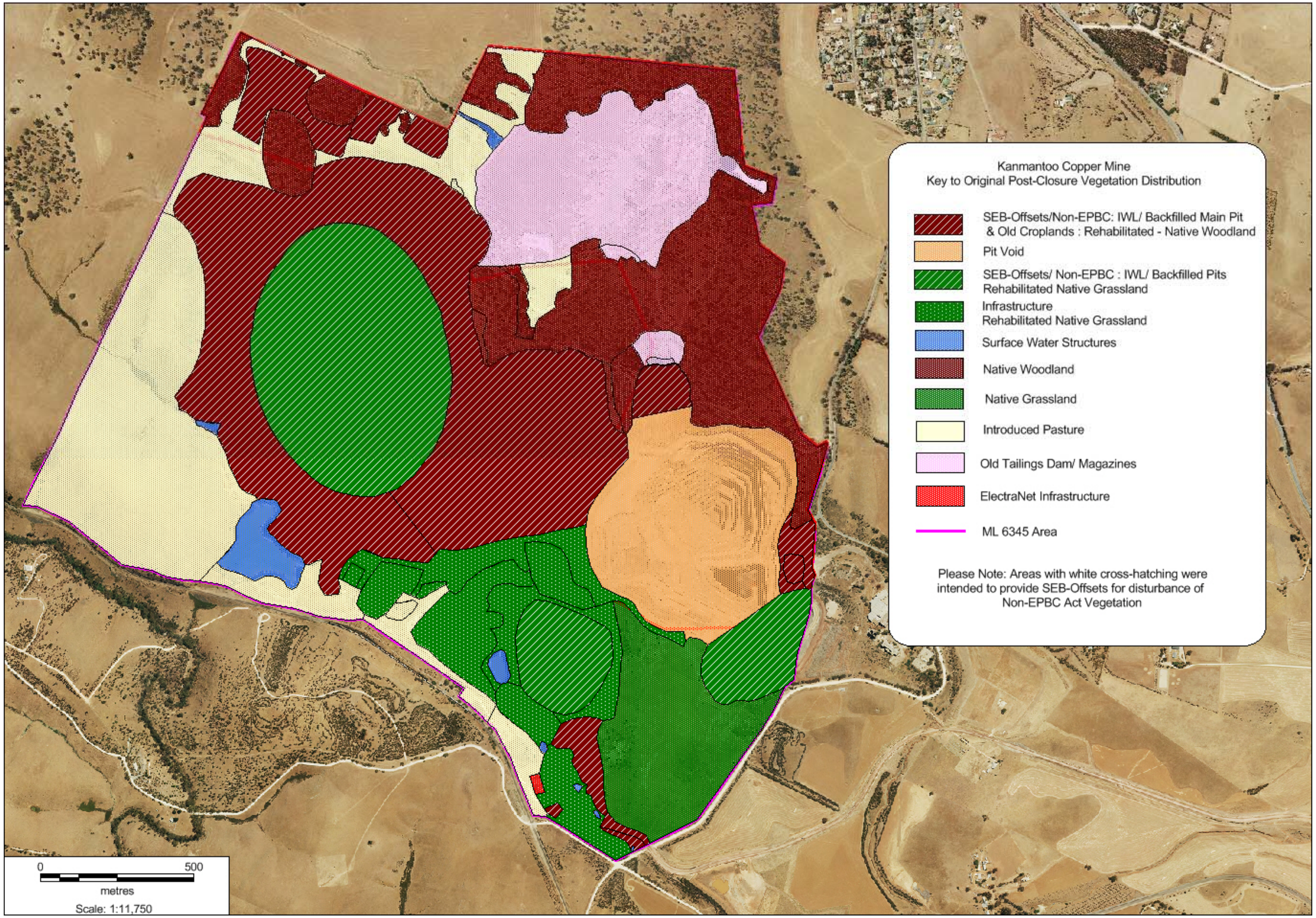

Figure 3-2 – Kanmantoo Copper Mine: Original Post-Closure Vegetation Distribution

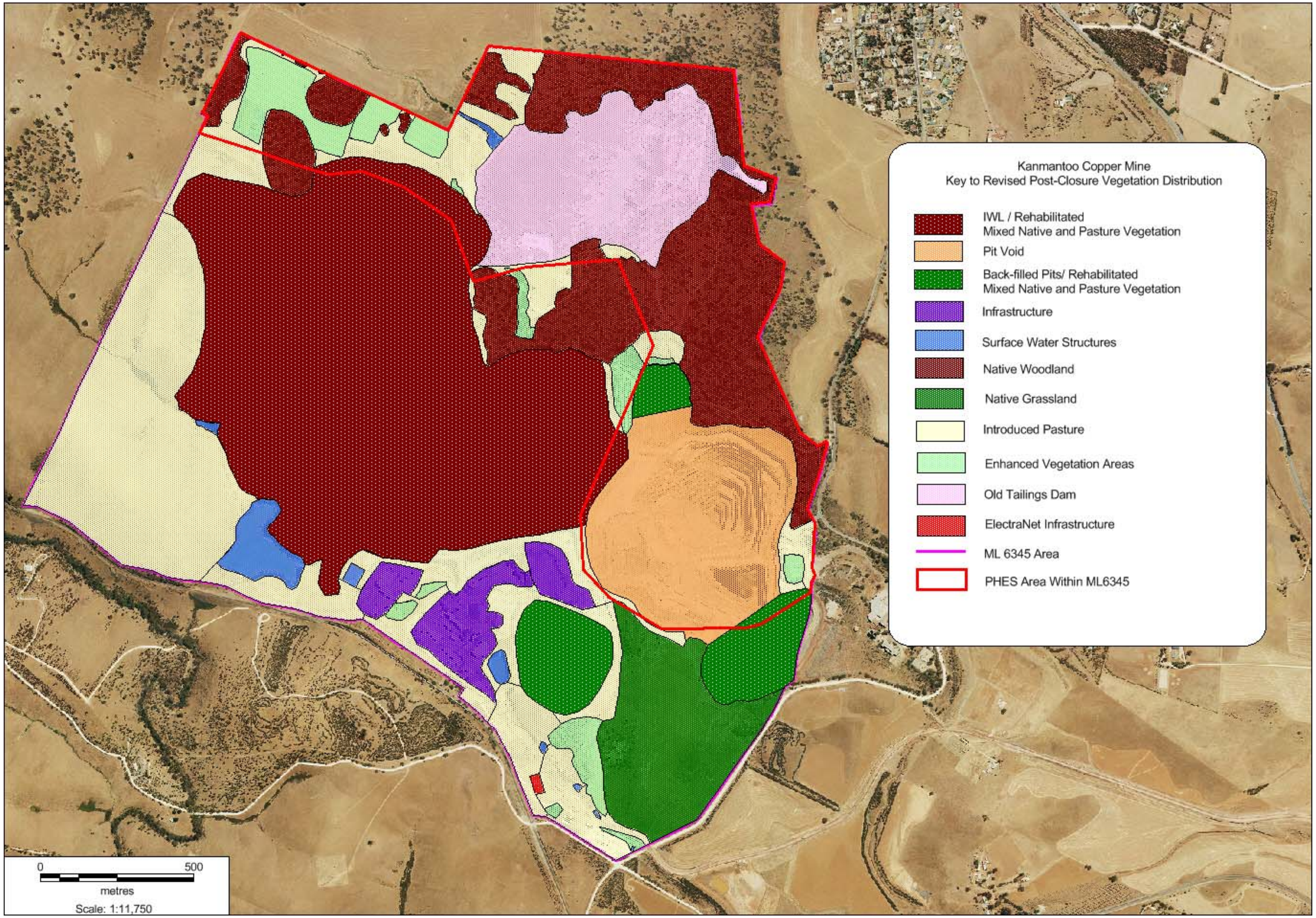

Figure 3-3 – Revised Post-Closure Vegetation Distribution Post-closure land use (base case)

Figure 3-4 - Backfilled Nugent pit during hydroseeding (light green areas) – May 2018

Nugent Pit was progressively backfilled and rehabilitated, following the same depositional sequence described for construction and rehabilitation of the IWL. Potentially acid forming (PAF) waste forms the core of the Nugent landform, with a Non-acid forming (NAF) shell, then topsoil encapsulating the outer layers of the landform. The topsoil was ripped, then immediately hydroseeded with a similar seed mix to that detailed in Table 3-2. Vegetation establishment in Year 2 (2019) has been promising, as illustrated by Figure 3-5.

Table 3-2 - Indicative seed mix composition for hydroseeding

Species	Native or pasture
Acacia pycnantha	Native
Eucalyptus odorata	Native
Dodonaea viscosa	Native
Callitris gracilis	Native
Maireana brevifolia	Native
Rytidosperma sp. (Danthonia)	Native
Atriplex semibaccata	Native
Enchylaena tomentosa	Native
Convolvulus erubescens	Native
Vittadinia blackii	Native
Maireana brevifolia	Native
Rytidosperma sp. (Danthonia)	Native
Austrostipa/Rytidosperma mix sp.	Native
Austrostipa sp.	Native
Cullen australasicum	Native
Enchylaena tomentosa	Native
Atriplex semibaccata	Native
Dodonaea viscosa	Native
Enchylaena tomentosa	Native
Callitris gracilis	Native
Allocasuarina verticillata	Native

Species	Native or pasture
Vittadinia sp.	Native
Maireana brevifolia	Native
Rytidosperma sp. (Danthonia)	Native
Austrostipa/Rytidosperma mix sp.	Native
Austrostipa sp.	Native
Chloris truncata	Native
Senna artemisioides	Native
Austrostipa/Rytidosperma mix sp.	Native
Chloris truncata	Native
Cullen australasicum	Native
Allocasuarina verticillata	Native
Dodonaea viscosa	Native
Callitris gracilis	Native
Dactylis spp. (grass)	Pasture*
Festuca spp. (grass)	Pasture*
Lolium spp. (grass)	Pasture*
Trifolium spp. (legume)	Pasture*
Medicago spp. (legume)	Pasture*

*** T**he pasture species which are best suited to the specific rainfall region (425mm), with the best prospects of establishing and persisting, will be selected.

Figure 3-5 - Year 2 vegetation establishment on the southeast batter slope of Nugent (left) and the top of Nugent (right) (June 2019)

Emily Star Pit: This area was progressively backfilled when mining was completed, with the process following the same depositional sequence previously described for construction the IWL and backfilling of Nugent pit. Backfilling was halted at approximately the same level as the pre-mining landform. A layer of red-brown clay subsoil was deposited over the backfilled pit surface as a visible interface marker, before a low-grade ore stockpile was constructed over the backfilled pit. Following the completion of open-cut mining on-site, approximately 3Mt of low grade ore will be processed from this stockpile during 2019 and the early months of 2020. Once the ore has been removed to the level of the interface marker layer, the rehabilitation process will follow the same sequence as previously described for the IWL and Nugent Pit. Once the final landform has been achieved, ripped topsoil will be hydroseeded with a stabilising seed mixture which will contain species included in or similar to those listed in Table 3-2 and will be maintained as described in Section 4.0 of this NVMP.

Figure 3-6 - Year 3 vegetation establishment on the SE batter slope of Emily Star Pit (August 2019)

Note that the low-grade ore stockpile is located beyond the batter crest in Figure 3-6. The stockpile area forming the remainder of the backfilled Emily Star pit will be rehabilitated in 2019 when ore supplies have been exhausted.

Key limitations and management practices for the Open Pit domain are discussed in Section 4.3.1.

3.3.2 Integrated Waste Landform Domain

Landform Rehabilitation

Details on the landform design, construction and rehabilitation of the Integrated Waste Landform (IWL) is provided in the PEPR.

Once the design criteria of the IWL landform have been met, the top non-acid-forming (NAF) layer is covered with a 0.15m layer of topsoil, which is then ripped parallel to the landform contours with a bulldozer. This acts to partially incorporate the topsoil and NAF at the surface, while creating surface dips and swales to intercept rainfall and limit runoff.

Where the IWL surface is too steep to rip, stockpiled topsoil with high residual pasture seed content (harvested during initial site clearance), is cast down-slope with an excavator bucket until the required topsoil deposition thickness is achieved.

Landform Revegetation

As soon as possible after topsoil ripping (or topsoil deposition, in the case of steep batters), the IWL surface is hydroseeded with a mixture of locally-grown and locally collected native plant species. The on-site seed production area (SPA) and off-site seed management area (SMA) have jointly produced over 1000kg of native seed to date. When added to wild-seed collections and seed harvested from established SEB-offset areas, these seed sources have provided the entire seed requirement for rehabilitation and SEB-offset establishment to date.

Hillgrove will continue to use the same seed sources for hydroseeding and will use a seed mix similar to that outlined in Table 3-2, for as long as seed sources remain viable. In the event of sit-base viable seed no longer being available, Hillgrove would investigate wild seed collection and seed purchase.

Hydroseeding uses between 15 and 20kg/ha of seed mix in a tank-mix of adjuvants applied with approximately 0.5t/ha wood-fibre hydromulch to aid seeding visibility and uniformity. The initial seed layer is then followed by a further 2t/ha layer of hydromulch. The hydromulch layer acts to inhibit wind and water erosion, limits predation by foraging insects or birds and reduces surface evaporation during seed germination. The hydromulch/topsoil layer also provides a benign hydroscopic nursey medium supporting initial seed growth.

Figure 3-7 illustrates hydroseeding operations on the IWL during 2019 while Figure 3-8 highlights the resultant vegetation growth.

Figure 3-7 - Hydroseeding operations on the KCM IWL (March 2019)

Figure 3-8 – Resultant vegetation germination 4 months after hydroseeding (August 2019)

As the IWL vegetation cover develops and evolves, it will ultimately become an amalgam of native and pasture species. It is expected that locally adapted native plant species will out-compete the predominantly Mediterranean weed and pasture species during dry seasons, while the Mediterranean species will generally have a competitive advantage during wet seasons.

Under this Mine Closure NVMP, Hillgrove will implement a vegetation cover on the IWL that will evolve to provide a resilient self-sustaining vegetation community, similar to that found in unimproved pastures in the Kanmantoo region. We expect that the local native mid-story and canopy species included in the hydroseeding seed mix, will establish to provide extra dimensions to the vegetation cover. Other than old remnant native trees, younger mid-story and canopy species have generally been removed by livestock in neighbouring properties and are not usually observed in commercially grazed pastures surrounding the ML.

In cases where subsoil areas are present in the topsoil layer placed on rehabilitated landforms, the subsoil may have a low level of encapsulated seed, or it may prove to be hostile to native seed establishment due to sodicity, instability or poor nutrient content. Where topsoil patches prove to be recalcitrant or the establishment of hydroseeded native species proves to be otherwise unsatisfactory, recalcitrant patches may be re-seeded in the following season with stabilising pasture species. This will be to ensure that a resilient, self-sustaining vegetation cover is established evenly over the IWL landform as soon as possible after topsoil placement.

Where native species have successfully established within rehabilitated areas of the IWL, it is expected that those native species will infiltrate and establish in recalcitrant areas. This will be particularly so for grass species, including those from the genera Rytidosperma, Austrostipa and Chloris.

Over time, it is expected that the rehabilitation of the IWL will result in a vegetation cover which is typical of that found elsewhere within the ML and on adjacent properties in the near-mine region. Results from LFA monitoring have demonstrated that rehabilitated landforms are on a trajectory towards stabilising with an overlying mixture of native vegetation and pasture vegetation.

Key limitations and management practices for the Integrated Waste Landform domain are also discussed in Section 4.3.1.

3.3.3 Infrastructure Area Domain

Infrastructure areas within the ML include the processing plant, workshops, office complex, ROM ore stockpile and workshops.

The community, through the Kanmantoo Callington Community Consultative Committee (K4Cs) Master Planning Sub-Committee, have expressed a strong desire to retain some of the infrastructure and the infrastructure area of the mine such that it can be re-purposed as a local industrial estate, or used in other ways to support community activities. On 13 August 2019 the Mount Barker District Council lodged a Statement of Intent to the Minister for Planning, Mr Stephan Knoll, to support a Developer funded Development Plan Amendment (DPA) to rezone the Infrastructure Area domain to “Urban Employment Zone”. This is expected to be formalised prior to mid-2020. This will allow for the establishment of an Industrial Park which will result in repurposing of all or some of the existing infrastructure and services in this domain.

Establishment of the Industrial Park will involve determination of which infrastructure and disturbance footprints are to be retained for future use.

Where some items of infrastructure require removal, or should the base case industrial park vision not be realised, infrastructure would be demolished or dismantled and removed. Following removal of machinery and buildings, concrete pads and structures would be demolished and disposed of appropriately. The resultant infrastructure footprint would then be covered with a NAF layer and then profiled to blend with the surrounding terrain. Finally, topsoil would be applied, ripped and hydroseeded with a seed mix and managed long-term as for the open pit domain (Section 3.3.1).

Key limitations and management practices for the Infrastructure domain are discussed in Section 4.3.2.

3.3.4 Surface Water Structures Domain

Surface water structures not retained for potential repurposing, e.g., as part of the Industrial Park, will be closed, retained or remediated in accordance with approved procedures outlined in our PEPR, i.e., the water storages will be allowed to silt up and reintegrate to the natural topography over time. As such, no revegetation work will be conducted on these structures.

Key limitations and management practices for the Surface Water Structures domain are discussed in Section 4.3.3.

3.3.5 Native Woodland Domain

Native woodland within ML6345 will continue to be protected from disturbance or degradation by Hillgrove until lease relinquishment is achieved, or some other agreement for management transfer is approved (e.g., AGL takes control of the PHES portion of the lease).

Key limitations and management practices for the Native Woodland domain are discussed in Section 4.3.4.

Under the previous NVMPs, this area formed part of the non-EPBC SEB offsets. With payment into the NVF, the requirement to maintain this domain as SEB offset is removed.

The community however has expressed a strong desire for this area to remain protected and options being considered are further discussed in Section 5.3.

3.3.6 Native Grassland Domain

As for the native woodland areas, native grassland within ML6345 will continue to be protected from disturbance or degradation by Hillgrove until lease relinquishment is achieved, or some other agreement for management transfer is approved (e.g., AGL takes control of the PHES portion of the lease). Key limitations and management practices for the Native Woodland domain are discussed in Section 4.3.5.

3.3.7 Introduced Pasture Domain

Introduced pasture areas within the ML will continue to be protected from disturbance or degradation by Hillgrove until lease relinquishment is achieved, or some other agreement for management transfer is approved (e.g., AGL takes control of the PHES portion of the lease). Key limitations and management practices for the introduced pasture domain are discussed in Section 4.3.6.

3.3.8 Enhanced Vegetation Domain

This domain, scattered throughout the ML area, consists a number of areas where introduced pasture has been enhanced through the planting of native species. These areas will continue to be protected from disturbance or degradation by Hillgrove until lease relinquishment is achieved, or some other agreement for management transfer is approved (e.g., AGL takes control of the PHES portion of the lease). Key limitations and management practices for this domain are discussed in Section **Error! Reference source not found.**.

3.3.9 Old Tailings Dam

The old tailings dam is a legacy from the 1970's pre-Hillgrove mining operation remains largely undisturbed. No rehabilitation activities are proposed for this domain. Key limitations and management practices for this domain are discussed in Section 4.3.8.

3.3.10 Other Disturbed Area Domain

Other disturbed areas include the SPA, magazine areas and various laydown areas across the site. This domain will be closed and rehabilitated and maintained in the same manner as the infrastructure domain (refer to Section 3.3.3). Key limitations and management practices for this domain are discussed in Section 4.3.9.

3.4 Criteria for satisfying Mine Completion Outcome 1

3.4.1 Background

The objective assessment of progressive vegetation cover development is essential to track the efficacy of rehabilitation activities and the progression of those activities towards mine completion and lease relinquishment.

As identified in Section 3.2.2, achievement of Mine Completion Outcome 1 (Ecosystem and landscape function is resilient, self-sustaining and indicating that an ecosystem and landscape function comparable to the surrounding areas will ultimately be achieved) will be measured through LFA and outcome achievement will be defined by:

A suitably qualified expert provides a report verifying, through assessment of annual LFA monitoring over a period of 5 years, that the rehabilitation presents a trend of continual improvement in landscape function and perennial plant cover to indicate the ecosystem and landscape function is resilient and self-sustaining and is or will become comparable to surrounding areas over time.

This outcome achievement definition was developed with independent advice from BlackOak Environmental. BlackOak's full response is attached as Appendix B, however the following paragraphs provide a summary of this advice;

> *"It is recommended that the key rehabilitation monitoring tool utilised is Landscape Function Analysis (LFA). After land rehabilitation has occurred LFA surveys are conducted at various intervals over time on the rehabilitated areas and compared against analogue (control) sites. LFA is a monitoring system that provides time series data from assessments of landscape functioning and perennial vegetative growth. LFA is a valuable tool for demonstrating progressive improvements in rehabilitation performance.*
>
> *LFA is based on the assessment of specific landscape characteristics. On a broad scale, LFA assesses the location and size of vegetation 'patches', where resources accumulate, and bare soil areas ('inter-patches'), where resources may be mobilised and lost. By measuring patches and inter-patches over time, the rate and extent of vegetation cover achieved by rehabilitation can be assessed, thus providing evidence of rehabilitation success. This information also gives an insight into whether the rehabilitation area is achieving self-sustainability (i.e. a landscape is developing in which minimal resources are lost due to stress or disturbance). A landscape where resources are well retained and utilised is referred to as 'functional', whilst one that loses resources is, to some extent, 'dysfunctional' (Tongway and Hindley, 2005).*
>
> *A series of LFA sites (analogue and rehabilitation) will need to be established approximately 12 months following landform rehabilitation and hydroseeding. The quantity and specific placement of sites to be determined following landform rehabilitation and hydroseeding. A particular importance should be placed*

on site aspect, slope, soil type and vegetation when selecting analogues sites for comparison to rehabilitation sites. Monitoring of the LFA sites (and reporting) should be conducted on an annual basis.

Recommended criteria: present a trend of continual improvement in landscape function and perennial plant cover at rehabilitation sites over a five-year monitoring period."

(BlackOak Environmental, June 2019).

3.4.2 Landscape Function Analysis

Landscape Function Analysis (LFA) monitoring has been conducted within the ML since 2012 by independent contractors, EBS Ecology, using the procedures established by Tongway and Hindley (2005). The purpose of LFA surveying to date has been to build up a body of knowledge across a succession of seasons, detailing the LFA characteristics of remnant native vegetation patches within the ML and using that data as a means of assessing the progression of SEB-offset establishment against comparable 'benchmark' vegetation communities.

It was the intention of Hillgrove to objectively assess the LFA characteristics of KCM SEB-offsets to determine '*if the offset patches have achieved or are on a demonstrable trajectory towards achieving the LFA characteristics inherent in comparable remnant native vegetation communities*'. The results of successive LFA surveys on and around the KCM have been published on Hillgrove's web page <http://www.hillgroveresources.com.au/article/Community/Mine_Life_Extension> (scroll down to 'Extension Documentation' and select the required LFA report).

With development of the Mine Closure NVMP and anticipated approval to pay into the NVF in lieu of SEB-offset establishment for approved non-EPBC Act listed native vegetation disturbance, the focus for vegetation monitoring will shift to meeting Completion Outcome 1.

3.4.3 LFA Surveying and Program Criteria for Assessing Rehabilitation Progress

With the focus of this NVMP shifting towards effective landform rehabilitation, rather than SEB-offset establishment on rehabilitated mine landforms, this NVMP proposes the following procedure for objective rehabilitation assessment:

- The establishment of at least five (5) new analogue LFA transects on similar aspect / landforms with an 'unimproved pasture vegetation cover', either within the ML or directly adjacent to the ML. The transects are to be established on slopes and aspects also represented on the rehabilitated areas. The analogue transects will provide baseline LFA data to establish the parameters represented by stable landforms with a resilient, self-replicating vegetation cover in the near-mine region.
- The establishment of at least ten (10) rehabilitation LFA transects, with at least two transects mimicking the slope and orientation of each analogue transect. Rehabilitation transects should not be established earlier than 12-months after seeding in each case.
- LFA monitoring surveys on the analogue and rehabilitation transects will be conducted at the same time each year, preferably in spring, however, to ensure vegetation cover and growth stage is comparable between seasons the actual survey date can be advanced or delayed as dictated by seasonal variation.
- After five years of LFA surveying or once a continual trend of improvement towards achieving LFA criteria has been established on rehabilitated mine landforms, results will be reported to the Regulator as achievement of mine completion (refer to Section 3.2.2).

Historical LFA data collected by Hillgrove from analogue sites in remnant vegetation and from surveyed sites on rehabilitation and SEB-offset areas, provides valuable data on the progressive stabilisation of rehabilitated landforms and the development of vegetation cover over time. This data will be used as part of the rehabilitation and analogue LFA monitoring identified above, including with respect to the impact of seasonal variation and terrain microclimates.

4.0 Management and Protection of Rehabilitation on the ML Area

4.1 Background

Progressive rehabilitation of mine landforms has been carried out throughout the operational life of the KCM. Some vegetation on the ML area has also been enhanced as part of the establishment of non-EPBC SEB offsets on the ML area (refer to Section 2.6).

This section discusses Hillgrove's intended management of all land and associated vegetation on the ML area until lease relinquishment is achieved, or some other agreement for management transfer is approved (e.g., AGL takes control of the PHES portion of the lease).

Commitments to management of the rehabilitation areas must be in compliance with lease conditions as identified in Section 3.1.

Hillgrove will continue to maintain land areas within the ML area until such time as the lease is relinquished and responsibility for land management is transferred to the new owners. During this period Hillgrove will comply with statutory obligations, including lease conditions, to control pest plants and feral animals. Hillgrove will carry out weed control programs on rehabilitated landforms to ensure that the vegetation cover has the best chance to establish, stabilise and consolidate.

Beyond the cessation of operations on-site, management of rehabilitated landforms within the ML will be continued by Hillgrove until completion criteria are met and the lease relinquished, i.e., when ongoing LFA monitoring proves that land function meets criteria.

4.2 Land Management Program

4.2.1 Land Management Program Aims

The focus of this Mine Closure NVMP and Hillgrove's land management programs within the ML area will be to continue management of areas under Hillgrove's stewardship until lease relinquishment or some other agreement for management transfer is approved.

Hillgrove's vegetation and land management programs will aim to achieve the following:

- The progressive establishment of resilient, self-replicating vegetative covers on safe, stable rehabilitated mine landforms and on other closure domains within the ML.
- The prevention of pest plant and feral animal proliferation within rehabilitation areas, through the system of programmed weed control and feral animal control programs established within the ML since 2010. Table 4-1 below provides a list of key pest plants and feral animals.
- Monitoring fauna within the ML and on Hillgrove-owned properties through annual spring fauna surveys, to ensure that species diversity is being maintained.
- The prevention of grazing by commercial livestock within the ML.
- The management of grazing by native animals within land under Hillgrove's control (predominantly kangaroos), through fence maintenance, interruption of grazing and/or or approved culling programs where necessary.

Details associated with Hillgrove's land management programs and spring fauna monitoring surveys can be found in successive EBS Restoration progress reports and fauna survey results published on Hillgrove's web page. These reports can be found via the following link;

http://www.hillgroveresources.com.au/article/Community/Mine_Life_Extension

Please scroll down to 'Extension Documentation' and select the required report

4.2.2 Key Pest Plant and Feral Animal Species to be Controlled

The key pest plant and feral animal species which will continue to be targeted during Hillgrove's land management programs are listed in Table 4-1. This list is not exhaustive and represents the baseline species that have been, or could be found within the ML area or near-mine region and will be targeted by plant and animal control programs under this NVMP. Additional pest species may be targeted where available resources permit us to do so.

Further information relating to pest plant species within our region and their control can be found via the following link.

https://www.naturalresources.sa.gov.au/samurraydarlingbasin/plants-animals/pest-plants-and-animals/pest-plants

Table 4-1 - Common pest plant and feral animal species to be controlled

Common Name	Species Name	KCM NVMP Control Status
Pest Plant Species		
Aleppo pine	*Pinus halpensis*	Invasive/ Control where possible
African Boxthorn	*Lycium ferocissimum*	Declared / Must be controlled
Bathurst burr	*Xanthium spinosum*	Declared / Must be controlled
Blackberry	*Rubus fruticosus*	Declared / Must be controlled
Bridal creeper	*Asparagus asparagoides*	Declared / Must be controlled
Bridal creeper	*Asparagus declinatus*	Declared / Must be controlled
Caltrop	*Tribulus terrestris*	Declared / Must be controlled
Cape Wattle	*Paraserianthes lophantha*	Invasive/ Control where possible
Coastal wattle	*Acacia longifolia*	Invasive/ Control where possible
Cotton bush	*Asclepias rotundifolia*	Invasive/ Control where possible
Cutleaf mignonette	*Reseda lutea*	Declared / Must be controlled
Dog rose	*Rose canina*	Declared / Must be controlled
English broom	*Cytisus scoparius*	Declared / Must be controlled
Flinders Ranges Wattle	*Acacia iteaphylla*	Invasive/ Control where possible
Gorse	*Ulex europaeus*	Declared / Must be controlled
Horehound	*Marrubium vulgare*	Declared / Must be controlled
Lincoln weed	*Diplotaxis tenuifolia*	Declared / Must be controlled
One-leaf cape tulip	*Moraea flaccid*	Declared / Must be controlled
Peppercorn tree	*Sichinus molle*	Invasive/ Control where possible
Salvation Jane	*Echium plantagineum*	Invasive/ Control where possible
Silverleaf nightshade	*Solanum elaeagnifolium*	Declared / Must be controlled
Skeleton weed	*Chondrilla juncea*	Declared / Must be controlled
Soldier thistle	*Picnomon acarna*	Declared / Must be controlled
Tree tobacco	*Nicotiana glauca*	Invasive/ Control where possible

Common Name	Species Name	KCM NVMP Control Status
Wild artichoke	*Cynara cardunculus*	Declared / Must be controlled
Feral Animal Species		
European hare	*Lepus europaeus*	Declared / Must be controlled
European rabbit	*Oryctolagus cuniculus*	Declared / Must be controlled
European red fox	*Vulpes vulpes*	Declared / Must be controlled
Feral cat	*Felis catus*	Declared / Must be controlled
Feral goat	*Caprahircus*	Declared / Must be controlled
Red deer	*Cervus elaphus*	Declared / Must be controlled

4.2.3 Pest Plant and Feral Animal Control Methodology

Control of pest plants (weeds) and feral animal species within the ML area will continue to be carried out by experienced, licenced operators, using recommended herbicides or vertebrate control practices until lease relinquishment or other management / liability transfer. Hillgrove will comply with relevant pest plant and feral animal pest control scheduling for the region.

Pest Plant Control

Where applicable, mechanical weed control methods will continue to be used for general weed control, for example, brush cutting, mowing and tractor slashing. Where necessary, herbicides for weed and pest plant control will be applied as spot-spray, boom spray or cut/swab treatments as recommended for the particular pest plant being targeted. In particular the following will continue to be conducted.

- The distribution of declared pest plants will be monitored as a component of annual flora monitoring programs within the ML and on adjacent Hillgrove-owned land.
- Weeds requiring control will be identified and mapped during routine management tasks where applicable.
- Control campaigns will be scheduled at the most suitable time for optimal control on a species by species basis (generally prior to flowering or seed set).
- Declared Pest Plants will be controlled wherever they can be safely accessed by operators.
- Other invasive weeds will be controlled where they can be safely accessed and to the extent of available resources.

Feral Animal Control

Feral animals will continue to be controlled within the ML by experienced, licenced operators, through the best practices available for humanely euthanizing the targeted species, such as the following.

- Rabbits and hares will be controlled through baiting with Pindone-treated carrot baits, or through Phostoxin fumigation of rabbit warrens.
- Disruption of rabbit warrens may be carried out using a tractor-mounted ripper, however, this will only be possible where safe tractor access can be assured and access of the tractor to the warren site will not cause adverse disturbance of remnant native vegetation.
- Fox control will be conducted annually, or on an as-needs basis, through a 1080-based baiting program, conducted by suitably authorised animal control contractors.
- Control of other vertebrate pests will be conducted through best-practice, using suitably qualified and experienced operators. Further information on acceptable vertebrate control techniques can be obtained via the following link:

  https://www.naturalresources.sa.gov.au/adelaidemtloftyranges/plants-and-animals/pest-plants-and-animals/pest-animals

- If baiting programs and other vertebrate pest control methods prove to be ineffective, shooting campaigns on may be conducted by appropriately qualified and experienced professional shooting contractors. Appropriate permission to shoot within an ML will be obtained from DEM before shooting programs are organized and appropriate safety measures for staff and neighbors will be established.

4.3 Management of Specific Domains

4.3.1 Integrated Waste Landform and Open Pit Domains

The back-filled portions of the open pit domain and the rehabilitated IWL will be protected and preserved by Hillgrove until lease relinquishment is achieved, or some other agreement for management transfer is enabled (e.g., AGL takes control of the PHES portion of the lease).

Key limitations and management activities will include:

- Access by foot will be restricted. Access will only be permitted for vegetation management and vertebrate pest management activities
- Vehicle traffic will only be permitted on established roadways;
- Weed control programs will be conducted as required; targeting the range of weeds listed in Table 4-1 of this NVMP;
- Feral animal control programs will be conducted as required, targeting the range of species also listed in Table 4-1 of this NVMP;
- Annual fauna and LFA surveys will continue to be conducted;
- Management of grazing by native animals; and
- No grazing of commercial livestock will be permitted.

4.3.2 Infrastructure Area Domain

Once the infrastructure domain is repurposed as an industrial park for local regional use, Hillgrove will maintain the domain until responsibility for ongoing management of the domain is transferred to future users of the area.

Until an agreement is reached, Hillgrove's management of the domain will be to maintain the area and infrastructure in a useable and safe manner, suitable for future use in accordance with Urban Employment Zone requirements.

Should the area be partially or completely rehabilitated (refer to Section 3.3.3), rehabilitation will be managed as per the IWL rehabilitation (Section 4.3.1).

4.3.3 Surface Water Structures Domain

Surface water structures not retained for potential repurposing will be closed, retained or remediated in accordance with approved procedures outlined in our PEPR, i.e., the water storages will be allowed to silt up and reintegrate to the natural topography over time. As such, no revegetation work will be conducted on these structures.

Hillgrove's management of surface water structures will be the same as it is for the IWL (Section 4.3.1). Hillgrove will continue to manage surface water structures until lease relinquishment, or until an alternate agreement for management responsibility is ratified with future users of the domain.

4.3.4 Native Woodland Domain

Native woodland within ML6345 will be preserved and protected from disturbance or degradation by Hillgrove until lease relinquishment is achieved, or some other agreement for management transfer is approved (e.g., AGL takes control of the PHES portion of the lease).

Key limitations and management activities within the Native Woodland domain will include:

- Access by foot will be restricted. Access will only be permitted for vegetation management or seed collection for rehabilitation seed mix preparation;
- Vehicle traffic will only be permitted on established roadways;
- Weed control programs will be conducted as required; targeting the range of weeds listed in Table 4-1 of this NVMP;
- Feral animal control programs will be conducted as required, targeting the range of species also listed in Table 4-1 of this NVMP;
- Annual fauna and LFA surveys will continue to be conducted;
- Management of grazing by native animals; and
- No grazing of commercial livestock will be permitted.

Enhancement of native woodlands within the ML area has been carried out by Hillgrove since 2009. Key actions included restriction of vehicular and foot access, no further (non-approved) disturbance, removal of commercial grazing by livestock, tube stock planting, weed control and feral animal control campaigns. The management activities outlined in the Mine Closure NVMP will allow enhancement of the native woodland areas to continue naturally, particularly where new plants recruited from the soil seed bank were assisted to survive through Hillgrove's management of this domain.

The only change under this Mine Closure NVMP, will be that further tubestock planting will not be carried out in this domain.

4.3.5 Native Grassland Domain

As for the native woodland areas, native grassland within the ML area will be preserved and protected from disturbance or degradation by Hillgrove until lease relinquishment is achieved, or some other agreement for management transfer is approved.

Key limitations and management activities will include the range of management actions outlined for native woodland domains (Section 4.3.4).

As for native woodlands, enhancement of native grassland domains within the ML has been carried out by Hillgrove since 2009 and it is expected that native grasslands will continue to be enhanced naturally, through the range of management actions outlined in this NVMP. No planting will be carried out, however, empirical observation of woodland areas and LFA surveying has highlighted that natural recruitment unimpeded by disturbance or commercial grazing results in improvement over time.

The only change under this Mine Closure NVMP, will be that further planting will not be carried out in this domain.

4.3.6 Introduced Pasture Domain

Introduced pasture areas within the ML will continue to be protected from degradation by Hillgrove until lease relinquishment is achieved, or some other agreement for management transfer is approved.

Key limitations and management activities will include:

- Vehicle traffic will only be permitted on established roadways;
- Weed control programs will be conducted as required; targeting the range of weeds listed in Table 4-1 of this NVMP;

- Feral animal control programs will be conducted as required, targeting the range of species also listed in Table 4-1 of this NVMP;
- Annual fauna and LFA surveys will continue to be conducted;
- Management of grazing by native animals; and
- No grazing of commercial livestock will be permitted.

4.3.7 Enhanced Vegetation

A number of recent and historic vegetation enhancement areas are scattered within the ML. They contain a mixture of local native and pasture species. These areas will continue to be protected from disturbance or degradation by Hillgrove until lease relinquishment is achieved, or some other agreement for management transfer is approved.

Key limitations and management activities will include:

- Vehicle traffic will only be permitted on established roadways;
- Weed control programs will be conducted as required; targeting the range of weeds listed in Table 4-1 of this NVMP; and
- Feral animal control programs will be conducted as required, targeting the range of species also listed in Table 4-1 of this NVMP.

The only change under this Mine Closure NVMP, will be that further planting will not be carried out in this domain.

4.3.8 Old Tailings Dam

This domain is largely undisturbed by Hillgrove. There are no activities specific to this domain other than the ML area wide commitments to maintain biodiversity and control pest and weed species as detailed in Section 4.2.

4.3.9 Other Disturbed Areas

Other disturbed areas include the SPA, magazine areas and various laydown areas across the site. Any other non-specified areas disturbed by Hillgrove and not required for future use by the local community (i.e., the industrial park if it proceeds), will be rehabilitated and will be managed by Hillgrove until lease relinquishment is achieved, or some other agreement for management transfer is approved.

Management of other disturbed areas will follow the same criteria as outlined for rehabilitated areas of the IWL, outlined in Section 4.3.1.

5.0 Management and Protection of SEB offsets off the ML area

5.1 Background

Progressive establishment of non-EPBC SEB-offsets has been carried out throughout the operational life of the KCM (refer to Section 2.6).

This section discusses Hillgrove's intended management of all non-EPBC SEB-offset areas off the ML area until lease relinquishment is achieved, or some other agreement for management transfer is approved (e.g., AGL takes control of the PHES portion of the lease).

5.2 Non-EPBC Act SEB-offset areas off the ML area

Though payment into the NVF in-lieu of non EPBC Act SEB-offset establishment will extinguish further SEB-offset related activity, Hillgrove will continue to manage the non-EPBC SEB-offset areas off the ML as a responsible land owner. This will include the following activities until such time as the land is sold and land management is no longer Hillgrove's responsibility.

- Weed control programs will be conducted as required and in a similar manner to that expected of any land holder, targeting the declared weed species listed in Table 4-1 of this NVMP; and

- Feral animal control programs will be conducted as required and in a similar manner to that expected of any land holder, targeting the declared feral species listed in Table 4-1 of this NVMP.

It is noted that the EPBC SEB-offset commitment has not yet been fully achieved in terms of area. In the event that the EPBC SEB-offset cannot be altered (refer to Section 5.3), the non-EPBC SEB offset areas may be turned into EPBC SEB offset areas. Should this occur, these areas will be managed in accordance with the requirements of Appendix C.

5.3 EPBC Act SEB-offsets off the ML area

5.3.1 Introduction

A number of SEB-offset areas have been established on Hillgrove-owned properties adjacent to the ML for approved disturbance of vegetation communities listed under the EPBC Act at the time that disturbance approval was granted. The distribution of EPBC Act SEB-offsets commenced by Hillgrove has been summarised in Figure 2-4

As outlined in Section 1.4, delivery of offsets for EPBC-Act listed vegetation disturbance is not addressed in this NVMP due to inability to engage the Commonwealth government on proposed alternatives at this time. Hence, until such time as alternatives can be agreed, Appendix C provides the Life of Mine Extension NVMP (2014) which covers all EPBC SEB-offsets.

Approximately 17ha of Eucalyptus odorata EPBC SEB-offsets have been commenced by Hillgrove for approved disturbance of that EPBC-act vegetation community. The location of all proposed EPBC SEB-offsets on Hillgrove-owned land is highlighted in Figure 7 Appendix C, where E. odorata areas are maroon. L. effusa areas are blue on the same map however have not yet been commenced by Hillgrove. The total areas of E. odorata and L. effusa offsets to be established under the 2014 LOM NVMP is 56.4ha (Table 2 in Appendix C).

Please note that a revised NVMP will be required for delivery of EPBC-Act SEB-offsets if Hillgrove are able to reach agreement with the Australian Government for payment of a fee in-lieu of establishing EPBC SEB-offsets.

5.3.2 Potential to Amend EPBC SEB Offset Requirements

Should the Commonwealth Government agree to allow Hillgrove to pay into the NVF (or similar) in lieu of EPBC Act SEB-offset establishment, then Hillgrove will seek to make appropriate reparations to the Government's nominated fund under the costing formula agreed to by the Government. In this event, payment into the nominated fund will extinguish further EPBC SEB-offset establishment by Hillgrove.

Should the Commonwealth Government not permit payment into a nominated fund in lieu of EPBC SEB-offset establishment, then Hillgrove will explore the possibility of either continuing EPBC SEB-offset establishment on Hillgrove-owned land under a revised NVMP for EPBC Act vegetation, or delivering the appropriate SEB-offsets under an alternate mechanism agreed to by the Commonwealth Government.

Until an agreement is reached with the Commonwealth Government, Hillgrove will continue to protect existing EPBC SEB-offsets from disturbance or degradation, though no new EPBC SEB-offsets will be established until such agreement is reached.

Key limitations and management activities within EPBC SEB-offset areas are detailed in Appendix C.

5.3.3 Potential to Move EPBC SEB Offset Requirements

Additional opportunities relating to the EPBC SEB offset areas are being explored. One such opportunity is detailed below.

Hillgrove are considering amending the EPBC SEB offset NVMP to relocate some of the EPBC offset to the Native Woodland and Grassland Domains on the ML area. There is also a strong preference for enhancement of remnant vegetation instead of conversion of farmland due to the long lead times for maturation and habitat development. The enhancement of remnants is conversion of farmland, such as the offsite EPBC SEB offsite areas.

To further protect remnants on the mining lease until the EPBC can be approved It is proposed the payments into the NVF will be staged with first payment covering all areas other than the Native Woodland and Grassland Domain SEB Offset areas and the final payment will occur when the negotiations with the Commonwealth government and the SA Native Vegetation Council regarding EPBC SEB offsets have been concluded in a way that results in the EPBC areas off the mining lease being moved onto the mining lease to cover and protect those areas of remnant vegetation and the NVMP amended to reflect the agreed outcomes.

5.4 Protection of SEB-offsets through Land Management or other Agreements

Prior to the sale of any land hosting SEB-offsets which have not been nullified by payment into the NVF, Hillgrove will establish Land Management Agreements, or other appropriate instruments, appended as caveats to the Land Titles of each relevant allotment in perpetuity.

The caveats will stipulate the conditions by which subsequent owners or overseers must agree to manage SEB-offsets established within their allotment. These conditions may include some or all of the following;

- Limitations to foot and vehicular access
- Minimum weed and feral animal control standards
- Prohibition from future development or disturbance
- Agreed access for community members to defined walking paths and open spaces
- Other currently undefined conditions stipulated by Government
- Other currently undefined conditions agreed with the Kanmantoo/Callington Community Consultative Committee (K4Cs) Master Plan Working Group

This provision is cognisant that the ultimate fate of land currently owned by Hillgrove is yet to be determined. For example, the land may be retained by Hillgrove or sold to a subsequent owner.

There is a need for further consultation with the community to determine the appropriate location for the potential use of NVF grants whose origin would be from Hillgrove's payment into the fund. Hillgrove and the community commit develop project plan(s) within 6 months of PEPR approval for NVF grant consideration. Any application for an NVF grant will be subject to assessment against NVC requirements set out in the council's policy for significant environmental benefit (SEB).

Appendix A - SEB-offset Review for the Kanmantoo Copper Mine (BlackOak Environmental, 2019)

SEB-offset Review for the Kanmantoo Copper Mine

May 2019

Prepared by: BlackOak Environmental NVC accredited consultant (Matt Launer) for Hillgrove Resources Ltd.

BlackOak Environmental

Document information and distribution

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Cover photographs: *Eucalyptus odorata* (Peppermint Box) low woodland, *Diuris behrii* (Golden Cowslips) and *Lomandra effusa* (Scented Iron-grass) (Photographs courtesy of John Crocker (Hillgrove Resources Ltd)).

Acronyms and definitions

Abbreviation	Description
DMITRE	Department for Manufacturing, Innovation, Trade, Resources and Energy
DWLBC	Department of Water, Land and Biodiversity Conservation
KCM	Kanmantoo Copper Mine
LOM	Life of mine
ML	Mining Lease
NVF	Native Vegetation Fund
NVMP	Native Vegetation Management Plan
PEPR	Program for Environmental Protection and Rehabilitation
SEB	Significant Environmental Benefit

Table of Contents

List of Tables

1 Introduction

BlackOak Environmental was engaged by Hillgrove Resources Ltd to undertake an independent re-assessment of their SEB (significant environmental benefit) offset obligations for the Kanmantoo Copper Mine (KCM). The KCM has operated since 2011 under a series of Program for Environmental Protection and Rehabilitation (PEPR) approvals, with associated revisions to the Mine's Native Vegetation Management Plans (NVMPs).

At the conclusion of open-pit mining in May 2019, a further revision of the PEPR and NVMP is required to position the Mining Lease (ML) for closure, rehabilitation and partial lease relinquishment.

2 Background

Previous NVMPs have been focused on the delivery of SEB-offsets within the ML on abandoned farming land, rehabilitated mine land forms and outside of the ML on Hillgrove-owned land immediately adjacent the Mine. The original KCM NVMP was developed with an expectation of additional mine asset developments by Hillgrove Resources Ltd. These would support progressive SEB-offset establishment for the KCM and fund the type of long-term SEB-offset management program required to achieve the KCM's SEB-offset objectives.

With the conclusion of mining at Kanmantoo in May 2019 and without the expected development of additional mine assets during the mine's life, further SEB-offset establishment and long-term support of the SEB-offset maintenance objectives described in the KCM's original NVMPs are now unlikely to be achievable by Hillgrove Resources Ltd. Subsequently, the revised KCM NVMP will calculate an appropriate fee for Hillgrove to pay to the South Australian Native Vegetation Fund (NVF) in lieu of the KCM's planned SEB-offset establishment as outlined in previous versions of the NVMPs.

The assessment of revised SEB-offset obligations was conducted under the framework current at the time of the original approvals were granted, which are outlined in the *Guidelines For a Native Vegetation Significant Environmental Benefit Policy for the Clearance of Native Vegetation Associated with the Minerals and Petroleum Industry* (DWLBC 2005) (Table 1).

Table 1. Initial SEB assessment guidelines.

Vegetation condition	Indicators for condition	SEB ratio
Poor: Weed-dominated with only scattered areas or patches of native vegetation.	Vegetation structure no longer intact (e.g., removal of one or more vegetation strata)	2:1
	Scope for regeneration, but not to a state approaching good condition without intensive management	
	Dominated by very aggressive weeds	
	Partial or extensive clearing (greater than 50% of area)	
	Evidence of heavy grazing (tracks, browse lines, species changes, no evidence of solid surface crust)	
Moderate: Native vegetation with considerable disturbance.	Vegetation structure substantially altered (e.g., one or more vegetation strata depleted)	4:1
	Retains basic vegetation structure or the ability to regenerate it	
	Very obvious signs of long-term or severe disturbance	
	Weed dominated with some very aggressive weeds	
	Partial clearing (10 to 50% of area)	
	Evidence of moderate grazing (tracks, browse lines, soil surface crust extensively broken)	
Good: Native vegetation with some disturbance.	Vegetation structure altered	6:1
	Most seed sources available to regenerate original structure	
	Obvious signs of disturbance	
	Minor clearing (less than 10 % of area)	
	Considerable weed infestation with some aggressive weeds	
	Evidence of some grazing (tracks, soil surface crust patchy)	
Very good: Native vegetation with little disturbance.	Vegetation structure intact (e.g., all structure intact)	8:1
	Disturbance minor, only affecting individual species	
	Only non-aggressive weeds present	
	Some litter build-up	
Intact vegetation:	All strata intact and botanical composition close to original	10:1
	Little or no signs of disturbance	
	Little or no weed infestation	
	Soil surface crust intact	
	Substantial litter cover	

Source: DWLBC (2005).

3 SEB-offset calculations

Where a payment into the NVF is proposed, and the required offset area has been established, a separate calculation is used to convert this into a monetary payment. The formula used has been adapted by the Native Vegetation Council (NVC) from the NVC *Policy on Achieving a Significant Environmental Benefit for the Mineral and Petroleum Industries* (DWLBC 2005). The components of the formula are as follows:

- the required SEB-offset in hectares
- the land value per hectare (the entire Kanmantoo project is located within the Mt Barker LGA which has a site value of $8,401.00 per hectare)
- the area of clearance in hectares
- a management fee of $800 per hectare.

The formula for calculating the SEB payment into the NVF: = (land value per hectare/ha x required SEB-offset in hectares) + (management fee/ha x area of clearance/ha) (DWLBC 2005).

All vegetation disturbance within the ML was completed as approved under previous NVMPs. The SEB-offset reassessment was conducted using data from the approved versions of the KCM's NVMPs (Hillgrove Copper Pty Ltd 2017). Previous disturbance areas have included Section 1 (initial phase of mining), Section 2 (life of mine (LOM) extension) and Section 3 ('Giant Pit' cut back).

The SEB-offset payment required for the native vegetation clearance (20.50 ha and 56 scattered trees) of Section 1 (initial phase of mining) is $1,531,100.30 (Table 2). The SEB-offset payment required for the native vegetation clearance (9.10 ha) of Section 2 (LOM extension) is $585,196.80 (Table 3). The SEB-offset payment required for the native vegetation clearance (0.99 ha) of Section 3 ('Giant Pit' cut back) is $51,198.00 (Table 4).

Table 2. Section 1 (initial phase of mining): SEB-offset calculations.

Vegetation community	SEB condition ratio	Clearance area (ha)	Required SEB-offset (ha)	LGA land value	Management fee	SEB-offset
Eucalyptus odorata low woodland	10:1	0.90	9.00	$8,401.00	$800.00	$76,329.00
	10:1	0.30	3.00	$8,401.00	$800.00	$25,443.00
	8:1	0.30	2.40	$8,401.00	$800.00	$20,402.40
	8:1	1.10	8.80	$8,401.00	$800.00	$74,808.80
	8:1	<0.10	0.00	$8,401.00	$800.00	-
	8:1	0.60	4.80	$8,401.00	$800.00	$40,804.80
	4:1	0.30	1.20	$8,401.00	$800.00	$10,321.20
	2:1	0.20	0.40	$8,401.00	$800.00	$3,520.40
	2:1	0.10	0.20	$8,401.00	$800.00	$1,760.20
Lomandra effusa open tussock grassland	10:1	6.80	68.10	$8,401.00	$800.00	$577,548.10
	10:1	0.30	3.00	$8,401.00	$800.00	$25,443.00
	4:1	0.20	0.80	$8,401.00	$800.00	$6,880.80
	4:1	0.10	0.40	$8,401.00	$800.00	$3,440.40
	4:1	0.10	0.40	$8,401.00	$800.00	$3,440.40
	4:1	0.20	0.80	$8,401.00	$800.00	$6,880.80
	4:1	1.00	4.00	$8,401.00	$800.00	$34,404.00
	4:1	0.50	2.00	$8,401.00	$800.00	$17,202.00
	4:1	0.20	0.80	$8,401.00	$800.00	$6,880.80
Austrostipa sp. open tussock grassland	10:1	0.10	1.00	$8,401.00	$800.00	$8,481.00
	10:1	0.10	1.00	$8,401.00	$800.00	$8,481.00
	4:1	0.60	2.40	$8,401.00	$800.00	$20,642.40
Eucalyptus gracilis, +/- *E. oleosa* open mallee	10:1	0.20	2.00	$8,401.00	$800.00	$16,962.00
	10:1	1.60	16.00	$8,401.00	$800.00	$135,696.00
	10:1	0.20	2.00	$8,401.00	$800.00	$16,962.00
Callitris gracilis low woodland	10:1	<0.10	0.00	$8,401.00	$800.00	-
Acacia pycnantha low woodland	8:1	2.10	16.80	$8,401.00	$800.00	$142,816.80
	8:1	0.40	3.20	$8,401.00	$800.00	$27,203.20
	4:1	0.10	0.40	$8,401.00	$800.00	$3,440.40
	4:1	0.10	0.40	$8,401.00	$800.00	$3,440.40
	4:1	1.80	7.20	$8,401.00	$800.00	$61,927.20
Sub-total	-	**20.50**	**162.50**	-	-	**$1,381,562.50**
Scattered trees	-	56 trees	17.80	$8,401.00	$800.00	$149,537.80
Total	-	**20.50**	**180.30**	-	-	**$1,531,100.30**

Table 3. Section 2 (LOM extension): SEB-offset calculations.

Vegetation community	SEB condition ratio	Clearance area (ha)	Required SEB-offset (ha)	LGA land value	Management fee	SEB-offset
Eucalyptus odorata low woodland	10:1	1.80	18.00	$8,401.00	$800.00	$152,658.00
Lomandra effusa +/- Helichrysum leucopsideum open tussock grassland	10:1	3.40	34.20	$8,401.00	$800.00	$290,034.20
	8:1	0.01	0.10	$8,401.00	$800.00	$848.10
	4:1	1.00	4.10	$8,401.00	$800.00	$35,244.10
Austrostipa sp. open tussock grassland	10:1	0.20	2.00	$8,401.00	$800.00	$16,962.00
Acacia pycnantha low woodland	8:1	1.50	6.00	$8,401.00	$800.00	$51,606.00
	4:1	1.10	4.40	$8,401.00	$800.00	$37,844.40
Total	-	**9.10**	**68.80**	-	-	**$585,196.80**

Table 4. Section 3 ('Giant Pit' cut back): SEB-offset calculations.

Vegetation community	SEB condition ratio	Clearance area (ha)	Required SEB-offset (ha)	LGA land value	Management fee	SEB-offset
Acacia pycnantha low woodland	6:1	0.99	6.0	$8,401.00	$800.00	$51,198.00

4 References

DWLBC (2005) Guidelines for a Native Vegetation Significant Environmental Benefit Policy for the Clearance of Native Vegetation Associated with the Minerals and Petroleum Industry. September 2005. Prepared for the Native Vegetation Council, Government of South Australia. Available from: https://www.environment.sa.gov.au/files/sharedassets/public/native_veg/con-nv-guideline-sebmining.pdf

Hillgrove Copper Pty Ltd (2017) Program for Environment Protection and Rehabilitation: Appendices Volume 3. Available from: http://www.hillgroveresources.com.au/article/Community/Mine_Life_Extension

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Appendix B - Recommended Criteria for the Assessment of Landform Rehabilitation at the Kanmantoo Copper Mine (BlackOak Environmental, June 2019)

Recommended Criteria for the Assessment of Landform Rehabilitation at the Kanmantoo Copper Mine (BlackOak Environmental, June 2019)

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John Crocker
Environmental Advisor
Hillgrove Resources
Éclair Mine Road (cnr Back Callington Road),
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Monday, June 17, 2019

RE: The criteria for the assessment of 'landform rehabilitation' at Kanmantoo Copper Mine

Dear John,

Thank you for considering BlackOak Environmental to provide recommendations to assist with the development of the criteria for the assessment of 'landform rehabilitation'. BlackOak Environmental understands that the criteria for the assessment of 'landform rehabilitation' will be included in the Kanmantoo Copper Mine 2019 Native Vegetation Management Plan (NVMP).

As discussed, Hillgrove Resources intend on hydroseeding rehabilitated landforms with a '*Eucalyptus odorata* Woodland' native seed mix. The hydroseeding method and seed mix has been utilised within rehabilitation areas of the Kanmantoo Copper Mine previously and has resulted in varying levels of success. The topsoil to be utilised for the landform rehabilitation is likely to contain the seed of a mixture of introduced pasture species. The main aims of the landform rehabilitation should be to stabilise the landform, create a functioning landscape and restore landform to blend in with surrounding natural landscapes.

It is recommended that the key rehabilitation monitoring tool utilised is Landscape Function Analysis (LFA). After land rehabilitation has occurred LFA surveys are conducted at various intervals over time on the rehabilitated areas and compared against analogue (control) sites. LFA is a monitoring system that provides time series data from assessments of landscape functioning and perennial vegetative growth. LFA is a valuable tool for demonstrating progressive improvements in rehabilitation performance.

LFA is based on the assessment of specific landscape characteristics. On a broad scale, LFA assesses the location and size of vegetation 'patches', where resources accumulate, and bare soil areas ('inter-patches'), where resources may be mobilised and lost. By measuring patches and inter-patches over time, the rate and extent of vegetation cover achieved by rehabilitation can be assessed, thus providing evidence of rehabilitation success. This information also gives an insight into whether the rehabilitation area is achieving self-sustainability (i.e. a landscape is developing in which minimal resources are lost due to stress or disturbance). A landscape where resources are well retained and utilised is referred to as 'functional', whilst one that loses resources is, to some extent, 'dysfunctional' (Tongway and Hindley, 2005).

A series of LFA sites (analogue and rehabilitation) will need to be established approximately 12 months following landform rehabilitation and hydroseeding. The quantity and specific placement of sites to be determined following landform rehabilitation and hydroseeding. A particular importance should be placed on site aspect, slope, soil type and vegetation when selecting analogues sites for comparison to rehabilitation sites. Monitoring of the LFA sites (and reporting) should be conducted on an annual basis.

Recommended criteria: <u>present a trend of continual improvement in landscape function and perennial plant cover at rehabilitation sites over a five-year monitoring period.</u>

Kind regards

Matt Launer
Director/Environmental consultant
E: matt.launer@blackoakenvironmental.com
Ausenco

Appendix C – Life of Mine Native Vegetation Management Plan (Hillgrove Resources, 2014)

Note that the Life of Mine NVMP now only applies to EBPC SEB-offset areas. All non-EPBC SEB offset described in this Appendix are superseded by the contents of the Mine Closure NVMP

Kanmantoo Copper Mine
Native Vegetation Management Plan For
Life of Mine Extension
February 2014

Version No.	Prepared By	Reviewed By	Approved By	Date
1	Hillgrove Resources	C. Davis	C. Davis	

Contents

Figures

Tables

Plates

Attachments

1. INTRODUCTION

1.1 Background

Hillgrove Resources Limited (Hillgrove or HGO) is an Australian copper-gold producer that has been listed on the Australian Stock Exchange since 2003. Hillgrove currently operates the Kanmantoo Copper Mines on Mining Lease (ML) 6345 in South Australia (SA) under the conditions approved in The Kanmantoo Copper Mines (KCM) Mining and Rehabilitation Program (MARP), February 2011 (see ftp://central.pir.sa.gov.au/Minerals/Kanmantoo_PEPR_main_v7.pdf). A MARP is now referred to as a Program for Environmental Protection and Rehabilitation (PEPR) by the SA Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE). All currently approved documentation and associated resources for the Kanmantoo Copper Mines can be accessed via the following link:

http://www.minerals.dmitre.sa.gov.au/mines__and__developing_projects/approved_mines/kanmantoo

KCM is located approximately 45km SE of Adelaide. The two closest townships to the ML are Kanmantoo, approximately 1.5 km to the northeast, and Callington, approximately 4 km to the southeast. There has been a long history of mining and agricultural activity within the ML and both activities have significantly altered many of the landscapes and vegetation types from those of pre-European occupation. The pre-2011 state of the ML is illustrated by Figure 1 (below), while the initial details of vegetation cover and condition are illustrated by Figs. 2 & 3 and Table 1. A total of 112.9 ha of native vegetation remained within the ML prior to the commencement of PEPR-approved mining operations in 2011.

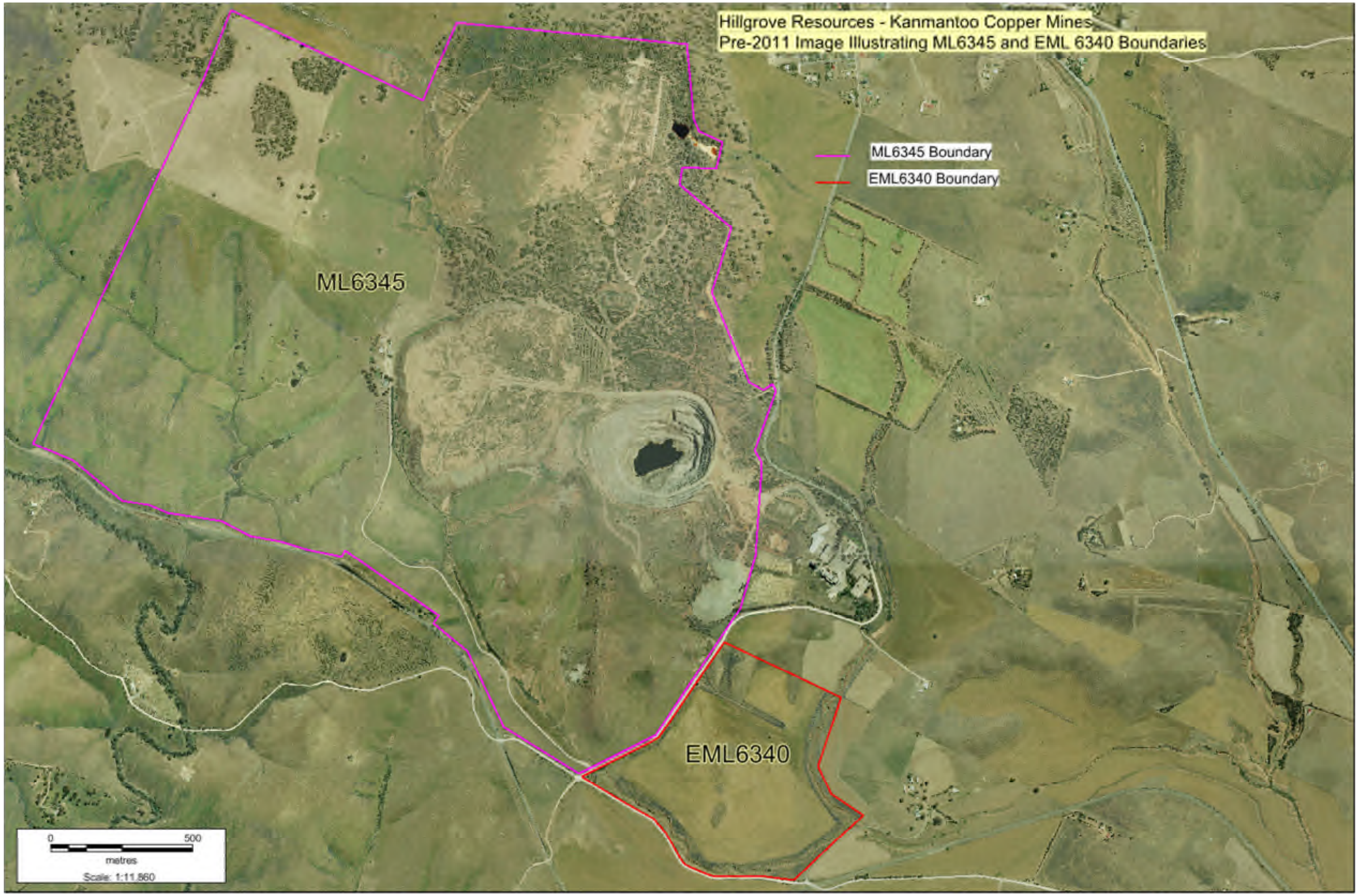
Hillgrove is currently expanding the historic Kanmantoo Copper Mines using open pit mining techniques. An initial mine life of seven years was proposed in the approved PEPR, however recent on-site exploration has defined additional mineral deposits which may allow operations to continue to at least 2019, based on current mining models. This document deals with aspects of a proposed extension to the life of mine (LOM), which extends mining operations and associated native vegetation disturbance into areas of vegetation not currently approved by the PEPR.

Details of how, where and when a Significant Environmental Benefit Offset (SEB-offset) would be provided for corresponding areas of native vegetation disturbance associated with the initial phase of mining operations were detailed in the ML's Native Vegetation Management Plan (NVMP), which contained within Appendix 3 of the approved PEPR, which can be accessed via the link to DMITRE's web page where it is referred to as Appendix 9, (2010):

ftp://central.pir.sa.gov.au/Minerals/Kanmantoo_Appendix_Volume3_v7.pdf

This document constitutes an appendix to the original NVMP. It should be viewed as a stand-alone NVMP, addressing additional areas of native vegetation disturbance and the corresponding areas of SEB-offset associated with the life of mine (LOM) extension only (hereby referred to as 'the LOM extension'). For full site details, operating and rehabilitation plans associated with the initial phase of mining operations at Kanmantoo, please refer to the approved PEPR and associated resources via the link provided above.

Figure 1. ML6345 and Adjacent EML6340 Areas – Pre 2011 Image



1.2 Regulatory Framework

1.2.1 *Mining Act 1971*

The principal legislation for the regulation of mining in South Australia is the *Mining Act 1971*, which is administered by the Department for Manufacturing, Innovation, Trade, Resources and Energy SA (DMITRE). Hillgrove Resources Ltd was granted mining lease (ML) 6345 under the provisions of this Act in order to proceed with mining on-site at Kanmantoo.

1.2.2 *Native Vegetation Act 1991*

All native vegetation in South Australia is protected under the provisions of the *Native Vegetation Act 1991*, where the South Australian Native Vegetation Council (NVC) must approve any clearance of vegetation not exempted under regulations.

DMITRE has been delegated the authority from the NVC to administer the SEB requirements (as they apply to mining operations) under the *Mining Act 1971*, on the basis that DMITRE will apply the policies of the NVC to clearance and revegetation as part of the requirements of a PEPR under Regulation 42 of that act (DWLBC, 2005).

1.2.3 *Environment Protection Biodiversity Conservation Act 1999*

The controlling provisions of the Environment Protection and Biodiversity Conservation Act (1999) or 'EPBC Act' are administered by the Australian Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). The currently proposed areas of vegetation disturbance within ML6345 associated with Hillgrove's LOM extension will disturb additional areas of Peppermint Box Woodland and Iron-grass Grassland not originally covered by the PEPR. Both communities are considered to be 'critically endangered' under the EPBC Act. Subsequently, independent surveys of proposed new disturbance areas were conducted by EBS-Ecology on 25 June 2013 (please see Attachment B).

Survey results, together with supporting information were referred to DSEWPaC, who determined that disturbance of critically endangered Peppermint Box Woodland and Iron-grass Grassland by the proposed LOM extension were assessed as '*Controlled Actions'* under the EPBC Act. This requires Hillgrove to clearly demonstrate how remnant vegetation will be preserved and how an SEB-offset will be delivered for corresponding areas of disturbance before this action can be approved by DSEWPaC. This NVMP addresses this condition and incorporates changes to earlier versions of this NVMP following public and State Government input.

It should be noted that Hillgrove have taken all practicable steps to minimise the potential impacts to EPBC Act-listed vegetation communities during mining operations to date. Ongoing refinements to LOM pit designs and day to day restriction of vehicle and pedestrian movement within the ML will work collectively to reduce the area of vegetation disturbance throughout the LOM extension.

1.3 Purpose of this Plan

This NVMP has been developed in accordance with the Draft Guidelines for a Native Vegetation Significant Environmental Benefit Policy for the Clearance of Native Vegetation Associated with the Minerals and Petroleum Industry (DWLBC, 2005). It provides a framework for managing and mitigating the potential impacts of vegetation clearance as a result of mining operations. This NVMP details the following in relation to new areas of native vegetation clearance associated with the LOM extension:

- Where native vegetation clearance will occur and how much clearance will be required
- The type and condition of native vegetation to be disturbed
- The type, condition and area of corresponding SEB-offset to be provided
- Where the SEB-offset will be delivered
- How the SEB-offset will be achieved

This NVMP encompasses and responds to comments provided by the South Australian Government (DEWNR) and our local community in relation to the original (August 2013) NVMP draft as a component of the EPBC Referral conducted by DSEWPAC.

Areas of new native vegetation disturbance have been substantially reduced from those proposed in the August 2013 version of the NVMP in response to community concerns raised during consultative meetings associated with revision of the PEPR to encompass the LOM extension.

1.4 NVMP Structure

This NVMP comprises a title page, a table of contents and six chapters:

- **Chapter 1** - (this chapter) – Background information.
- **Chapter 2** – Site and vegetation and fauna description.
- **Chapter 3** – Management and mitigation measures.
- **Chapter 4** – SEB Offset calculation.
- **Chapter 5** – SEB Offset implementation
- **Chapter 6** – References.

2. SITE AND VEGETATION DESCRIPTION

ML 6345 contained approximately 113 ha of remnant vegetation; consisting of 7 differing vegetation communities distributed over approximately 440 ha prior to 2011 (see Table 1). Vegetation condition ranged from degraded and highly modified patches, given an SEB Condition Ratio of ‘2:1’, to patches with high levels of diversity in very good to excellent condition, given an SEB Ratio of 8:1. A total of 20.5ha of native vegetation disturbance was approved in our initial PEPR, requiring the establishment of 125.5 ha of SEB-offset vegetation within the ML, in conjunction with measures to protect and enhancement all remnant vegetation within the ML.

Surveys of potential new disturbance areas associated with the LOM-extension proposal were conducted by EBS-Ecology in June 2013. Significant rainfall through the winters of 2011, 2012 and 2013 and associated vegetation recovery following previous drought affected seasons, enabled the survey team to accurately represent the endemic flora of each area for referral to DSEWPaC. ML vegetation condition was significantly improved at the time of the 2013 survey, when compared to that viewed by Ecological Associates during the dry spring of 2007.

Though the June 2013 EBS survey was not conducted at the seasonal peak, we consider that the surveyors were sufficiently experienced to accurately identify emergent flora within the survey areas and we are comfortable that their findings provide an accurate representation of patch composition and quality. Regardless of this, have applied an 8:1 offset-ratio to disturbance in vegetation patches listed as 6:1, and a 10:1 offset-ratio to disturbance in patches listed as 8:1 vegetation in the EBS 2013 survey. The distribution of vegetation communities described by EBS is illustrated by Figure 3 (below).

2.1 Land Use History

The Kanmantoo Copper Mines have a long history of mineral exploration and mining which began in 1846 and continued to 1874, with intermittent prospecting continuing in the area until the 1960s. In the early 1970s, Kanmantoo Mines Limited commenced open-cut mining over the northernmost workings of the earlier underground Kanmantoo mines. The first open-cut mine operated for six years. Mining infrastructure remaining on the site from these operations included an open pit (approximately 120 m deep), processing plant (now used as a site for fertiliser manufacture), a partially revegetated waste rock dump and a tailings dam. The site also has been disturbed by past works to establish hardstands, roadways and other historic infrastructure.

In late 2003, Hillgrove began an exploration program in the Kanmantoo area and in April 2004, the company acquired the historic Kanmantoo Copper Mines mining lease (ML 5776).

Grazing and cereal cropping has been occurring in the Kanmantoo/Callington region for over 100 years. The flora in and around the Kanmantoo Copper Mines has been substantially altered through a long history of clearing to support intensive grazing and dry-land cropping. Woody weeds now occur in many remnant stands of native vegetation and introduced grasses occupy large parts of the ML area, particularly over former cropping land and around fenced grazing paddocks. Hillgrove discontinued grazing and cropping within ML6345 prior to the commencement of on-ground works in 2011.

2.2 Vegetation Communities

The Kanmantoo Copper Mines are located in the region covered by the Biodiversity Plan for the South Australian Murray–Darling Basin and within the Eastern Mount Lofty Ranges Regional Ecological Area (REA). The ML is in a 425mm rainfall zone. It is on the cusp between two adjacent floristic regions of SA, driven by high and low rainfall respectively. Subsequently, the ML's flora is diverse, containing a broad range of species which are routinely seen in either rainfall zone.

There has been extensive clearance of native vegetation within the Eastern Mount Lofty Ranges REA, with only 6% of the pre-European settlement vegetation cover remaining (Ecological Associates, 2007). As with most settled areas in Australia, the majority of regional clearance has been associated with agricultural enterprises, housing and establishment of related infrastructure.

Eight native vegetation communities were listed within the ML area by Ecological Associates in 2007. This was revised to 7 communities by EBS-ecology in 2013, due to the absence of significant stands of *Eucalyptus gracilis* within the woodland 'Patch 18' to the north of the historic open-pit (Fig 2). Vegetation communities impacted by the LOM extension are summarised in Table 1 and described in detail below. The total area of native vegetation represented by the EA 2007 and EBS 2013 surveys remains the same. The 2013 EBS survey is appended as Attachment B, below.

Table 1. Native Vegetation Communities within ML 6345

		PEPR/EA Survey			Revised EBS 2013 Survey	
Vegetation Community	**Conservation Significance**	**Condition (SEB Ratio)**	**Patch Numbers**	**Area (ha) Within ML**	**Patch Numbers**	**Area (ha) Within ML**
Eucalyptus odorata low woodland	National level, critically endangered. State level - Priority 3	8:1	10, 14	14.93	10, 14	20.28
		6:1	12, 17, 23	9.66	12, (17 inc in 10), 23	8.29
		4:1	1, 2, 3, 4, 5, 6, 11, 13	28.50	1, 2, 3, 4, 5, 6, 11, 13	28.50
		2:1	15, 30	1.05	15, 30	1.05
Lomandra effusa +/- Helichrysum leucopsideum open tussock grassland	National level, critically endangered. State level - Priority 1	8:1	22, 28, 37	17.77	22, 28, 37	15.86
		6:1	29, 36	2.06	29, 36	6.94
		4:1	24, 25, 31, 32, 33	3.46	24, 25, 31, 32, 33	3.46
Austrostipa sp. open tussock grassland	Regional level - threatened	8:1	27	11.61	27	8.66
		6:1	26	4.66	26	4.66
		4:1	34, 35	0.73	34, 35	0.73
Callitris gracilis low woodland	Regional level - threatened	8:1	16	0.19	16	0.19
Eucalyptus leucoxylon +/- Lomandra effusa woodland	Regional level - threatened	6:1	8	1.27	8	1.27
Eucalyptus gracilis +/- Eucalyptus oleosa open mallee	Not listed	8:1	18	4.00	(Inc in 10)	0.00
Acacia pycnantha low woodland	Not listed	6:1	19	7.74	19	7.74
		4:1	7, 20, 21	3.49	7, 20, 21	3.49
Allocasuarina verticillata +/- Callitris gracilis woodland	Not listed	8:1	9	1.84	9	1.84
Scattered Trees	Not listed	n/a	n/a	56 trees	n/a	56 trees
			Total	**112.96**	Total	**112.96**

Figure 2. Original ML vegetation survey as described by Ecological Associates in 2007

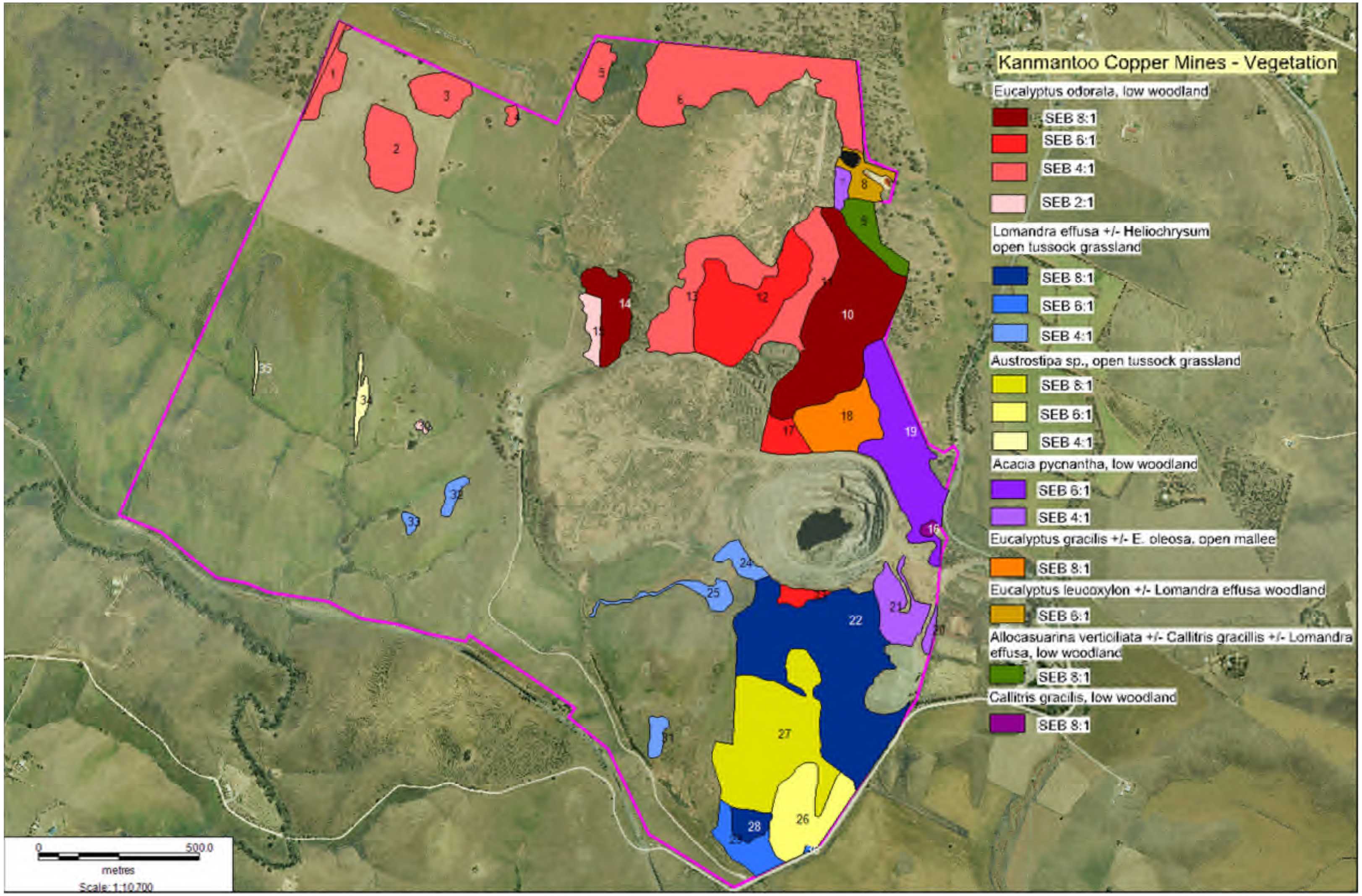
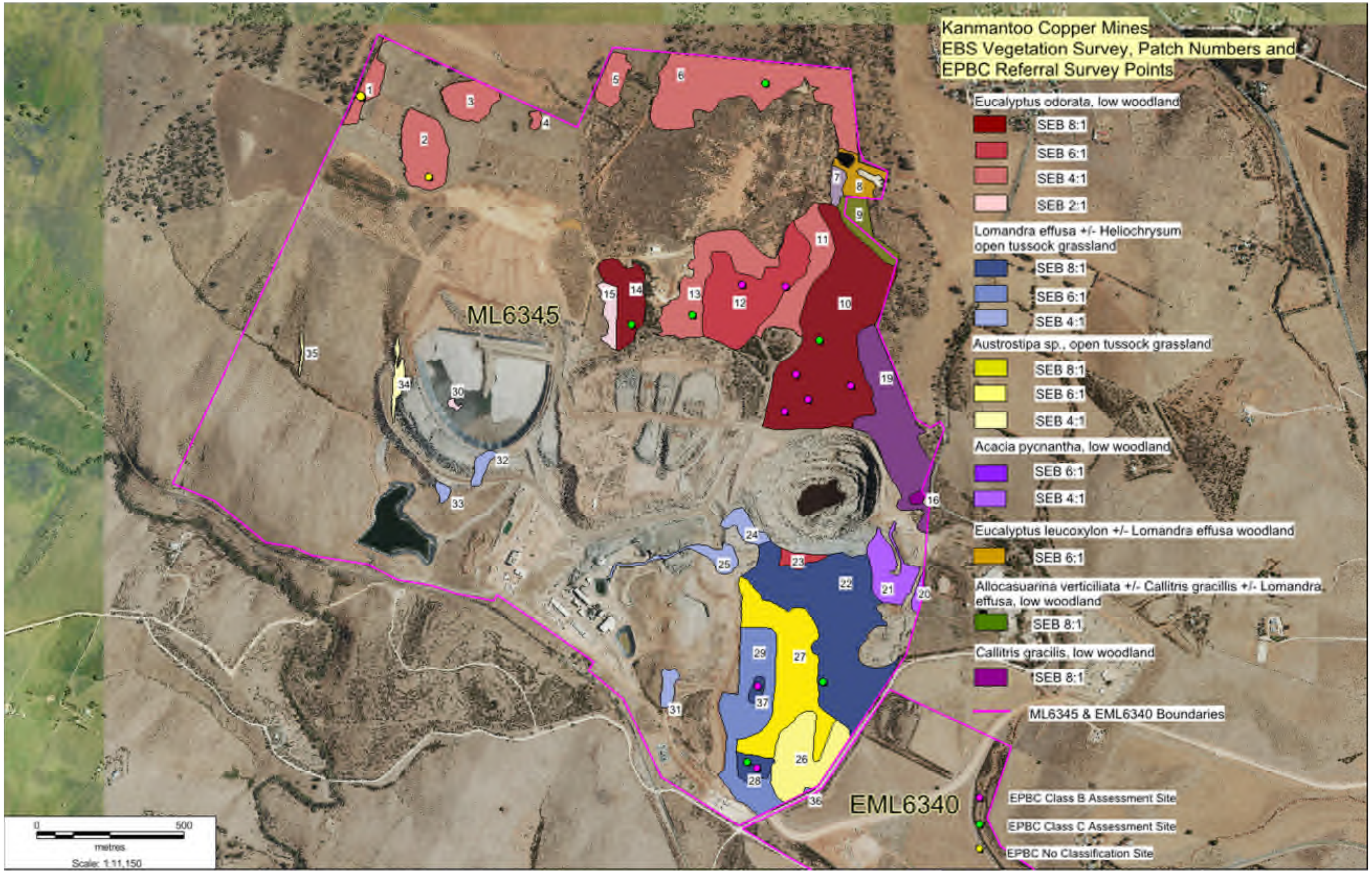


Figure 3. Revised 2013 EBS Vegetation Survey, Listing Patch Numbers, and EPBC Survey Points



Key changes to patch areas between the EA (2007) survey and EBS (2013) survey include the reassignment of Patch 18, '*E. gracilis*+/- *E. oleosa* open mallee to become part of an expanded Patch 10 (8:1 *E. odorata* low woodland). The inclusion of Patch 17 (6:1 *E. odorata*) into Patch 10 upgrades this area to 8:1. Minor realignment of boundaries between Patch 22 (*L. effusa* grassland) and Patch 27 *(Austrostipa sp*. Grassland) and the creation of a new Patch 37, 8:1 *L. effusa* +/- *H. leucopsideum* open tussock grassland within Patch 29 were possible due to improved vegetation expression. These changes are illustrated by the differences between vegetation patch boundaries observed in Figures 2 & 3.

The native vegetation communities which were approved for disturbance by the initial phase of mining operations are fully described by the current NVMP (PEPR, (2010) and are illustrated by the yellow disturbance footprint in Fig 4. Vegetation communities which will be disturbed by activities associated with the LOM extension are within the red LOM disturbance footprint, illustrated by Figs. 4 & 5 (below), and within the hatched areas illustrated by Fig. 6 (below).

2.2.1 *Eucalyptus odorata* low woodland

This is the most extensive vegetation community in the ML area, originally occupying approximately 58 ha with patch conditions ranging from 2:1 (EPBC unclassified) to 8:1 (EPBC Class B). The greatest areas are rated as 4:1 (EPBC Class C).

The LOM extension will disturb a total of 1.8ha of 8:1 *E. odorata* woodland in patch 10, rated as EPBC Category B by EBS (2013). This area is in very good condition and was classified as Class B due to the presence of more than 15 native species, more than 3 additional herbaceous species and more than 2 grass species over an area of more than 1ha (see Fig 5, below).

2.2.2 *L. effusa ± Helichrysum leucopsideum* open tussock grassland

This vegetation community originally occupied approximately 26 ha of the ML area and occurs predominantly to the south of the existing open pit on the crest and slopes of MacFarlane Hill.

The LOM extension will disturb a total of 3.4 ha of 8:1 *L. effusa* grassland in patch 22, rated as EPBC Category C by EBS (2013). This area is in very good condition and was classified as Category C due to the presence of more than 5 native species and more than 1 grass species.

Other areas of *L. effusa* grassland disturbance attributable to the LOM extension include 0.01ha of 6:1 grassland in patch 29 and 1.0ha of 4:1 grassland in patches 25, 31 and 33. These areas are highlighted by Fig. 5 (below).

2.2.3 *Austrostipa* sp. open tussock grassland

Remnant patches of *Austrostipa* sp. open tussock grassland originally occupied approximately 14 ha within the ML. The community is floristically similar to *L. effusa* open tussock grassland; however, *L. effusa* is absent and the native grass *Austrostipa* sp. is the dominant species. *Austrostipa* sp. open tussock grassland occurs predominantly on the southern crest and slopes of MacFarlane Hill.

The LOM extension will disturb a total of 0.2ha of 8:1 Austrostipa sp. Grassland within patch 27. This area is highlighted by Fig. 5, below.

2.2.4 *Acacia pycnantha* low woodland

Remnant patches of *Acacia pycnantha* low woodland occur to the immediate east and northeast of the existing pit and originally occupied 11.2 ha within the ML. Vegetation disturbance attributable to the LOM extension will include 1.5 ha of 6:1 *A. pycnantha* woodland in patch 19 and 1.1ha of *A. pycnantha* woodland in patches 20 and 21 as illustrated by Fig.5.

Figure 4. ML Vegetation Communities, Highlighting PEPR-Approved Disturbance Boundary and Proposed LOM Disturbance Boundary

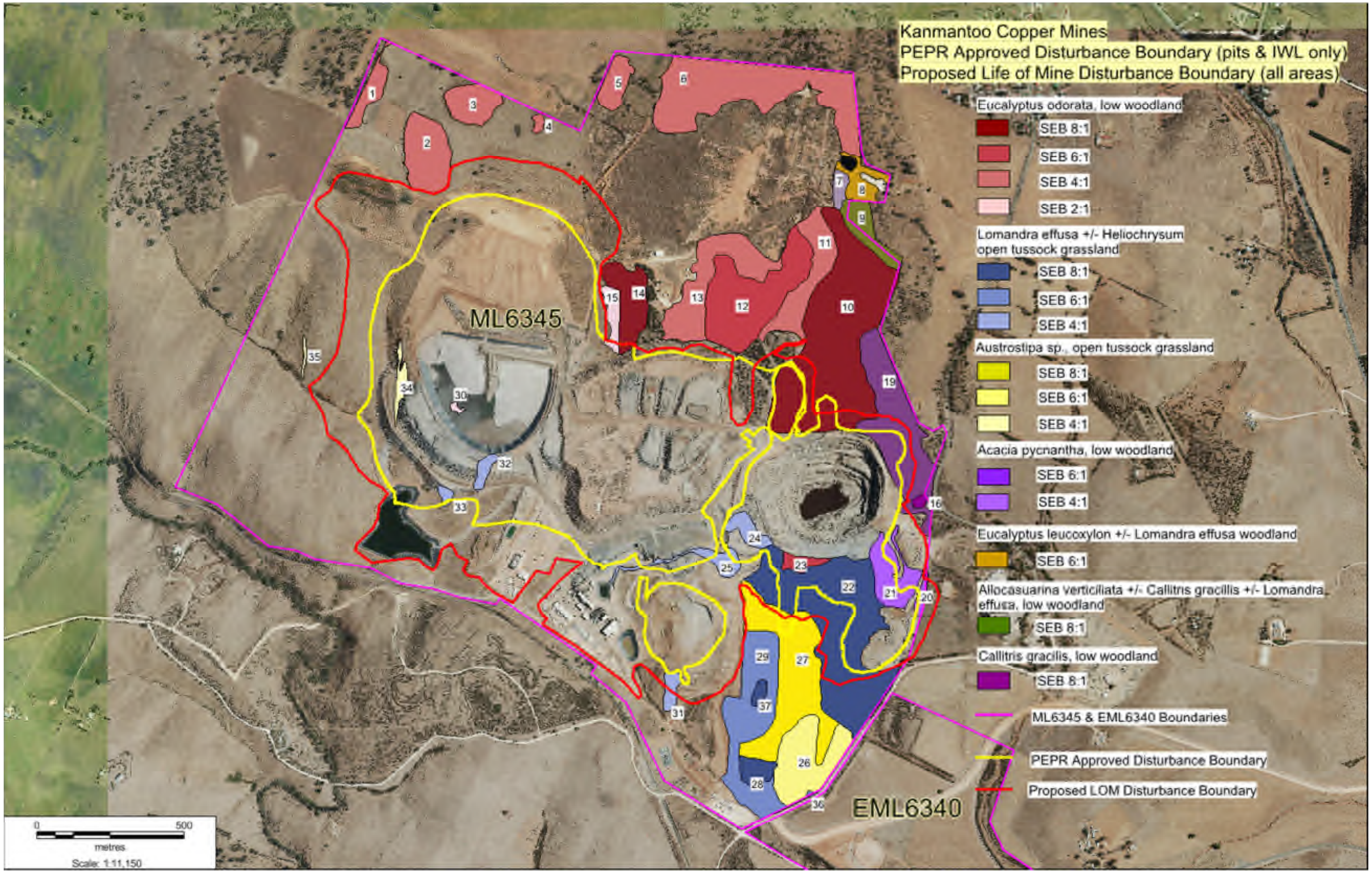
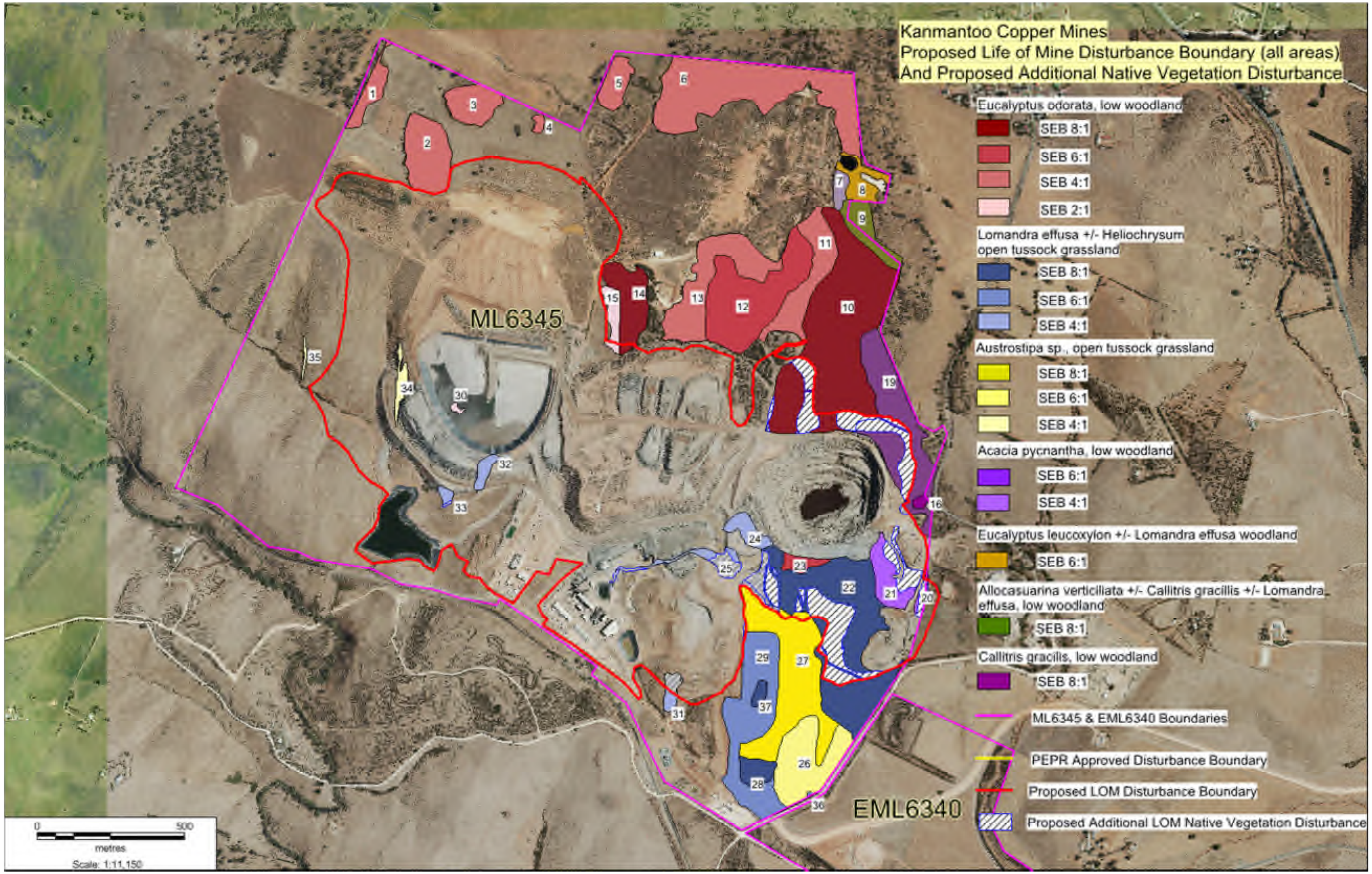


Figure 5. Proposed Additional Native Vegetation Disturbance Associated with LOM Extension



2.3 Flora of Conservation Significance

2.3.1 Plant Species of Conservation Significance

No individual plant species of national (EPBC Act-listed) conservation significance (Section 179) have been recorded in the ML and none are considered likely to be present.

Two flora species of state-listed conservation significance (i.e., listed under the NPW Act) have been recorded in the ML, and may be within LOM extension areas, however only one species has been located during recent surveys:

- ***Diuris behrii* (Behr's cowslip orchid)** - Listed as vulnerable. This species was recorded to the north of the main pit during the spring 2007 survey. It has not been observed within the proposed LOM extension areas within patch 10; however we will continue to look for it and will rescue any specimens if they are found. Rescued plants will be cared for by the Native Orchid Society of SA (NOSSA), under arrangements described by the current NVMP for preservation and propagation of *D. behrii* rescued from initial mine clearance areas. As with current *D. behrii* plants being cared for by NOSSA, future plants will be returned to the ML in prepared and protected areas within woodlands and suitable SEB-offset patches (see Plate 7, below).
- ***Ptilotus erubescens* (hairy-tails) -** Listed as rare. There is one historical record of *Ptilotus erubescens* within the ML Region. This record is from the Biological Database of South Australia (managed by the Department of Environment and Natural Resources) and dates from 1994. *P. erubescens* has not been observed within LOM extension areas and is not expected to be present.

The shrub *Acacia iteaphylla*, listed under the NPW Act as rare in South Australia, occurs within the ML and is within the LOM extension area; however, this species is growing outside of its natural range and can be considered introduced in the context of the ML's native vegetation. The species is commonly planted elsewhere in revegetation projects, but has the potential to become an invasive woody-weed at Kanmantoo.

2.3.2 Vegetation Communities of Conservation Significance

Three communities occur within the ML; all of which are likely to be disturbed by the LOM extension:

- ***E. odorata* low woodland.** This vegetation community is significant at the national level, listed as a critically endangered ecological community (as Peppermint Box (*E. odorata*) Grassy Woodland) under the EPBC Act (DEWR, 2007), at a state level, listed as Priority 3 for conservation under the NPW Act, and at the regional level, listed as threatened within the South Australian Murray–Darling Basin (Ecological Associates, 2007). Proposed LOM extension disturbance within EPBC Class B woodland is currently the subject of an EPBC referral.
- ***L. effusa* ± *Helichrysum leucopsideum* open tussock grassland.** This vegetation is significant at the national level, listed as a critically endangered ecological community (as Iron-grass Natural Temperate Grassland) under the EPBC Act (DEWR, 2007), at the state level, listed as Priority 1 for conservation in South Australia under the NPW Act, and at the regional level, listed as threatened within the South Australian Murray–Darling Basin (Ecological Associates, 2007).

Proposed LOM extension disturbance within the ML's 'Class C' *L. effusa* open tussock grassland communities are currently the subject of an EPBC Referral.

- ***Austrostipa* sp. open tussock grassland**, ***E. leucoxylon* ssp. *leucoxylon*** ± ***L. effusa* open woodland** and ***Callitris gracilis* low woodland** are significant at the regional level, listed as threatened within the South Australian Murray–Darling Basin.

2.4 Fauna of Conservation Significance

The following fauna species of national and state-listed conservation significance are present in the ML area. All species have been observed during each of the spring fauna surveys since the commencement of mining operations.

Birds

The **rainbow bee-eater** (*Merops ornatus*), a marine-listed species under the EPBC Act, was recorded across the ML area. Rainbow bee-eaters recorded in the ML area may be significant at the local level as they are likely to breed in sandy banks along water courses and use woodland habitat within the ML area, however, the presence of this species is unlikely to be significant at the regional, state or national level due to its wide distribution and transient nature. It is not expected that LOM extension disturbance will significantly impact rainbow bee-eater populations within the ML.

The **diamond firetail** (*Stagonopleura guttata*), listed as vulnerable under the NPW Act, has declined over most of its historical range across south-eastern and eastern Australia in both extent and density (Ecological Associates, 2007). The *E. odorata* low woodland in the ML area is likely to provide habitat for this species and the population in the ML area is likely to be significant at the local and regional level. It is not expected that disturbance of an additional 1.8 ha of *E. odorata* woodland by the LOM extension will significantly impact local or regional diamond firetail populations.

The **peregrine falcon** (*Falco peregrinus*) is listed as rare under the NPW Act. The species has a worldwide distribution; however, it has declined significantly in most countries other than Australia. In Australia the population is substantial, widespread and viable, while in South Australia the resident population is small, with the total population estimated at less than 3000 mature individuals (Ecological Associates, 2007). A study in Victoria (Ecological Associates, 2007) suggests that nesting pairs of this species are tolerant to disturbance associated with mines and quarries. It is not expected that disturbance associated with the LOM extension will adversely impact peregrine falcon populations in the ML.

The **white-winged chough** (*Corcorax melanorhamphos*) is listed as rare under the NPW Act, The species has a distribution across south eastern and eastern Australia and the population across this range has declined. Although still common in good habitat patches of drier woodland and open forest, choughs are weak flyers and do not cope well with habitat fragmentation, so many isolated populations are vulnerable (BIRD, 2007). A Chough family group have been observed in the woodland habitat within the ML area, ranging to the north of the main pit and the northern-boundary of the ML. It is not expected that disturbance associated with the LOM extension will adversely impact chough populations in the ML.

Mammals

The **brushtail possum** (*Trichosurus vulpecula*) was the only mammal species of listed conservation significance under the NPW Act that was recorded in the ML area. No mammal species of listed conservation significance were recorded under the EPBC Act, or considered likely to be present, within the ML area. The brushtail possum has the widest distribution of any Australian mammal, being found across southern, eastern, and northern Australia.

The relatively large *E. odorata* low woodland habitat in the ML area is considered important to this species at the local and regional level. A total of eighty-eight Brushtail possum sightings were recorded during the 2012 Spring Fauna Survey (EBS, 2013). Most of these were in the isolated *E. odorata* patches near the Mine's Seed Production Area (SPA) in the North West quadrant of the ML and are well outside of the LOM extension area in Patch 10.

It is not expected that disturbance associated with the LOM extension will adversely impact the region's brushtail possum population, however if displaced possums are encountered during clearance operations, we will seek expert advice to assist with their rescue. We understand that relocated brushtail possums have a low survival rate, so alternative options including (but not limited to) re-homing through wildlife sanctuaries or accredited private collectors will be considered. As new areas of SEB-offset vegetation are progressively created within and adjacent to the ML, it may become possible to create new home ranges for displaced possums through the use of nesting boxes and imported hollows. Should the opportunity arise, expert advice will be sought on the best way to implement this.

2.5 Distribution of Weed Species

Introduced Species

Forty-seven introduced plant species have been recorded in the ML area, including:

- **Grasses**. Wild oats (*Avena barbata* and *Avena fatua* are the most abundant grass species within the ML and are very common throughout the agricultural regions of South Australia. Within the ML area, they were most abundant within the *Austrostipa* sp. open tussock grassland, *L. effusa* open tussock grassland and abandoned cropping land, which is also prone to infestation by great brome (*Bromus diandrus*), annual ryegrass (Lolium rigidum), phalaris (Phalaris aquatica) and silver grass (Vulpia sp.)
- **Herbs.** Herb species include bridal creeper (*Asparagus asparagoides*), South African weed orchid *(Disa bracteata)*, artichoke thistle (*Cynara cardunculus ssp. flavescens*), blackberry nightshade (*Solanum nigrum),* Horehound (*Marrubium vulgare*), Sour-sob (*Oxalis pes-caprae),* spiny rush (Juncus acutus) and small amounts of Salvation Jane (*Echium plantagineum*).
- **Shrubs.** Shrub species include red-head cotton-bush (*Asclepias curassavica*), Flinders Ranges wattle (*Acacia iteaphylla*), western coastal wattle (*Acacia cyclops*), gorse (*Ulex euopaeus*) and boneseed (*Chrysanthemoides monilifera* ssp*. monilifera*).
- **Woody weeds.** Woody weeds recorded within the ML area include olive (*Olea europaea* ssp. *europaea*), Aleppo pine (*Pinus halepensis*), Cape Leeuwin wattle/Albizia (*Paraserianthes lophantha*), wild tobacco (*Nicotiana glauca*) and African boxthorn (*Lycium ferocissimum*).

3. MANAGEMENT AND MITIGATION MEASURES

Avoidance, management and mitigation measures have been developed to reduce the potential impacts on flora and fauna associated with the initial phase of mining operations as described in the approved PEPR and its NVMP. Mitigation measures are currently applied to all areas of remnant vegetation within the ML and will be similarly applied to the adjacent land areas available for SEB-offset as highlighted in Figs. 7 & 8.

Mitigation measures for the purpose of limiting the impact to native vegetation of disturbance associated with the LOM extension are as follows…

3.1 Vegetation Clearing

The management of the risks associated with additional areas of vegetation clearing will be based on the following hierarchy:

1. Avoiding areas with communities of conservation significance where possible and minimising approved vegetation clearance where this can be achieved
2. Avoiding disturbance in all other remnant native vegetation
3. Appropriately managing the approved clearance of native vegetation
4. Monitoring and reporting the clearance of all vegetation
5. Mitigating approved vegetation disturbance through the provision of corresponding SEB-offset areas

3.1.1 Avoiding Areas with Communities of Conservation Significance & Minimising Clearing where it is Deemed Necessary

The Hillgrove Environment Department works with mine planners and shift supervisors to ensure that the disturbance of native vegetation with conservation significance is minimised at all times and that staff are aware of the conservation value placed on patches adjacent to the mining footprint.

One example of this was the reduction in native vegetation disturbance necessary to proceed with the LOM extension. This was achieved by negotiating modifications to pit designs and subsequent disturbance footprints with the Mining Department. In this case, the area of native vegetation which would be disturbed by the LOM extension was reduced from approximately 12.8ha in earlier versions of the LOM extension plan to approximately 9.1 ha in its current form. The majority of this reduction was achieved by limiting the area of *E. odorata* woodland disturbance in patches 10, 11, 12, 14 & 15 from 5.2ha to 1.8ha. This change incorporates the concerns of our local community with regard to northern extension of the main pit and limits fragmentation of patches 10, 11 and 12 in particular (see Figs 5 & 6).

Approved native vegetation disturbance is strictly controlled and cannot proceed without HGO Environment Department Approval and issuing of Land Clearance Certificates together with an Excavation Permit, which is reviewed and countersigned by each of HGO's department Managers (see details below). The Hillgrove Environment Department will continue to work with mine planners to ensure that disturbance to remnant vegetation of conservation significance is avoided wherever possible and that mine staff remain aware of the importance of our remnant vegetation stands in all aspects of our operations.

3.1.2 Avoiding Disturbance in all Other Remnant Native Vegetation

Measures to minimise disturbance in all other remnant vegetation types, both within and adjacent to the ML on Hillgrove-owned properties include:

- Employing a strictly enforced land clearance permit system for all disturbance activities. This permit system requires detailed mapping of proposed disturbance by the proponent, sign-off by each of the Mine's operational Departments, an on-ground vegetation survey by Environment Department staff and final HGO Environment Department approval before disturbance is authorised.

  The HGO Environment Department routinely place restrictions on disturbance areas or request redesign of proposals to avoid sensitive vegetation where this can be practically achieved. The HGO Environment Department also walks cleared areas following earthmoving activities to ensure that Permit conditions have been followed. Any breaches of Permit conditions are formally reported and are followed up with the responsible HGO Department Manager.

- Strictly limiting any form of disturbance in all areas of native and non-native vegetation
- Limiting disturbance by locating access tracks, bunds and other mine infrastructure outside of vegetation remnants wherever possible.
- Minimising the length and number of access tracks in remnant vegetation. This includes closing off redundant tracks where feasible.

3.1.3 Appropriately Managing the Approved Clearance of Native Vegetation

Measures to appropriately manage the clearing of vegetation, where the above steps cannot avoid this, include:

- Educating workers in the importance of protecting native vegetation by:
  - Including information on the importance of threatened plant species, vegetation clearance restrictions and conservation aims in the induction process.
  - Ensuring staff are aware that plant identification charts, conservation information and plant identification expertise are readily available through Environment Department Staff.
- Protecting areas of vegetation to be retained by:
  - Ensuring areas of vegetation to be retained are clearly marked on site plans.
  - Clearly marking 'no go' zones (e.g., with fencing, bunding and/or instructions) to ensure areas to be protected are clearly defined, identified and avoided.
  - Avoiding introduction of soil pathogens to areas of remnant vegetation by identifying and clearly demarcating soil stockpile sites. This includes pre-entry inspections of all new vehicles and earthmoving equipment and issuing of Equipment Inspection Certificates to compliant plant before they can commence work within the ML
- Developing site-specific vegetation clearance protocols for all personnel to follow. These protocols include:

– A step-by-step process to follow prior to commencing the clearing of any native vegetation. This includes an Excavation Permit, which requires a separate Land Clearance Certificate to be completed and approved by Environment Department staff in cases where vegetation clearance is required. This process ensures that:

– Areas to be cleared are mapped, pegged and verified.

– Areas to be retained are mapped, pegged and verified.

– A continuous-checking system is employed to minimise the potential for inadvertent clearing of native vegetation.

– Areas are only cleared immediately prior to their development.

– Ground disturbance is only undertaken within designated and approved areas.

– Clearance activities are coordinated to allow topsoil recovery and stockpiling

- Plant rescue campaigns are scheduled for designated clearance areas within appropriate seasonal windows prior to the commencement of land clearance. Plant rescue campaigns are carried out by collaboration between local Landcare volunteers and HGO Environmental Staff, with assistance provided through qualified Contractors (e.g., EBS and COOE).

Disturbed areas are progressively rehabilitated and unnecessary future disturbance of these areas will be avoided.

3.1.4 Monitoring of all Vegetation Clearance

Total vegetation clearance within the ML will be regularly monitored through routine on-ground observations, aerial photography and GIS-based mapping. Monitoring results will be reported annually in the MARCR. Regular auditing will also be carried out to assess the compliance of all personnel with vegetation clearance protocols listed above.

3.1.5 Mitigation of Approved Vegetation Disturbance Through the Provision of Corresponding SEB-offset Areas

Where vegetation clearance must be carried out to progress mining operations and approval has been granted clearance, care will be taken to ensure that the provision of SEB-offsets will commence at the same time that vegetation clearance occurs. The following measures are undertaken to ensure that clearance is mitigated through the provision of corresponding SEB-offsets:

• Working with local interest groups and other stakeholders where possible to maximise the benefits of SEB-offset programs, both in terms of the results achieved and in terms of creating both interest by and benefit for local groups (for example, the Kanmantoo Callington Landcare Group (KCLG) and other similar parties).

• Revegetating, using appropriate local species and local provenance seed sources (wherever possible), to link isolated vegetation remnants within the ML and provide a degree of continuity to offset areas located on properties immediately adjacent to the ML (See Figs 7 & 8).

• Relocating any threatened flora species to be disturbed by approved mining activities.

- Ensuring in-house environmental capabilities have been established and are maintained to develop, apply and manage revegetation and SEB-offset programs associated with the LOM extension. To date this has included (but will not be limited to) the construction and operation of a 1.0ha irrigated, Seed Production Area (SPA) within the ML and the establishment of a 5ha Seed Multiplication Area (SMA) on land directly adjacent to the ML in 2013 (please see Plates1 & 2, below).

  The SPA has been populated using native seed collected within the ML and near ML region. The SMA was sown in July 2013 using a combination of SPA-grown and local provenance seed. It is expected that a blend of SPA, SMA and annual wild seed collection will provide sufficient stock for progressive rehabilitation through the LOM extension and for final closure operations following the conclusion of mining. SPA, SMA and wild-seed collection programs are currently conducted in association with staff from EBS-Restoration.

- Establishing methods to monitor and maintain progressively rehabilitated and revegetated areas, including:
  - Establishing 360º photo-monitoring points throughout the ML area and at adjacent ML vantage points.
  - Establishing a series of Landscape Function Analysis (LFA) transects through benchmark vegetation communities (after Tongway & Hindley 2004). Data has been collected in association with staff from EBS-Ecology since the commencement of mining operations and will be used to gauge the progress of SEB and Rehabilitation plantings through regular LFA transect monitoring in newly established patches (EBS, 2013).
  - Developing procedures for conducting post closure follow-up visits to the ML area on a regular basis (of a decreasing frequency with time) to monitor the success rate of seedling emergence and survival, weed invasion, browsing levels (i.e., insect and animal attack of regenerating vegetation) and erosion, using photo-monitoring points to track progress.
  - Ensuring that the monitoring program reflects agreed closure criteria established through consultation with stakeholders.
- Acting where monitoring has identified erosion, weed invasion, failure of revegetation (to a material degree) or excessive browser damage to regenerating vegetation. This may include:
  - Repairing eroded areas.
  - Controlling weeds (chemical, mechanical, and manual methods).
  - Controlling pests (baiting, fencing, ripping etc.).
  - Infill planting.
  - Spot sowing.
  - Reseeding.

4. SEB- OFFSET CALCULATION

4.1 Extent of Vegetation Clearance

Native vegetation was cleared within the Kanmantoo ML between late 2010 and 2013 in PEPR-approved areas to accommodate mining infrastructure associated with the initial phase of mining operations. Details associated with approved vegetation clearance areas and their respective SEB-offsets are discussed in the PEPR NVMP (2010) and won't be discussed further in this plan.

A further 9.1ha of native vegetation disturbance will be required to extend the life of the mine. This will involve additional native vegetation disturbance to the north-west and south-east of the open pit and to the south of Emily Star pit as follows (Please note Fig. 8, below):

4.1.1 *Eucalyptus odorata* low woodland

The LOM extension will disturb a total of 1.8ha of 8:1 *E. odorata* woodland in patch 10, rated as EPBC Category B by EBS (2013). This area is in very good condition and was classified as Class B due to the presence of more than 15 native species, more than 3 additional herbaceous species and more than 2 grass species over an area of more than 1ha.

4.1.2 *L. effusa ± Helichrysum leucopsideum* open tussock grassland

The LOM extension will disturb a total of 3.4 ha of 8:1 *L. effusa* grassland in patch 22, rated as EPBC Category C by EBS (2013). This area is in very good condition and was classified as Category C due to the presence of more than 5 native species and more than 1 grass species.

Other areas of *L. effusa* grassland disturbance attributable to the LOM extension include 0.01ha of 6:1 grassland in patch 29 and 1.0ha of 4:1 grassland in patches 25, 31 and 33.

2.2.3 *Austrostipa* sp. open tussock grassland

The LOM extension will disturb a total of 0.2ha of 8:1 Austrostipa sp. Grassland within patch 27.

2.2.4 *Acacia pycnantha* low woodland

The LOM extension will include 1.5 ha of 6:1 *A. pycnantha* woodland in patch 19 and 1.1ha of *A. pycnantha* woodland in patches 20 and 21

The additional native vegetation clearance required to achieve the LOM plan is detailed in Table 2 and is illustrated by Figs 7 & 8. SEB-offset calculations for new disturbance areas have not been discounted as mitigation efforts currently in place for existing PEPR approved operations are associated with previously approved vegetation disturbance and are not the subject of this NVMP.

Areas assigned for the provision of SEB-offsets on properties adjacent to the ML do not contain known areas of remnant native vegetation, so discounts to SEB-offset areas do not apply.

As previously outlined, higher SEB ratios have been applied to 6:1 and 8:1 patches to adjust for any species which may not have been evident at the time of the 2013 EBS survey.

Table 2. Summary of Native Vegetation Disturbance and SEB-Offset areas – LOM Extension.

		LOM Extension - Additional Disturbance Areas					
Vegetation Communities	**Patch Numbers**	**Condition (SEB Ratio)**	**SEB Offset Ratio Applied**	**Area to be Cleared (ha)**	**Offset Area (ha)**	**Mapped LOM Extension SEB Areas**	**Offset Patch Numbers (Fig 9)**
Eucalyptus odorata low woodland	10	8:1	10:1	1.8	18.0	18.0	41, 43, 48, 49
Lomandra effusa +/- Helichrysum leucopsideum open tussock grassland	22	8:1	10:1	3.4	34.2	34.2	42, 50, 51, 53, 55
	29	6:1	8:1	0.01	0.1	0.1	56
	25, 31, 33	4:1	4:1	1.0	4.1	4.1	57, 58, 59, 60, 61
Austrostipa sp. open tussock grassland	27	8:1	10:1	0.2	2.0	2.0	44, 46, 62
Acacia pycnantha low woodland	19	6:1	8:1	1.5	6.0	6.0	38, 39, 45, 47
	20, 21	4:1	4:1	1.1	4.4	4.4	40, 52, 54
				9.1	**68.8**	**68.8**	**24 Patches**

4.1.1 Significance of Vegetation to be Disturbed

The significance of threatened flora species and vegetation communities within the ML is described in Section 2. Vegetation disturbance associated with the proposed LOM extension will affect the four significant vegetation types described above, but in particular:

- ***Vegetation of state and national significance*** - *E. odorata* low woodland and *L. effusa* open tussock grassland.
- ***Vegetation of regional significance*** - *Austrostipa sp.* open tussock grassland.

Of these vegetation types, *E. odorata* low woodland in particular, is known to support threatened fauna species. Two plants of state conservation significance, *Diuris behrii* (Behr's cowslip orchid) and *Ptilotus erubescens* (hairy-tails) have been recorded in areas to be affected by mining activities (although the *Ptilotus erubescens* has not been located in any of the recent flora surveys or on-ground plant rescue campaigns).

4.1.2 Conservation Value of Vegetation

The Draft Native Vegetation SEB Guidelines (DWLBC, 2005) list five conservation values that should be considered in association with vegetation clearing (summarised from Table 3 of DWLBC, 2005):

- Threatened vegetation communities.
- Wetland environments.
- Remnant vegetation.
- Threatened flora.
- Threatened fauna habitat.

The vegetation to be cleared is of conservation value for four of the five points. Wetland environments of conservation value do not occur within the ML area.

Figure 6. Proposed Native Vegetation Disturbance for LOM Extension

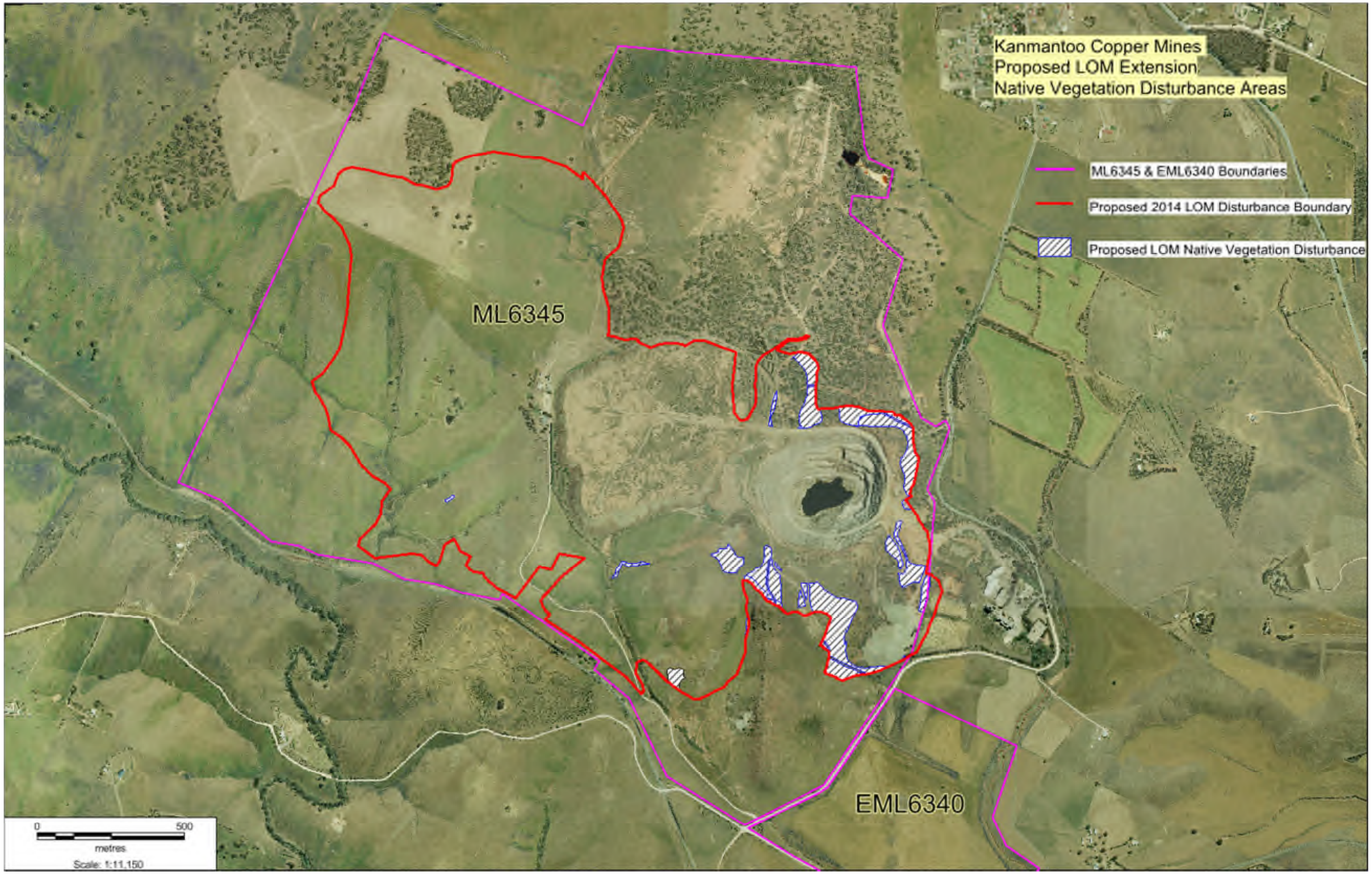


Figure 7. Proposed LOM Vegetation Disturbance & Corresponding SEB-Offsets on Nearby Hillgrove-Owned Properties

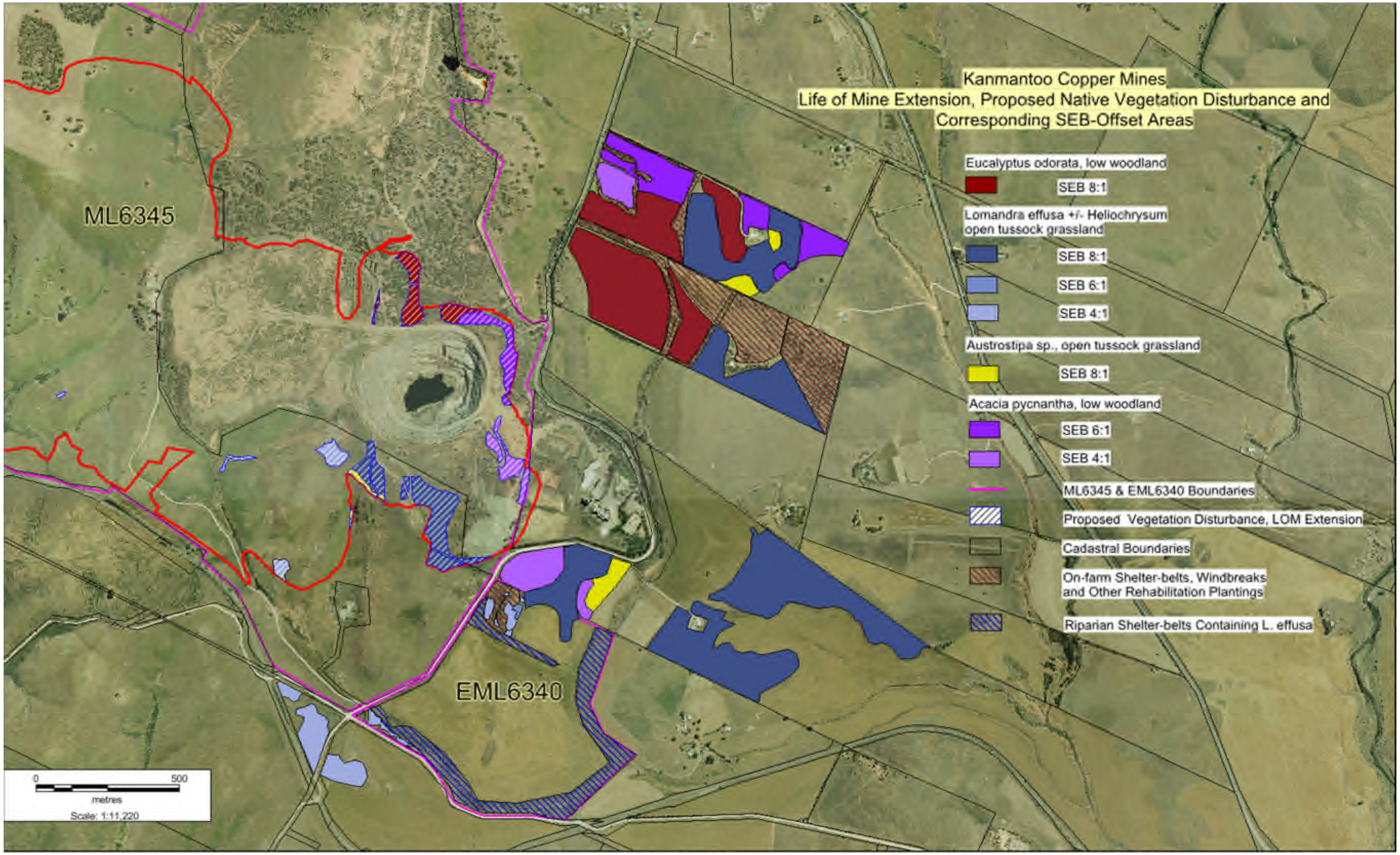
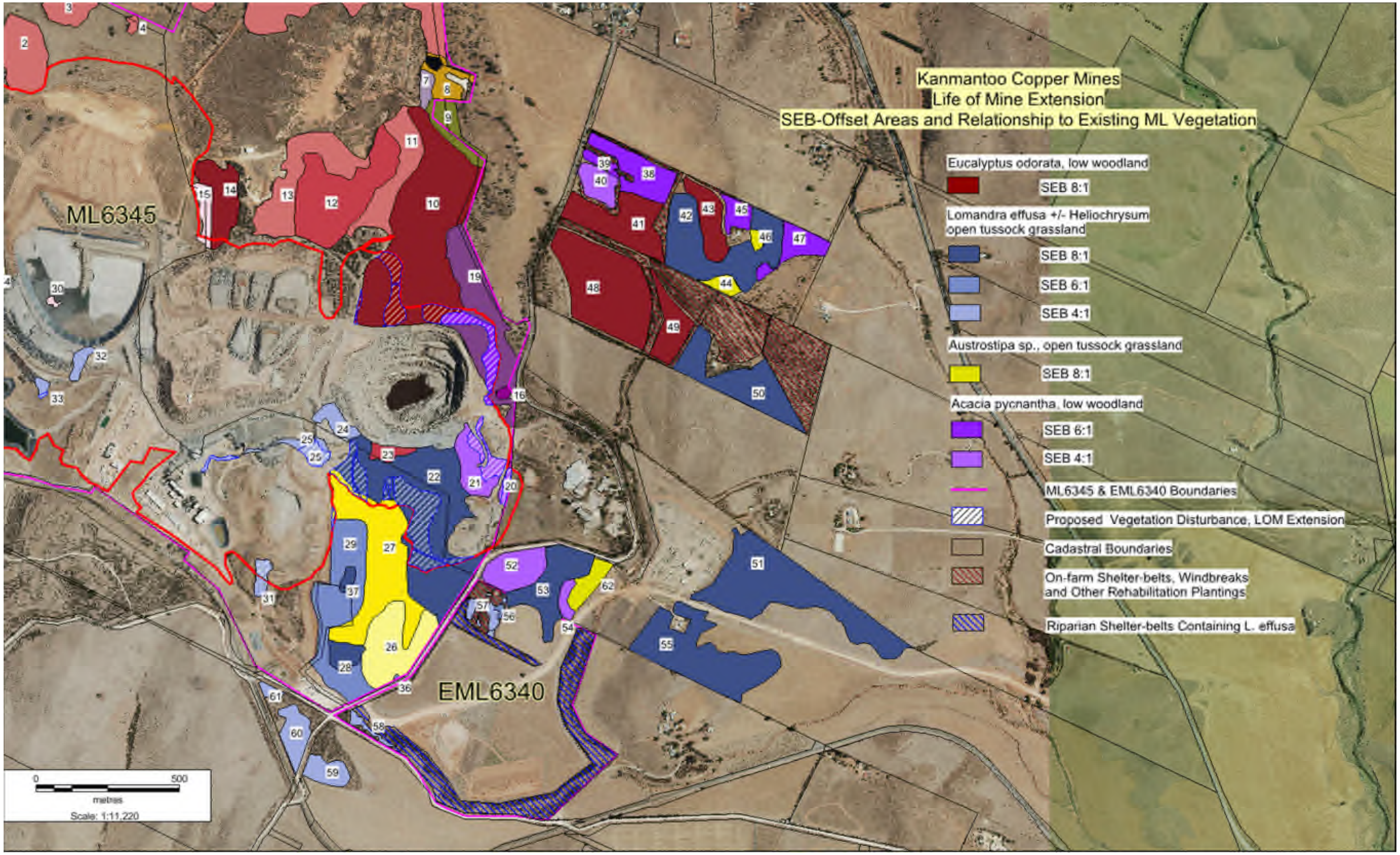


Figure 8. Proposed SEB-Offset Areas Illustrating Relationship to Existing ML Native Vegetation and LOM Extension Disturbance Areas



4.2 Impacts of Vegetation Clearance

The residual impacts of the proposed levels of disturbance to flora and fauna may include:

- Impacts to threatened vegetation communities.
- Impacts to threatened flora and fauna species.
- Reduced conditions favourable for plant growth due to dust.
- Reduced abundance of individual species (both flora and fauna).
- Increased abundance of introduced species (pest plant and animals).

4.3 Estimated Significant Environmental Benefit

4.3.1 Initial SEB Assessment

An SEB offset area of 125.25 ha was originally calculated to offset vegetation disturbance associated with the initial phase of mining operations. These areas rest within the yellow disturbance boundary and intersect native vegetation communities as highlighted by Fig. 4 (above). Disturbance areas and their corresponding offset sites for the initial phase of mining operations are described by the PEPR and will not be discussed by this NVMP.

The vegetation assessment criteria for the assignment of SEB Offset condition scores are listed in Attachment A, below. Details of the 2013 EBS vegetation survey are provided below in Attachment B.

When assessing the condition of native vegetation for SEB-offset purposes, the Native Vegetation Council advocates the substitution of 6:1 SEB ratios with an 8:1 ratio and an 8:1 ratio with a 10:1 ratio. This convention compensates for species which may not have been present during on-ground surveys of proposed disturbance sites. This convention has been applied to SEB-offset calculations for the LOM extension presented in Table 2 (above).

As outlined in Table 2, a total of 9.1ha of native vegetation disturbance will be associated with the LOM extension, requiring the establishment of 67.6ha of mixed SEB-offset vegetation (see Figs 7 & 8). As much of the ML has been previously allocated to SEB-offsets for PEPR-approved native vegetation disturbance, SEB-offsets associated with the LOM extension are proposed on Hillgrove-owned land, directly to the east of the ML. Table 4 lists the properties owned by Hillgrove and indicates which offset patches are earmarked for each property.

4.3.2 SEB Credit for On-site Restoration Activities

Basis

DWLBC (2005) guidelines allow for the initial SEB offset requirement to be reduced by approximately 50% where on-site ecological restoration activities will be achieved on completion of mining.

Ecological restoration is achieved by: 'Returning the ecosystem to as a close approximation of its natural condition prior to disturbance'. The goal is to emulate a natural, functioning self-regulating system that is integrated with the landscape in which it occurs' (DWLBC, 2005).

Application to the LOM Extension.

SEB-credits have already been applied to on-site restoration areas as assigned and approved in the PEPR. There is insufficient additional land within the ML to accommodate SEB-offsets for additional vegetation disturbance associated with the LOM extension. Subsequently, SEB-offset areas associated with the LOM extension have been located as near as possible to the ML on suitable Hillgrove-owned land parcels. SEB-offset reductions associated with on-site restoration have not been applied to calculations associated with the LOM extension.

4.3.3 SEB Credit for Mitigation of Impacts

Basis

As with on-site restoration activities, the SEB ratio may be reduced by 50% when a project is likely to impact upon one or more of the conservation values, e.g., threatened flora and fauna and vegetation communities, but the proponent will commit to mitigating these impacts through measures additional to on-site ecological restoration (DWLBC, 2005).

As is the case for on-site restoration activities, on-site mitigation programs are already in place within the ML and there are no additional ML areas to which mitigation allowances can be claimed.

The adjacent Hillgrove-owned land parcels do not contain known areas of remnant native vegetation. Where revegetation has been attempted by previous landowners, many of the species chosen are non-provenance and would be largely unsuitable for enhancement to ML vegetation types without structural change. The remaining areas have been significantly modified by agricultural activity and have no significant native vegetation present.

Application to the LOM Extension

The reduction of SEB-offset areas for mitigation programs on Hillgrove-owned land parcels has not been applied to SEB-offsets associated to the LOM extension.

4.3.4 Calculated SEB Offset Requirement

The calculated SEB offset required for the proposed LOM extension is 68.8 ha (see Table 2).

The SEB offset area has been determined in accordance with the minimum area of vegetation disturbance required to achieve the LOM extension.

5. PROVISION OF SEB

5.1 Rationale

The rationale for provision of an SEB Offset is based on the premise that the clearance of native vegetation will result in a loss of biological diversity values (which include flora and fauna habitat), with the degree of loss dependent on the quality and amount of vegetation to be cleared (PIRSA, 2004).

To compensate loss of biological diversity values, the SEB offsets should not only replace the environmental values lost through clearing, but also lead to a net gain that contributes to improving the condition of the environment, either on the site of the operations or within the same region of the state. Alternatively, an appropriate sum can be paid into the SEB Offset Fund administered by the SA Government for disbursement to other offset creating programs.

An SEB-offset is intended to commence at the time of vegetation clearance and should be located on land as near as possible to the site of clearance.

It is intended that the conversion of farming and grazing land adjacent to the ML will provide a significant benefit to the environment as outlined below. Table 3 provides a list of properties owned by Hillgrove immediately adjacent to the ML. It highlights which properties have been earmarked to host SEB offset areas for corresponding new areas of native vegetation disturbance within the ML.

Table 3. Hillgrove-owned properties adjacent to the ML and Assignment of SEB Offsets

Property Name	**CT Reference/ Owner**	**Allocated offset Patches (see Fig 8)**	**Offset Types**
141 Mine Rd	F160800 A61/ Hillgrove	38, 39, 40, 41, 42, 43, 44, 45, 46, 47	*E. odorata* – 8:1; *L. effusa* – 8:1, *Austrostipa* – 8:1, A. pycnantha – 6:1 & 4:1
Mullewa	F1636 A1/ Hillgrove	48, 49, 50	*E. odorata* – 8:1; *L. effusa* – 8:1,
Ferguson's	D80644 A21/ Hillgrove	51, 55	*L. effusa* – 8:1
Lot 25	D60948 A25 (EML6340)/ Hillgrove	52, 53, 54, 56, 57, 58, 62	*L. effusa* – 8:1, 6:1 & 4:1; Austrostipa – 8:1
Back-Callington Rd/ Éclair Mine Rd	D47967 A4 and D30934 Q1/ Hillgrove	59, 60, 61	*L. effusa* – 4:1

It is intended that an SEB offset will be created on the assigned areas through the following means;

- Removing agricultural activity from allocated areas
- Installing rabbit-proof fencing and controlling rabbits/hares/foxes within fenced areas
- Carrying out ongoing weed control programs to remove introduced plant species
- Carrying out erosion mitigation works within assigned areas where possible
- Planting local plant species derived from local provenance seed within designated vegetation areas to create areas of high-value vegetation
- Following up planting programs with infill plantings where required
- Progressively providing nesting boxes, perches and/or refuges for local fauna within revegetated patches as they become increasingly capable of supporting local fauna populations.
- Involving local community groups and local contractors in all work where possible (to create both regional interest and regional employment)
- Protecting SEB-offset patches through appropriate Heritage Agreements

These steps are described in detail by Section 5.2 and Table 4, below.

It is important to note that successful implementation of the intended SEB offset program on agricultural land currently owned by Hillgrove and the subsequent protection of planted areas through Heritage Agreements will remove these areas from future agricultural production in perpetuity. This requires considerable investment by Hillgrove as the assigned land parcels will lose their real-estate value as productive agricultural land and will have a limited future niche market value if they are sold at a later date. This will be particularly so if plans to build a new water supply pipeline to the ML are realized and the land could have been sold as productive areas with associated irrigation licences.

5.2 Implementation

Hillgrove proposes to meet the SEB requirements of the LOM extension at the Kanmantoo Copper Mines by implementing the following SEB-Offset program on the land areas illustrated in Figs. 7 & 8 and highlighted by Table 4 (above):

Please note:

- SEB-offsets are provided on a 'like for like' basis with an area of vegetation disturbance being offset by the establishment of a corresponding area of offset vegetation
- The area of offset vegetation is proportionately larger than the area of vegetation to be disturbed. The size of the offset area is governed by the patch condition of the disturbed area and its assigned SEB offset ratio as highlighted by Table 2 (above)
- Work on the establishment of SEB-offsets (as outlined below) will commence at the same time as approved clearance occurs
- The floristic composition and plant density of the offset area will be the same as the disturbance area it offsets as illustrated by Fig. 8
- *Should the results of 'investigative studies' as discussed in point 5.2.7, below, prove that the provision of SEB Offsets on any particular allocated land parcel is impractical or financially unreasonable, Hillgrove reserves the right to directly fund the establishment of an equivalent SEB offset on private land in the near-mine region by third-party providers, following an appropriate Government approval process*

Table 4. Proposed SEB-Offset Work Program

		Year 1				Year 2				Year 3				Year 4… onwards			
Item No.	Description	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
1	Removal of grazing/cropping pressure																
2	Schedule offset programs																
3	Survey revegetation plots																
4	Install rabbit-proof fencing																
5	Source equipment/ engage contractors																
6	Weed (W) and feral animal control (F)	F	W/F	W	W	F	W/F	W	W	F	W/F	W	W	F	W/F	W	W
7	Investigative Studies																
8	Enhancement of Native Veg Remnants																
9	Adjustment of boundaries & resurvey																
10	Build up seed reserves/order seeds																
11	Land preparation																
12	Planting programs																
13	Assess results and adjust methods																
14	Replanting program																
15	Establish Heritage Agreement																
16	Inspect & maintain fences																

Notes: *'Year 1' commences at the time of native vegetation disturbance associated with the LOM extension. The precise date of commencement will vary in accordance with variations to the mine plan. Conclusion of the SEB Offset program will occur when the offset communities are considered to be representative of the vegetation disturbance they offset (as determined by LFA and vegetation surveys) and the offset patches have become stable and self-sustaining. We understand that his may occur some years after Hillgrove's mining operations finish within ML 6345.*

5.2.1 Sharefarmer Negotiations – Removal of Grazing & Cropping Pressure from Designated SEB-offset Areas

Objective

To halt farming and livestock grazing activity within areas allocated for SEB-offset plantings as a first step to re-establishing native vegetation within assigned allotments on Hillgrove-owned land immediately adjacent to the Kanmantoo Mining Lease.

Discussion

One of the most significant drivers to the loss of regional biodiversity over the last 150 years has been the introduction of cropping and livestock grazing to the detriment of native woodlands and grasslands in the Kanmantoo area and other arable areas within Australia.

Historically, opening land to agriculture required extensive land clearance, generally through chaining and burning, followed by European-style cultivation including deep ripping and deep ploughing using mouldboard ploughs in early years. This effectively destroyed biodiversity and removed native fauna habitat throughout much of the Kanmantoo region.

Subsequent cropping activity and intensive cultivation destroyed regrowth, caused extensive erosion of our fragile, often dispersive soils and depleted native seed reserves over time. Northern-hemisphere weed seeds and other species from Southern Africa were unwittingly introduced as crop seed contaminants or as seed within fodder imported during droughts. This significantly altered the region’s flora and as a consequence, the native wildlife it could support. Introduced fauna, including hares and rabbits followed, further acting to deplete regrowth of native seedlings and herbaceous plants and erode diversity within remnant native vegetation stands.

The removal of agricultural activity from land parcels assigned to SEB-offset rehabilitation will not in its-self reverse this progress. However, when coupled with rabbit-proof fencing and feral animal control, it will allow the land to commence rehabilitation and will permit the accumulation of native seed reserves once offset plantings begin to mature. In time, this will support natural recruitment driven by microclimate niches within the landscape and will aid in the establishment of self-sustaining native vegetation communities.

Activities

To meet this objective, Hillgrove proposes to:

- Negotiate with our neighbour and share-farmer to cease agricultural activities within the Hillgrove-owned allotments highlighted in Fig. 8 and Table 3
- Provide appropriate compensation to our neighbour to offset loss of income, either through employment or monetary means
- Eventually establish Heritage Agreements over assigned areas to prevent reintroduction of alternate land uses in later years.

5.2.2 Scheduling Offset Programs for Each Offset Patch

Objective

Schedule the commencement of SEB-offset work to coincide with corresponding approved land clearance areas within the ML as dictated by the Mine Plan.

Discussion

Work towards the establishment of SEB-offsets for approved native vegetation clearance should commence at the time that the clearance occurs on a '1 for 1 basis'. This is to ensure that there will be no net-loss of biodiversity or habitat in the long-term and the region's environment is delivered a net gain or 'significant benefit' to counteract loss of remnant vegetation areas.

While mining plans are broadly predicted and scheduled, variations to those plans may occur as a result of new resource information, operational variances or climatic events. Variations are reported to DMITRE in the annual MARCR (Mining and Rehabilitation Compliance Report) and may be the subject of both revisions to, and approval of, a revised PEPR if significant variances are required.

The current mine plan allows the commencement of land clearance within specific areas to be broadly predicted and correspondingly, work on the establishment of SEB-offset areas to be commenced at the appropriate time. Annual review of this program will be required to adjust for periodic changes in the mine plan. This will ensure that the seed, tube stock, physical and budgetary resources are available when needed and that planting will occur within seasonal windows of opportunity for each SEB-offset area. It is expected that the first areas of native vegetation disturbance associated with the LOM extension will occur in the 3rd quarter of 2014, which currently corresponds with 'Year 1' of Table 4, for the offset-patches related to this disturbance.

Activities

To meet this objective, Hillgrove proposes to:

- Work with mine planners to ensure that land clearance schedules are known and are updated in accordance with changes to the mine plan
- Periodically adjust the commencement of SEB-offset work and related work schedules to correspond with the timing of approved vegetation clearance
- Ensure that land preparation, budgetary resources, seed reserves and physical resources are available when required

5.2.3 Surveying proposed revegetation plots within assigned SEB-offset land parcels

Objective

Conduct detailed surveys of designated SEB-offset patches to ensure that they meet initial requirements in terms of area, land class and aspect for their intended offset vegetation type. If any area is determined as unsuitable, survey and allocate equivalent land parcels within Hillgrove-owned land immediately adjacent to the ML.

Discussion

The areas assigned to specific SEB-offset patches, as illustrated in Fig 8, are well known but they haven't been surveyed in detail at the time of writing this NVMP. The selection of SEB-offset patches for each vegetation class and community is based on current knowledge the aspect, terrain and soil type being broadly suitable for its intended end-use.

Detailed ground-based survey of each patch may identify localised features which exclude portions of designated areas from their intended rehabilitation purpose, or conversely confirm their suitability. If so, detailed survey will allow unsuitable areas to be identified and mapped. Any variance to the area available for SEB-offset patch establishment will be compensated by the assignment of alternate areas of appropriate size within the same land parcel or on an adjacent Hillgrove-owned land parcel.

Activities

To meet this objective, Hillgrove proposes to:

- Conduct a detailed ground-based survey of designated SEB-offset patches
- Delineate patch boundaries
- Map areas within delineated patches which are unsuitable for their intended end use
- Identify alternative areas of a suitable size within the same land parcel or on Hillgrove-owned land adjacent to the ML
- Survey, map and delineate alternate patch boundaries
- Modify NVMP maps and program plans as appropriate

5.2.4 Install and maintain rabbit-proof fencing to protect land parcels or individual SEB-patches as appropriate

Objectives

Contain and control feral herbivores and other feral animals within designated land parcels or SEB-offset patches. Prevent reintroduction of feral pests into designated offset areas from surrounding properties. Protect new offset vegetation from grazing by feral and domestic animals. Allow native seed reserves to accumulate within offset patches, both in the short and long term. Regularly inspect and maintain fences to ensure that pest reintroduction does not occur following control.

Discussion

Hares rabbits, goats and deer can devastate new plantings of native vegetation during the summer months when they are often the only source of palatable green feed. Similarly, unintended grazing by escaped livestock due to poor perimeter fences can significantly retard offset patch development. This is particularly so for direct-seeded areas, where tree guards can't be used cost-effectively.

Intensive, prolonged baiting programs with Pindone or 1080 are effective and can reduce rabbit and hare numbers in the short-term. However, such programs are expensive and poor perimeter fencing can lead to the ongoing reintroduction of feral pests from surrounding properties.

Numerous studies over the last 50-years have demonstrated the ability for native vegetation to re-establish within fenced exclosures, where the only driving forces for re-establishment are appropriate seasonal conditions and the removal of all grazing pressure. While areas of long-term cropping land are unlikely to contain significant quantities of remnant native seed, the exclusion and eradication of rabbits from newly planted rehabilitation areas can significantly aid seedling survival and establishment.

In the long-term, rabbit proof fencing allows feral animals to be controlled within fenced areas through baiting and other means. Once feral animals have been removed, appropriate fencing significantly reduces ongoing feral animal control costs by preventing the reintroduction of pests from surrounding properties. The absence of grazing pressure by rabbits in particular, will aid plant establishment, canopy development, seed accumulation, natural recruitment and ultimately, the establishment of self-sustaining vegetation communities.

Once fences have been established it will be necessary to carry out regular fence inspections and repairs throughout the life of the SEB offset program.

Activities

To meet this objective, Hillgrove proposes to:

- Survey land parcels to establish the most cost-effective means of installing rabbit proof fences to contain and protect designated SEB-offset patches
- Seek quotes for fence installation and reserve budgets for capital programs
- Engage contractors to complete fencing ahead of land preparation
- Regularly inspect and maintain fences throughout the life of the SEB Offset program

5.2.5 Purchase of specialist equipment and/or engagement of Contractors

Objectives

When SEB-offset plans for the LOM extension have been approved, ensure that planned SEB-offset programs are appropriately resourced through internal budget allocations and executed either through direct employment of staff and purchase of specialist equipment or through engagement of appropriately skilled and equipped contractors or other groups.

Discussion

The delivery of SEB-offset on former farming and grazing land requires specialist skill sets and equipment to be achieved successfully and cost effectively. The details of this are discussed in sections 5.2.10 to 5.2.14 below.

Activities

To meet this objective, Hillgrove proposes to:

- Discuss proposed SEB-offset patches and intended outcomes with our current contractor group and other specialist groups
- Seek quotes for the delivery of SEB-offsets on designated areas from our current contractors and other specialist groups (which could include the Kanmantoo/Callington Landcare Group, Goolwa to Wellington LAP, State Flora etc.)
- Review quotes and perform a cost-benefit analysis to determine if offset is best delivered in-house, or through external agents
- Engage staff and acquire equipment, or engage contractors or other specialist groups

5.2.6 Commence weed control and feral animal control programs within designated SEB-offset areas prior to planting and through the establishment phase

Objectives

Control feral animal populations within fenced SEB-offset areas prior to the commencement of planting operations. Maintain population control through ongoing feral animal control programs during the life of the SEB-offset program.

Control pest plants within designated SEB-offset areas. Begin weed population reduction prior to SEB-offset planting and continue weed control throughout the establishment phase.

Discussion

Significant populations of rabbits, hares cats and foxes currently occupy farming land around the Kanmantoo ML and within the Kanmantoo ML. Ongoing baiting programs within the ML have proven to be successful in reducing feral animal numbers for a short time, however the populations are resilient and we suspect that they are replenished by influx from surrounding areas when numbers are reduced within the ML.

Direct seeded rehabilitation areas within the ML have proven to be successful in terms of seedling germination and plant establishment; however they are prone to grazing by rabbits, particularly in drier months when seedlings offer a source of green feed at a time when introduced annual plants have senesced. This can slow the accumulation of biomass in rehabilitation areas and promote seed loss and slower recruitment as rehabilitation plants mature.

The commencement of feral animal control programs prior to planting within designated SEB-offset areas will act to significantly reduce damage to rehabilitation plantings during the establishment phase. When coupled with rabbit proof fencing, sustained feral animal control within protected areas will reduce grazing pressure to acceptable levels and will significantly assist the establishment and development of SEB-offset plantings.

Weed control within former cropping land is essential for the successful establishment of SEB-offset vegetation and will need to be carefully managed throughout the life of the offset program. A number of weed control strategies can be used and these will necessarily vary depending on the planting situation, the composition of the intended foundation seed mix and the ongoing program aims for each offset patch. Weed control programs will capitalize on herbicide selectivity for different species at differing developmental stages or physical treatments, such as pre cultivation burning or topsoil removal where this is warranted.

Typically, preparation of planting areas through the use of systemic herbicide sprays on fallowed areas as summer weed control can be followed by cultivation, pre-sowing herbicide application, post sowing-pre-emergent selective herbicide application and selective post emergent herbicide application. If a foundation seed mix containing perennial C3 and C4 native grasses is used to initially colonise farming land, contact desiccants can be used to control annual weeds and reduce vigour in perennial weeds. Once the foundation seed mix achieves canopy closure, selective herbicides and spot-spray programs can be used to further reduce weed numbers or create planting nodes for direct seeding and/or tube plantings

Activities

To meet this objective, Hillgrove proposes to:

- Commence feral animal control programs within designated SEB-offset areas as soon as possible and maintain feral animal control programs within SEB-offset patches throughout the life of the program
- Commence pre-sowing control of crop and pasture weeds and other pest plants as soon as possible. Maintain selective control programs post-planting and throughout the establishment phase

5.2.7 Investigative studies to quantify the parameters for successful revegetation on specific SEB-offset patches

Objectives

Conduct a range of detailed site-specific studies to define and understand the significance of parameters which may have a direct impact on the establishment and success of SEB-offset vegetation in particular offset patches.

Use Landscape Function Analysis and vegetation surveys on assigned offset patches prior to the commencement of on-ground works to define the benchmark state of each patch as a means of objectively assessing progress towards required offset outcomes.

Apply the outcomes of investigative studies to pre-sowing land preparation, foundation seed mix compositions, planting methodologies, post sowing management and follow-up maintenance programs for specific SEB-offset patches.

Discussion

Small-scale variations in soil characteristics, weed flora composition, site aspect, site terrain, land-use history and location can have a significant impact on the ultimate success of offset-patch establishment. Understanding the viability of available native seed lots can have a significant influence on the best seed mix composition and sowing rates for offset patch establishment.

Similarly, understanding the best propagation and planting methods for recalcitrant species (for example *L. effusa*) is essential to ensure that species diversity can be delivered successfully and by the most cost-effective means.

Understanding the benchmark state of each offset patch prior to the commencement of ground works provides a basis for the objective assessment of progress towards the establishment of intended plant communities on each offset patch.

To define these parameters for each assigned offset area, a range of investigative studies will need to be completed for each patch and their allocated seed lots prior to land preparation (see below).

Activities

To meet this objective, Hillgrove proposes to carry out a range of site-specific investigative studies prior to land preparation and planting. These studies *may include, but will not be limited to* the following subject areas:

- Detailed site survey, mapping and planting niche identification for target plant communities
- Survey and mapping of weed populations and the location of any remnant native species
- Soil surveys and lab tests to define and map the physical characteristics, soil types profiles and nutrition status of soils in each offset patch
- Soil tests to establish freedom from critical soil pathogens which could cause offset patch failure, for example Phytophthora cinnamomi (or Dieback)
- Studies to determine the identity of weed seeds, their density and distribution through the soil profile
- Test patches to evaluate the efficacy of varying depths of topsoil removal to assist with weed seed bank depletion, detrimental nutrient removal (e.g., phosphate) and the establishment of direct-seeded patches
- Test patches to evaluate the direct seeding techniques best suited to assigned patches
- Specific studies through an alliance with the Adelaide Botanic Gardens Seed Conservation Centre (SCC), focussing in particular on the viability of foundation seed mix species and the relationship of this to optimal direct seeding rates for the establishment of representative offset vegetation communities
- Specific studies through the SCC to determine the best propagation, planting and establishment methods for recalcitrant species. For example continue investigating *Lomandra effusa* propagation, seed viability studies etc.

- Continue liaison with other mine sites to adapt successful niche-specific mine-site rehabilitation systems to Kanmantoo's SEB-offset and Rehabilitation program
- Surveying feral animal populations and rabbit warren distributions within each patch to tailor-make effective control programs
- Conducting Landscape Function Analysis (LFA) and vegetation surveys on each patch prior to the commencement of on-ground works. Survey temporary transect sites with a view to permanently establishing LFA transects following initial planting operations.
- Incorporating of site-specific knowledge into SEB Offset programs
- Conducting other studies as required, for example to determine optimal selective weed control, both pre and post planting for any previously unknown weed species located during site specific surveys
- *Where investigative studies identify a critical problem with an individual offset patch (for example, presence of Phytophthora cinnamomi), a suitable alternate offset patch will need to be located as near as practical to the ML. Appropriate investigative studies will need to be repeated on the alternate offset patch as required*

5.2.8 & 9 Commencement of vegetation enhancement programs for remnant native vegetation located during detailed site studies and adjustment of offset patch boundaries where necessary

Objectives

Delineate, protect and enhance any native vegetation remnants identified during detailed site studies. Incorporate any remnant native vegetation into the establishment of appropriate SEB offset patches

Discussion

The long-term selective pressures applied by cropping and grazing have degraded native plant populations within properties adjacent to the ML and in the surrounding region to a point where native species are either absent, or sparsely distributed. This is particularly so for cropping land where successive years of cultivation, the application of phosphate fertilizers, agricultural chemicals and inter-crop grazing have all but removed any remnant native species from seed banks.

This situation is similar on higher, rocky non-arable land where grazing by sheep and feral ruminants has progressively modified the flora to the detriment of native species. However, there may be a slow, currently indeterminate recovery of native flora through recruitment due to the germination of hard-seeded species and their subsequent survival in the absence of grazing pressure (for example, members of the Fabaceae, Sapindaceae and others).

It highly likely that irregular native seed germinations have occurred in the past during ideal conditions, but this process has been masked by grazing losses. Once areas of land have been earmarked for SEB offset establishment and external selective pressures have been removed, it is likely that areas of remnant native vegetation will be expressed.

Activities

- Survey allocated SEB offset areas and map any currently visible remnant native vegetation
- Incorporate vegetation remnants into appropriate SEB offset areas where appropriate
- Enhance identified native vegetation patches through ongoing weed suppression, direct seeding and infill plantings with specific tube stock lines to match known vegetation community compositions
- Continue to survey allocated areas for the expression of native vegetation remnants in future years. Map remnants, incorporate them into SEB offsets where possible and adjust offset-patch boundaries where necessary

5.2.10 Build up seed reserves and order specific seed supplies or tube stock to meet planting schedules

Objectives

Ensure that adequate seed supplies and tube stock are available for scheduled offset patch planting and replanting programs at the various stages of patch establishment. Ensure that only species represented in ML floristic communities are included in planting programs. Ensure that local provenance seed and tube stock sources are used wherever possible. If supplies of local species are needed and can't be obtained from local sources, ensure they are acquired from sources as near as practical to the ML in the first instance or from other sources within the same climatic conditions as a last resort.

Discussion

It is expected that the majority of seed required for successful offset patch establishment will be available through annual wild seed collection campaigns conducted both within the ML and in the near-mine region. Past collection programs have yielded significant quantities of seed from a wide range of local species and over 390kg of seed is currently in store at the EBS seed storage facility. Further seed lines collected during 2013/14 are yet to be processed and weighed. It is understood that wild seed collection programs can be (and have been) very successful in good seasonal conditions, but they can fall short of requirements where winter rainfall is inadequate.

The ML's Seed Production Area is a 1 ha irrigated intensive seed production facility populated with local native species and planted with local provenance seed sources (see Plate 1). It has been established to provide a predictable quantity of key species efficiently and independently of seasonal conditions. Following an initial establishment period, the SPA is beginning to produce commercial quantities of seed. For example, our first harvest of seed *Austrodanthonia* yielded over 98kg.

Early seed yields form the SPA, together with wild-seed collections have been used to establish a large-scale seed multiplication area (SMA) on a plot of former cropping land directly adjacent to the ML (see Plate 2). The SMA was planted in mid-2013 and contains plots of Austrodanthonia, Austrostipa, Chloris, Themeda and Vittadinia. Plot sizes vary from 0.25ha to nearly 1.0ha each. It is anticipated that our first seed yields will be obtained in spring 2014, with seed being incorporated into SEB offset establishment programs shortly afterwards.

Where seed-derived establishment of particular native species within an offset plot is not possible by direct seeding, it will be necessary to propagate tube stock via reputable specialist nurseries (e.g., State Flora at Murray Bridge, or Provenance Indigenous Plants at Hendon SA etc.). Appropriate tube stock supplies will be sourced as required to meet ongoing planting and replanting schedules throughout the offset patch establishment program. Where possible, tube stock will be grown from seed derived through annual wild seed collection campaigns.

Activities

- Continue to conduct seasonal wild-seed collection programs on the ML, in the vicinity of the ML and near ML region, focussing on the quantities and range local native species required for SEB offset patch establishment programs
- Continue to propagate local provenance seed supplies through management of the ML's Seed Production Area (SPA – see Plate 1) and large-scale Seed Multiplication Area (SMA – see Plate 2).
- Purchase supplementary seed supplies from local suppliers if necessary.
- Order and purchase tube stock supplies

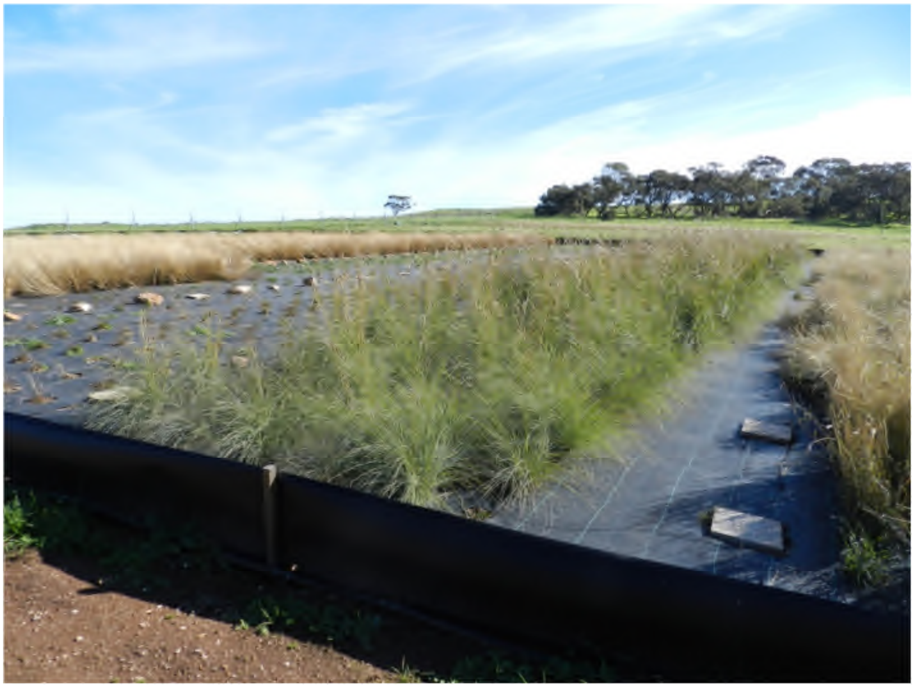


Plate 1. Seed Production Area highlighting diversity grass seed plots

Plate 2. Seed Multiplication Area established on former cropping land adjacent to the ML

5.2.11 Land Preparation

Objectives

Schedule and conduct land preparation activities to meet offset-patch establishment programs. Carry out pre-sowing and pre-planting weed reduction programs to reduce both the levels of weed competition in newly established plantings and subsequent weed contamination in mature offset vegetation patches. Carry out on-ground works necessary to prevent soil erosion during patch establishment or ameliorate current erosion features in patch areas where possible before planting. Cary out any cultivation or soil amelioration activities necessary for patch establishment prior to sowing.

Discussion

Inadequate land preparation will lead to offset patch failure, with weed competition being the greatest single risk to establishment success. Extensive soil seed banks have accumulated through decades of agricultural activity and a diverse range of weed species can be found on most land in the Kanmantoo area, including wild oats, brome grass, barley grass, wire weed, wild turnip, blackberry nightshade, horehound, Chenopodium, and salvation jane, to mention a few.

It is expected that the range of investigative studies discussed in point 5.2.7 (above) will provide the data necessary to define and program the necessary range of land preparation operations on a patch by patch basis. Pre-planting land preparation will be necessarily tailored to meet the specific needs of each offset patch and will vary dependant on previous site or cropping history, soil type, terrain and the intended end result for that patch.

For example, controlled burning, followed by a program of selective and non-selective herbicide applications will be necessary on higher rocky land with a history of grazing by sheep. Mechanical cultivation or direct seeding in these areas would is either impossible due to steep slopes and outcropping rock, or imprudent due to erosion risk. Where niche plantings are planned on rocky ground, small areas can be hand prepared, followed by a herbicide program prior to hand sowing or seed or planting tube stock. Ongoing weed control will be required to aid establishment.

Conversely, land preparation on former cropping land may involve the phased stripping of topsoil down to a carefully controlled depth with a wheel tractor-scraper, with the depth of topsoil removal determined by the seed bank studies cited in 5.2.7 (above). This practice acts to physically remove the soil weed-seed bank and accumulated phosphate fertilisers and some residual herbicides (e.g. metsulfuron-methyl), leaving prepared areas better able to support direct-seeding to a foundation seed mix (see 5.2.12, below). Topsoil removal was advocated during the 2012 Grassy Woodlands Establishment Forum, hosted by the City of Salisbury and has been subsequently used to successfully establish foundation seed mixes within the ML rehab area and on the former cropping land adjacent to the ML used to establish the SMA.

Topsoil removal is essentially the same process as that is used by conventional direct-seeders, where an offset disk scrapes away a layer of topsoil and seeds are sown onto exposed subsoil – only this is carried out on a much larger scale. Care will be taken to strip alternate bands of topsoil in scraper-width rows, leaving intermediate areas untouched to act as erosion protection and dust prevention. The intermediate areas will be managed with a program of mowing, knockdown and selective herbicides before being stripped in a later season when initial direct sown areas have commenced establishment.

Land preparation may also involve the application of specific soil ameliorants as highlighted by the results of patch-specific investigative studies outlined above. For example, where the soil is shown to be sodic or dispersive, dressings of gypsum may be warranted to displace sodium, reduce soil dispersion and erosion and increase water infiltration. Other soil ameliorants will be applied as indicated by investigative studies.

Further soil pre-conditioning of former cropping land will be required following pre-stripping and immediately prior to planting. This may include ripping where warranted or cultivation as required. For example, seed bed preparation for direct seeding of pre-stripped land has been successfully carried out on the ML by EBS using a modified turf soil conditioner, which cultivates only the top 25mm of the soil surface immediately prior to direct seeding.

It is important to note that the examples provided above are not represent and exhaustive list of land preparation methodologies which can or will be used during the offset establishment program.

Activities

- Carry out land preparation operations tailored by investigative studies to establish specific offset patches on specific land areas
- Apply specific soil ameliorants to address issues identified in the investigative studies
- Prepare seed beds or planting sites ahead of planting programs as required

5.2.12 Planting Programs

Objectives

Schedule planting programs in accordance with seed and tube stock availability to meet land preparation, seasonal deadlines and SEB offset patch requirements. Tailor offset patch species lists and/or seed mixes to deliver the required floristic species range and planting densities necessary to successfully establish the required SEB offsets for the LOM extension. Use planting methods which are best suited to the terrain being sown and the vegetation type being established. Involve the local community, local groups and local contractors wherever possible to ensure benefit to our community and increase both interest in the SEB offset program and ownership by our communities.

Discussion

It cannot be overstressed that land preparation and forward planning are the keys to successful SEB offset area establishment. Pre-sowing land preparation for specific offset patches will be scheduled in accordance with seed and tube stock availability. Correspondingly, seed multiplication, collection and tube stock propagation programs will need to be planned to meet proposed planting schedules. The commencement of planting on specific offset patches will be governed by the time that successful land preparation is achieved and planting material is available during ‘Year 1’ for each SEB offset patch as outlined by the program presented in Table 4 (above). Planting will generally be commenced after opening rains in late April to late May and should conclude by late June. However, planting too late in the season or during adverse seasonal conditions will lead to poor success and the waste of limited seed resources; as such planting times may also be determined and varied by seasonal factors.

The specific species lists used to establish particular plant communities and conditions in all SEB offset patches will be governed by;

1) The EPBC Condition Class of the vegetation patch disturbed by clearance associated with the LOM extension
2) The species range observed within the disturbed vegetation patch during the 2007 EA survey and the subsequent 2013 EBS survey
3) The species densities described by LFA surveys conducted within the ML since 2011

As a general principle, direct seeding of appropriately prepared sites with a suitable ‘Foundation Seed Mix’ containing a tailor-made range of understorey coloniser species will be preferred to other planting methods on former cropping land. Typically, this mix will include Austrodanthonia, Austrostipa, Themeda, Enneapogon, Chloris and a range of other herbaceous and shrub species representative of the floristic community being established. The aim of this phase is to provide competitive pressure for remnant weed species through colonisation with a dense stand of appropriate native species and to allow a degree of understorey development prior to planting appropriate mid and canopy-level species.

Establishment of the foundation seed mix may be followed by a combination of direct-seeded and tube-stock plantings to introduce mid-level and canopy species in *E. odorata* and *A. pycnantha* woodlands, while direct seeding and tube stock planting may be used to introduce diversity into *L. effusa* grasslands. In all cases, the most appropriate planting methods will be varied to meet the needs of individual patches and the end result to be achieved.

Where essential species are difficult to propagate or are known to establish poorly (for example *L. effusa*), the results gained through specific investigative studies (e.g. the Botanic Gardens Alliance) will be used to solve propagation issues and implement appropriate large-scale propagation programs. This may be carried out by specialized providers (e.g. State Flora – Murray Bridge) and will be geared to provide sufficient planting material to meet program needs.

For example, Alcoa's Huntley operation in WA achieves near 100% species return to areas of rehabilitation in wet-sclerophyll forest through a combination of direct seeding and niche plantings of recalcitrant species propagated as a result of tissue-culture and other seed research conducted in liaison with Kings Park Botanic Gardens in WA. Tissue cultured plants are established through specialized planting and post-planting protection regimes for particular species (i.e. *Lomandra*). We expect that a similar alliance with the Adelaide Botanic Gardens SCC will greatly assist the overall quality and success of planting programs at the KCM.

Similarly, the reintroduction of rescued *Diuris behrii* following propagation by NOSSA will allow specific niche patches of *Diuris* to be reintroduced within *E. odorata* offset patches throughout the offset program. Of the 100 rescued *Diuris* plants, there are now more than 300 in the NOSSA nursery. This is expected to continue through successive daughter generations and will provide a continued stream of planting material of local provenance (see Plate 7, below).

There will be considerable scope for involvement of local community groups and service providers in offset patch planting programs throughout the life of the SEB offset program. This may take the form of planting days where school groups assist with tube stock plating into swards of established foundation species, funded planting campaigns assisted by volunteers from the local Kanmantoo Callington Landcare Group, through to funded planting programs by other providers (for example, possibly the Goolwa to Wellington LAP), where works are carried out either on designated offset patches or if the need arises, other Government approved near-mine areas.

Activities

- Integrate planting program timing with land preparation activities, seasonal windows of opportunity and the availability of appropriate seed reserves and tube stock
- Apply appropriate planting methodologies to individual offset patches in accordance with the vegetation community being established, past history of the patch and the land class available
- Engage in alliances to conduct research on the propagation and establishment of key recalcitrant species which prove to be unsuitable candidates for normal direct seeding or tube stock planting programs
- Engage appropriate expert assistance with large-scale propagation of recalcitrant species (for example State Flora – Murray Bridge & NOSSA)
- Engage the local community and community groups in offset patch planting programs
- Engage other specialist providers to provide planting program services where warranted
- *Directly fund Government approved offset patch establishment by 3rd party providers on other suitable near-mine areas, should offset patch establishment on allocated areas prove to be impractical or financially prohibitive*

5.2.13 Assess results and adjust methods

Objectives

Regularly objectively assess the establishment and development of offset patches against known patch analogues by recognised means. Continue with establishment methodologies where they are proven to be successful and adjust processes where they are proven to be inappropriate.

Discussion

The condition and functionality of native vegetation patches within the ML have been regularly assessed through a combination of both Landscape Function Analysis (LFA) transects in key vegetation patches and vegetation surveys conducted by EBS-Ecology over the past 3-years (Tongway and Hindley 2004), (EBS, 2013). We now have good volume of data to support the progressive improvement of remanent patch condition within the ML since 2011. This data also allows us to define the LFA characteristics of key vegetation communities and their respective SEB condition scores, with a view to providing analogue benchmarks for the structured assessment of SEB offset patch establishment on assigned areas.

The progress of SEB offset patch establishment will be objectively monitored against the characteristics exhibited by established analogue communities within the ML. This will be achieved by establishing and assessing a series of permanent LFA transects in each offset patch shortly after the first phase of planting is completed and regularly reassessing each patch during spring in subsequent years.

Where objective data proves the progression of offset patch condition and composition towards their intended outcome, management and planting programs will be continued. Where the data shows that poor progress is being made, supplementary actions will be scheduled to correct deficiencies (for example, improved weed control, different planting methods, additional planting programs or the application of supplementary soil ameliorants).

In extreme cases, patch failure may require reestablishment at an alternate approved site in the near-mine region. This would only be considered as a last resort if all other corrective measures have been exhausted, or a suitable alternate site offers a higher probability of success with fewer interventions.

Activities

- Continue LFA and vegetation surveys within key vegetation communities on the ML
- Establish permanent LFA transects in each offset patch over pre-planting transect sites
- Conduct regular LFA and vegetation surveys to objectively monitor development progress in each offset patch
- Continue and replicate patch establishment methodologies where LFA data shows promise
- Discontinue establishment methodologies where LFA data demonstrates poor progress
- Modify methods and address patch deficiencies where warranted
- In extreme cases, identify alternate offset patches near the ML, seek Government approval and re-establish offsets on alternate sites

5.2.14 Replanting and Amendment Programs

Objectives

Monitor and address poor offset patch establishment through appropriate replant programs. Identify and address plant losses caused by adverse seasonal events as required.

Discussion

Poor planting program success can be caused by inappropriate land preparation, poor timing of planting operations, poor seed viability, poor tube stock quality, inappropriate planting methods, inappropriate planting locations for specific species, inadequate follow-up maintenance or adverse seasonal events (to mention a few).

In order for intended SEB offset outcomes to be achieved, adverse establishment results identified through regular objective monitoring must be addressed through a schedule of amendment works. These may range from the complete re-work and replanting of failed SEB plantings, through to replacement of individual tube-stock plants as required.

Activities

- Evaluate routine site monitoring data to identify and schedule appropriate improvements
- Organise the propagation or collection of appropriate replacement planting material
- Carry out site preparation works as required
- Schedule planting, replanting or site replacement programs as required

5.2.15 Establishment of Heritage Agreements

Objectives

Protect successful SEB offset areas from future disturbance through the establishment of recognised Heritage Agreements defined as follows:

> "A Heritage Agreement is a private conservation area, established in perpetuity through an agreement (contract) between the landholder and the Minister for Sustainability, Environment and Conservation"

Discussion

Considerable investment will be required by Hillgrove Resources over many years to establish appropriately functioning SEB Offset vegetation communities on land currently owned by Hillgrove and assigned for this process. Once SEB Offsets have been demonstrated to be functioning as intended in a floristic and ecological sense, the land areas will need to be protected from future disturbance. It is conceivable that areas planted to SEB offsets could be sold at some point in the future and land use under a new owner cannot be guaranteed.

Heritage Agreements will prevent this by providing perpetual protection for SEB offset patches. The Heritage Agreement contract specifies that the indigenous plants and animals in the Agreement area are to be protected from the time the agreement is made. Heritage Agreements are binding on future landholders and are ongoing, i.e. perpetual.

It is understood by Hillgrove that entering into Heritage Agreement contracts for specific offset patches will have the potential to significantly alter the value of assigned allotments in the event of a future sale and may considerably restrict both future land use and the sale price which can be realized.

Activities

- Use the results of objective monitoring to determine when an SEB offset area is approaching its intended floristic composition and ecological function
- Enter into Heritage Agreements for assigned offset patches to prevent future disturbance and degradation

5.3 Additional Illustrations

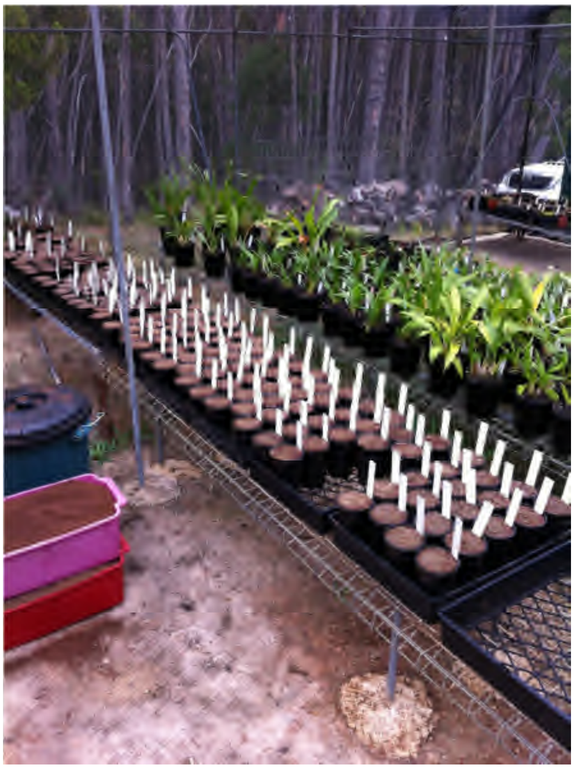
Plate 3. 8:1 *E. odorata* protected from disturbance by amendments to the LOM extension plan, Northern–end Patch 10

Plate 4. 4:1 *E. odorata* – woodland enhancement, Patch 2, NW corner of ML

Plate 5. Revegetating disturbed areas within the ML, Gate 1 near Patch 29

Plate 6. Landcare Volunteers, COOE and EBS staff assisting with Plant Rescue in PEPR-approved Disturbance Area of Patch 10 (November 2011)

Plate 7. Diuris behrii Daughter-tubers (foreground) under Propagation in the Native Orchid Society of SA's Shadehouse near Mt George SA



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Attachment A

Initial SEB assessment guidelines

Vegetation Condition	Indicators for Condition	SEB Ratio
Poor. Weed-dominated with only scattered areas or patches of native vegetation	Vegetation structure no longer intact (e.g., removal of one or more vegetation strata).	2:1
	Scope for regeneration, but not to a state approaching good condition without intensive management.	
	Dominated by very aggressive weeds.	
	Partial or extensive clearing (greater than 50% of area).	
	Evidence of heavy grazing (tracks, browse lines, species changes, no evidence of solid surface crust).	
Moderate. Native vegetation with considerable disturbance	Vegetation structure substantially altered (e.g., one or more vegetation strata depleted).	4:1
	Retains basic vegetation structure or the ability to regenerate it.	
	Very obvious signs of long-term or severe disturbance.	
	Weed dominated with some very aggressive weeds.	
	Partial clearing (10 to 50% of area).	
	Evidence of moderate grazing (tracks, browse lines, soil surface crust extensively broken).	
Good. Native vegetation with some disturbance	Vegetation structure altered.	6:1
	Most seed sources available to regenerate original structure.	
	Obvious signs of disturbance.	
	Minor clearing (less than 10 % of area).	
	Considerable weed infestation with some aggressive weeds.	
	Evidence of some grazing (tracks, soil surface crust patchy).	
Very good. Native vegetation with little disturbance	Vegetation structure intact (e.g., all structure intact).	8:1
	Disturbance minor, only affecting individual species.	
	Only non-aggressive weeds present.	
	Some litter build-up.	
Intact vegetation	All strata intact and botanical composition close to original.	10:1
	Little or no signs of disturbance.	
	Little or no weed infestation.	
	Soil surface crust intact.	
	Substantial litter cover.	

Source: Table 1 of DWLBC (2005).

Attachment B

2013 EBS Vegetation Survey of Peppermint Box and Irongrass Communities at Kanmantoo Copper Mines

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Friday, 30 May 2014

Re: Vegetation Survey of Peppermint Box and Irongrass communities at Kanmantoo Copper Mine

Dear Andy,

Coffey Environments Australia Pty. Ltd. engaged EBS Ecology to undertake an assessment of the Peppermint Box Woodland and Irongrass Tussock Grassland communities mapped within the Hillgrove Resources Kanmantoo mining lease. Primarily this was to determine whether these remnant patches meet the criteria of the nationally threatened ecological communities (TEC), set out in the DEWHA document 'EPBC Act Policy Statement 3.7 Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia and Iron-grass Natural Temperate Grassland of South Australia' (2007). A particular focus was placed on the relevant communities located within the proposed Life of Mine (LOM) disturbance increase area and these were assessed against the policy statement criteria.

Methodology

Field Survey

The field survey was undertaken by EBS Ecology staff on the 25th June, 2013.

Floristic Mapping

Previous floristic mapping was provided prior to the survey. The vegetation associations and boundaries were checked and corrected where necessary.

Extent of communities

The extent of *Lomandra* grassland patches and Peppermint Box Woodland were recorded using hand held Garmin GPS (Accuracy +/- 15m) units which are carried around the extent of the communities present. The track log was saved with the relevant patch number and entered into Arc GIS software to enable the total area to be calculated.

Species diversity

Species diversity totals were obtained from a 50 x 50m quadrat for each representative area. All species observed within the quadrats were recorded with totals compared against benchmark criteria outlined in the *Commonwealth Listing Advice on Iron-grass Natural Temperate Grassland of South* Australia (Table 1) (TSSC 2007) and the Commonwealth Listing Advice on Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia (Table 1) (TSSC 2007).

Table 1. Condition classes for Iron-Grass Natural Temperate Grassland of South Australia.

Condition Class	Minimum Size	Diversity of Native Species[1]	No. of Broad-leaved Herbaceous Species[1] in addition to identified disturbance resistant species[2]	No. of Perennial Grass Species[1]	Tussock Count[3]
Listed ecological community					
A	0.1 ha	> 30	+10	≥5	1/m
B	0.25 ha	> 15	+3	>4	1/m
Degraded patches amenable to rehabilitation					
C		> 5	No minimum	≥1	No minimum

[1] As measured in a 50m X 50m quadrat;

[2] The following species are identified as disturbance resistant species: *Ptilotus spathulatus* forma *spathulatus; Sida corrugata; Oxalis perennans; Convolvulus erubescens; Euphorbia drummondii;* and, *Maireana enchylaenoides;* and,

[3] As measured along a 50m transect.

Table 2. Condition classes for Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia.

Condition Class	Minimum Size	Diversity of Native Species[1]	No. of Broad-leaved Herbaceous Species[1] in addition to identified disturbance resistant species[2]	No. of Perennial Grass Species[1]
Listed ecological community				
A	0.1 ha	> 30	+10	≥5
B	1 ha	> 15	+3	≥2
Degraded patches amenable to rehabilitation				
C		> 5	No minimum	≥1

[1] As measured in a 50m X 50m quadrat;

[2] The following species are identified as disturbance resistant species: *Ptilotus spathulatus* forma *spathulatus; Sida corrugata; Oxalis perennans; Convolvulus erubescens; Euphorbia drummondii;* and, *Maireana enchylaenoides*

Tussock Density

Tussock density was calculated by using a 50m transect through the centre of the 50m x 50m quadrat. This is used to quickly and accurately establish whether the density of tussocks meets the minimum criteria for the TEC which is 1/m^2. Tussocks bases or aerial parts of the plants need to be intersected by the tape to be recorded.

Survey Limitations

The survey was undertaken at a time of year which did not allow for the highest potential species diversity, which coincides with the emergence of annual herbaceous species and bulbous species from families such as Liliaceae (*Bulbine bulbosa, Wurmbea dioica,* and *Arthropodium* spp.), Stackhousiaceae (*Stackhousia monogyna*) and Orchidaceae.

Results

Thirteen sites were assessed in the Peppermint Box (*Eucalyptus odorata*) Woodland remnants across the mine site, whilst four sites were assessed in the Irongrass (*Lomandra* spp.) Grassland remnants. Seven Peppermint Box (*Eucalyptus odorata*) Woodland sites qualified as the TEC condition class B, whilst four qualified as condition class C which are regarded as degraded patches amenable to rehabilitation. Of the four Irongrass (*Lomandra* spp.) Grassland sites assessed, two qualified as the TEC condition class B, and r two qualified as condition class C which are regarded as degraded patches amenable to rehabilitation. Table 3 shows the species recorded for each of the sites. Table 4 and 5 displays the results of the assessment against the EPBC listing criteria for each site. Figure 1 shows locations of each site and condition rating assigned as assessed against the EPBC listing criteria. In addition, the mapping also displays the amendments to the vegetation mapping across the mine site.

Table 2. Species lists for Peppermint Box (*Eucalyptus odorata*) Woodland sites and Irongrass (*Lomandra* spp.) Grassland sites.

TYPE	Scientific Name	Common Name	Comm. Status	SA Status	OD1	OD2	OD3	OD4	OD5	OD6	OD7	OD8	OD9	OD10	OD11	OD12	OD13	LOM1	LOM2	LOM3	LOM4
G	*Lomandra effusa*	Scented Mat-rush			✓	✓		✓	✓			✓						✓	✓	✓	✓
H	*Enchylaena tomentosa var.*	Ruby Saltbush			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		
	Acacia pycnantha	Golden Wattle			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓				✓	✓	
G	*Austrostipa scabra ssp. scabra*	Rough Spear-grass			✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
G	*Austrostipa sp. 2*	Spear-grass												✓	✓				✓		
G	*Austrostipa sp. 3*	Spear-grass							✓		✓						✓	✓			
H	*Vittadinia cuneata var. cuneata f. cuneata*	Fuzzy New Holland Daisy			✓	✓	✓	✓	✓	✓				✓				✓	✓		✓
H	*Maireana enchylaenoides*	Wingless Fissure-plant			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓			
H	*Liliaceae sp.*	Lily Family			✓	✓	✓	✓	✓	✓				✓							✓
G	*Austrodanthonia setacea*	Small-flower Wallaby-grass			✓	✓	✓	✓	✓	✓											
G	*Austrodanthonia caespitosa*	Common Wallaby-grass												✓				✓	✓		✓
G	*Austrodanthonia sp.*	Wallaby-grass									✓										
G	*Elymus scaber var. scaber*	Native Wheat-grass			✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		
H	*Oxalis perennans*	Native Sorrel			✓	✓												✓	✓	✓	✓
H	*Gonocarpus tetragynus*	Small-leaf Raspwort			✓	✓	✓		✓	✓				✓					✓		✓
H	*Thysanotus patersonii*	Twining Fringe-lily			✓	✓	✓			✓				✓					✓		
H	*Einadia nutans ssp.*	Climbing Saltbush			✓		✓		✓	✓	✓	✓	✓								
H	*Senecio spanomerus*				✓	✓	✓		✓	✓		✓									✓
	Atriplex semibaccata	Berry Saltbush									✓	✓									
	Allocasuarina verticillata	Drooping Sheoak			✓	✓			✓					✓	✓						
H	*Cheilanthes austrotenuifolia*	Annual Rock-fern				✓	✓			✓		✓		✓					✓		✓
H	*Dianella revoluta var. revoluta*	Black-anther Flax-lily				✓													✓		
	Senecio quadridentatus	Cotton Groundsel					✓														
	Eutaxia microphylla	Common Eutaxia				✓	✓		✓	✓				✓							✓
H	*Dichondra repens*	Kidney Weed					✓	✓		✓											
H	*Plantago drummondii*	Dark Plantain					✓											✓			

TYPE	Scientific Name	Common Name	Comm. Status	SA Status	OD1	OD2	OD3	OD4	OD5	OD6	OD7	OD8	OD9	OD10	OD11	OD12	OD13	LOM1	LOM2	LOM3	LOM4
	Acacia microcarpa	Manna Wattle					✓			✓	✓										
H	*Vittadinia blackii*	Narrow-leaf New Holland Daisy					✓		✓									✓			
H	*Chenopodium desertorum* ssp.	Desert Goosefoot							✓		✓							✓			
	Maireana brevifolia	Short-leaf Bluebush							✓		✓	✓				✓					
	Rhagodia candolleana ssp. *candolleana*	Sea-berry Saltbush																			
H	*Lepidosperma viscidum*	Sticky Sword-sedge								✓				✓							
	Pittosporum angustifolium	Native Apricot							✓												
G	*Lomandra multiflora* ssp. *dura*	Hard Mat-rush							✓	✓		✓		✓					✓		
G	*Lomandra densiflora*	Soft Tussock Mat-rush								✓				✓					✓		
G	*Lomandra micrantha* ssp. *micrantha*	Small-flower Mat-rush																			
H	*Goodenia robusta*	Woolly Goodenia							✓										✓		
G	*Austrostipa elegantissima*	Feather Spear-grass								✓											
H	*Burchardia umbellata*	Milkmaids								✓											
H	*Goodenia pinnatifida*	Cut-leaf Goodenia								✓									✓		
H	*Prasophyllum* sp.	Leek-orchid																			
H	*Lagenophora* sp.	Bottle-daisy								✓											
H	*Compositae* sp.	Daisy Family								✓											
G	*Austrodanthonia* sp.																				
H	*Wahlenbergia stricta* ssp. *stricta*	Tall Bluebell										✓	✓					✓			✓
	Dodonaea viscosa ssp. *spatulata*	Sticky Hop-bush										✓		✓					✓		
H	*Calostemma purpureum*	Pink Garland-lily								✓		✓									
	Cryptandra amara var.	Cryptandra												✓					✓		
H	*Erodium* sp.	Heron's-bill/Crowfoot																✓			✓
H	*Acaena echinata*	Sheep's Burr																	✓	✓	✓
G	*Themeda triandra*	Kangaroo Grass																	✓		✓
	Pomaderris paniculosa ssp.																		✓		✓
H	*Haloragis aspera*	Rough Raspwort																	✓		

TYPE	Scientific Name	Common Name	Comm. Status	SA Status	OD1	OD2	OD3	OD4	OD5	OD6	OD7	OD8	OD9	OD10	OD11	OD12	OD13	LOM1	LOM2	LOM3	LOM4
G	*Amphipogon strictus*	Spreading Grey-beard Grass																	✓		✓
	Scaevola aemula	Fairy Fanflower																	✓		
	Bursaria spinosa ssp.	Bursaria																	✓		
H	*Asperula sp.*	Woodruff																	✓		
G	*Enneapogon nigricans*	Black-head Grass																			✓
H	*Diuris behrii*	Behr's Cowslip Orchid		V	✓					✓											
H	*Ptilotus erubescens*	Hairy-tails		R			✓														
H	*Stackhousia monogyna*	Creamy Candles			✓																
H	*Wurmbea dioica* ssp.				✓																
H	*Arthropodium strictum*	Common Vanilla-lily			✓							✓									
H	*Cynoglossum suaveolens*	Sweet Hound's-tongue			✓					✓											
H	*Ptilotus spathulatus*	Pussy-tails						✓													

Vegetation type, G = Grass, H = Broadleaf Herbaceous species (count excludes disturbance resistance species listed in Tables 1 & 2.)

Table 3. EPBC assessment against the criteria results.

Peppermint Box sites								
Site	**Easting**	**Northing**	**Size**	**Native species**	**Herbaceous species additional to disturbance resistant**	**Grass species**	**TEC? (ABC)**	**Patch**
A			**0.1ha**	**>30**	**10**	**≥5**		
B			**1ha**	**>15**	**3**	**≥2**		
C				**>5**	**no minimum**	**≥1**		
OD1	318098	6115279	17.454	20	12	4	B	10
OD2	318020	6115236	17.454	16	8	3	B	10
OD3	318060	6115367	17.454	20	12	3	B	10
OD4	318142	6115473	17.454	11	4	4	C	10
OD5	318025	6115659	7.657	21	9	6	B	12
OD6	318246	6115323	17.454	27	17	6	B	10
OD7	317505	6115534	2.83	11	3	3	C	14
OD8	317882	6115668	7.657	16	7	4	B	12
OD9	317710	6115563	5.331	6	3	2	C	13
OD10	318226	6115846	17.454	17	7	5	B	10
OD11	317954	6116352	11.137	7	1	3	C	6
OD12	316597	6116330	1.22	3	0	2	NO	1
OD13	316816	6116033	3.541	4	1	3	NO	2

Table 4. EPBC assessment against the criteria results.

Irongrass Grassland sites									
Site	**Easting**	**Northing**	**Size**	**Native species**	**Herbaceous species additional to disturbance resistant**	**Grass species**	**TEC? (ABC)**	**Patch**	**Tussocks per m²**
A			**0.1ha**	**>30**	**10**	**≥5**			**>1**
B			**1ha**	**>15**	**3**	**>4**			**>1**
C				**>5**	**no minimum**	**≥1**			**>1**
LOM1	318155	6114317	14.542	14	7	5	C	22	>1
LOM2	317930	6114029	0.98	27	10	9	B	28	>1
LOM3	317919	6114045	0.98	5	1	2	C	28	>1
LOM4	317932	6114303	0.337	17	8	6	B	30	>1

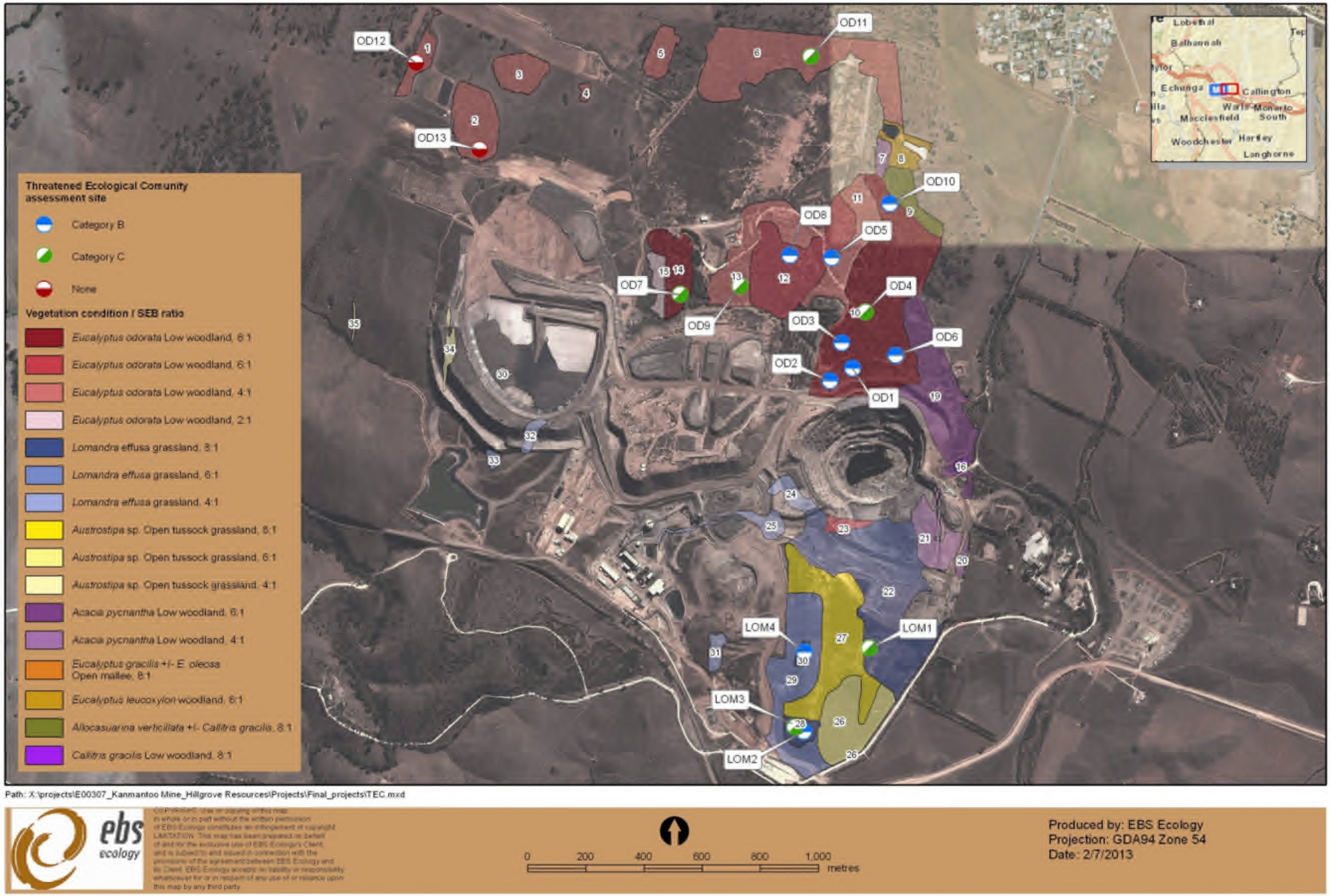

Figure 1. Vegetation mapping and EPBC assessment sites.

References

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Threatened Species Scientific Committee (TSSC) (2007) *Commonwealth Listing Advice on Iron-grass Natural Temperate Grassland of South Australia* [Listing Advice].

Please let me know if you have any queries,

Yours sincerely,

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Appendix B - Kanmantoo Visual Impact Assessment (JBS&G, 2019)

Hillgrove Resources Ltd

Kanmantoo Visual Impact Assessment

Kanmantoo Copper Mine,
Kanmantoo, South Australia

27 August 2019

57085/ 123,995 (R01_Rev1_FINAL)

JBS&G

www.jbsg.com.au

Hillgrove Resources Ltd
Kanmantoo Visual Impact Assessment

Kanmantoo Copper Mine,
Kanmantoo, South Australia

27 August 2019

57085/ 123,995 (R01_Rev1_FINAL)
JBS&G

Table of Contents

List of Tables

List of Figures

Abbreviations

Term	Definition
CLGR	Central Local Government Region of South Australia
DEM	Digital Elevation Model
EPBC	*Environment Protection and Biodiversity Conservation*
Hillgrove	Hillgrove Resources Ltd
JBS&G	JBS&G Australia Pty Ltd
m AHD	Metres Australian Height Datum
m RL	Metres Relative Level
OTD	Old Tailings Dam
PEPR	Environmental Protection and Rehabilitation
SA EP	South Australia Environment Protection
TSF	Tailings Storage Facility
TZVI	Theoretical Zone of Visual Influence
VIA	Visual Impact Assessment
WA EPA	Government of Western Australia Environmental Protection Authority

Executive Summary

JBS&G Australia Pty Ltd (JBS&G) was engaged by Hillgrove Resources Ltd (Hillgrove) to undertake a Visual Impact Assessment (VIA) as part of the revised Program for Environmental Protection and Rehabilitation (PEPR) at the Kanmantoo Copper Mine located in Kanmantoo, South Australia (the Site). The VIA is required for the proposed lift of the existing tailings storage facility (TSF).

JBS&G understands that Hillgrove is considering an expansion to the resource at the Site associated with a proposed underground mining operation. As part of this expansion, it is anticipated that the TSF will need to be raised a further 3 m. Also, that there is strong sentiment from the community and government to clean up a mining legacy issue by re-locating tailings from the "Old Tailings Dam" (OTD) from a 1970s operation to the TSF of the current operation to improve the environmental outcomes for the natural environment. To include this material a lift of 11 m will be required.

JBS&G further understands that Hillgrove undertook a VIA in 2014[1] as part of the PEPR[2] requirements. This VIA utilised baseline data from a previous VIA completed in 2007[3].The 2014 VIA assumed a final TSF height based on the current permitted of 1,265 metres relative level (m RL) (265 metres Australian Height Datum (m AHD)).

The VIA, analysis and modelling for the TSF are based on information provided by Hillgrove. The TSF model heights are:

- TSF height of 1,263 m RL (263 m AHD) (current);
- TSF height of 1,266 m RL (266 m AHD) (3 m lift); and
- TSF height of 1,274 m RL (274 m AHD) (11 m lift).

The Project area for the VIA has been defined as all areas within 6 km of the TSF. The zone within the Project area could potentially be visually impacted by the development of the TSF and is known as the Theoretical Zone of Visual Influence (TZVI).

The change to the current TSF height will result in the following:

- The TSF height of 1,266 m RL (266m AHD) (3m lift) will increase the approximate height by 5.08 %; and
- The TSF height of 1,274 m RL (274m AHD) (11m lift) will increase the approximate height by 18.64 %.

The increase in the TSF height is not expected to significantly alter the current landscape within proximity to the Kanmantoo Site, which is already dominated by extractive/ mining industry land use.

The receptors that are closest to the TSF are likely to be more significantly impacted compared to those further away. Of the 148 receptors within the Project Area, 63 of these receptors fall within the TZVI of the 11 m lift. Those within 1,200 m would potentially be most impacted by the increase in the TSF height, however no sensitive receptors fall within this distance of TZVI for the Current, 3 m and 11 m TSF.

The change to the current TSF height is not expected to significantly alter the character of the current landscape, bearing in mind that there is currently a TSF present and related mining activities in the area.

[1] Program for Environment Protection and Rehabilitation – Life of Mine (2014), ML6345 and ML6436 - Kanmantoo Copper Mine – Appendix 14, Visual Impact Assessment (Report Reference No.: ENAUDARW09119_02_v5)

[2] Program for Environment Protection and Rehabilitation – Life of Mine (2014), ML6345 and ML6436 - Kanmantoo Copper Mine (Ver: V6)

[3] Wax Design Space (2007) Hillgrove Resources Kanmantoo Copper Project, Visual Impact Assessment

1. Introduction

JBS&G Australia Pty Ltd (JBS&G) was engaged by Hillgrove Resources Ltd (Hillgrove) to undertake a Visual Impact Assessment (VIA) as part of the revised Program for Environmental Protection and Rehabilitation (PEPR) at the Kanmantoo Copper Mine located in Kanmantoo, South Australia (the Site). The VIA is required for the proposed lift of the existing tailings storage facility (TSF).

1.1 Project Background

JBS&G understands that Hillgrove is considering an expansion to the resource at the Site associated with a proposed underground mining operation. As part of this expansion, it is anticipated that the TSF will need to be raised a further 3 m. Also, that there is strong sentiment from the community and government to remediate a mining legacy issue by re-locating tailings from the “Old Tailings Dam” (OTD) from a 1970s operation to the TSF of the current operation to improve the environmental outcomes for the natural environment. To include this material, a lift of 11 m will be required.

JBS&G understands that Hillgrove currently undertakes annual photographic monitoring in compliance with the lease conditions and environmental objectives at the Site. The photographic monitoring programme tracks visual changes as the Site develops. These locations track both the mine development/ rehabilitation and topsoil stockpile locations.

We understand that Hillgrove undertook a VIA in 2014[4] as part of the PEPR[5] requirements. This VIA utilised baseline data from a previous VIA completed in 2007[6].The 2014 VIA assumed a final TSF height based on the current permitted of 1,265 metres relative level (m RL) (265 metres Australian Height Datum (m AHD)).

JBS&G understands that the current TSF height is 1,263 m RL (263 m AHD).

The 2019 VIA (herein referred to as the Project) considers the current TSF height and calculates the additional visual impact based on the two different TSF AutoCAD models provided by Hillgrove (discussed further in **Section 1.4**)

1.2 Objectives

The objectives of the VIA are:

- Describe the existing environment in which the Project is set, including current impacts from existing mine infrastructure;
- Identify the current TSF height visual surrounding environment and assess the magnitude of change resulting from the two different TSF AutoCAD models;
- Provide a comparison between the current TSF height and calculated additional visual impact of the two TSF AutoCAD models; and
- Describe the impact on key sensitive receptors within the project area.

1.3 Scope of Works

The scope of works addressed during this VIA includes the following:

- A literature review of existing documents;

[4] Program for Environment Protection and Rehabilitation – Life of Mine (2014), ML6345 and ML6436 - Kanmantoo Copper Mine – Appendix 14, Visual Impact Assessment (Report Reference No.: ENAUDARW09119_02_v5)
[5] Program for Environment Protection and Rehabilitation – Life of Mine (2014), ML6345 and ML6436 - Kanmantoo Copper Mine (Ver: V6)
[6] Wax Design Space (2007) Hillgrove Resources Kanmantoo Copper Project, Visual Impact Assessment

- Identify and describe visual elements within the Project area, encompassing natural and built forms;
- Develop a visual baseline of the current TSF height;
- Analyse the two TSF AutoCAD models and determine the associated magnitude of change;
- Identify key receptors affected by current TSF height and two TSF AutoCAD models and determine if any new receptors may be impacted;
- Utilise the two TSF AutoCAD models to calculate the change in visual impact at selected receptors; and
- Complete a photomontage analysis of the current TSF height and two TSF AutoCAD models from public viewing locations/ land.

1.4 Project Elements (Model Inputs)

The VIA, analysis and modelling for the TSF are based on information provided by Hillgrove. The TSF model heights are:

- TSF height of 1,263 m RL (263 m AHD) (current);
- TSF height of 1,266 m RL (266 m AHD) (3 m lift); and
- TSF height of 1,274 m RL (274 m AHD) (11 m lift).

Table 1.1 below presents the TSF model height and corresponding file name as provided by Hillgrove

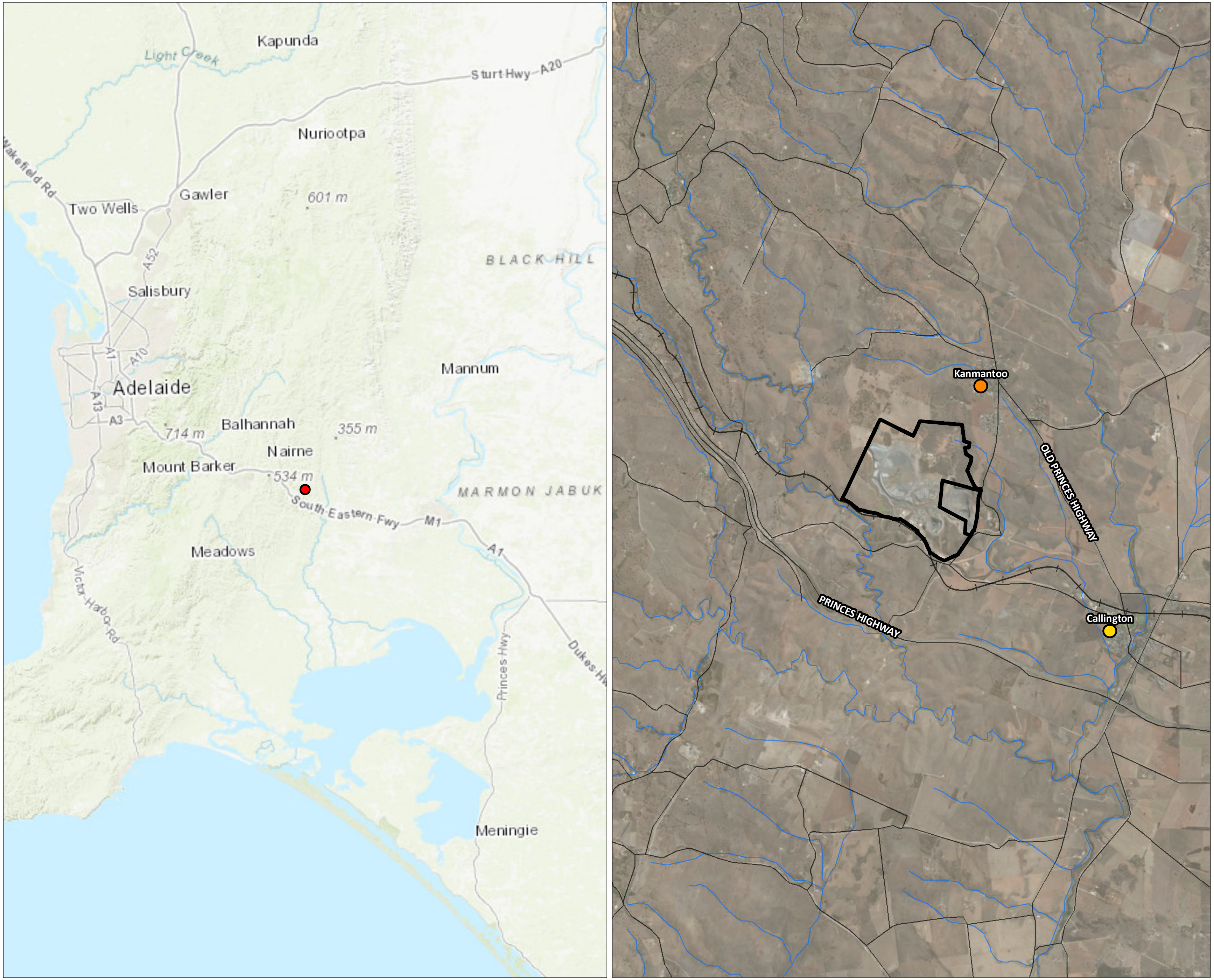
Table 1.1: TSF Model Height

TSF Model Height	AutoCAD Model File Name
TSF height of 1,263 m RL (263 m AHD) (current)	-
TSF height of 1,266 m RL (266 m AHD) (3 m lift)	2019_07_iwl_design_rl1266_with_borrow
TSF height of 1,274 m RL (274 m AHD) (11 m lift)	rl1274_opt2_site_2019_07_27

1.5 Project Area Definition

The Kanmantoo Copper Mine is located approximately 44 km east of Adelaide in the Adelaide Hills, South Australia. The Project location is presented in **Figure 1** and the Project area is shown on **Figure 2**.

The Project area for the VIA has been defined as all areas within 6 km of the TSF. The zone within the Project area could potentially be visually impacted by the development of the TSF and is known as the Theoretical Zone of Visual Influence (TZVI).



Legend:

- Site Location
- Mine Lease Boundaries
- Roads
- Railways
- Watercourses

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Version: FINAL	Date: 27-Aug-2019
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0 1 2

Kilometers

Coor. Sys. GDA 1994 MGA Zone 54

Kanmantoo Copper Mine, Kanmantoo, South Australia

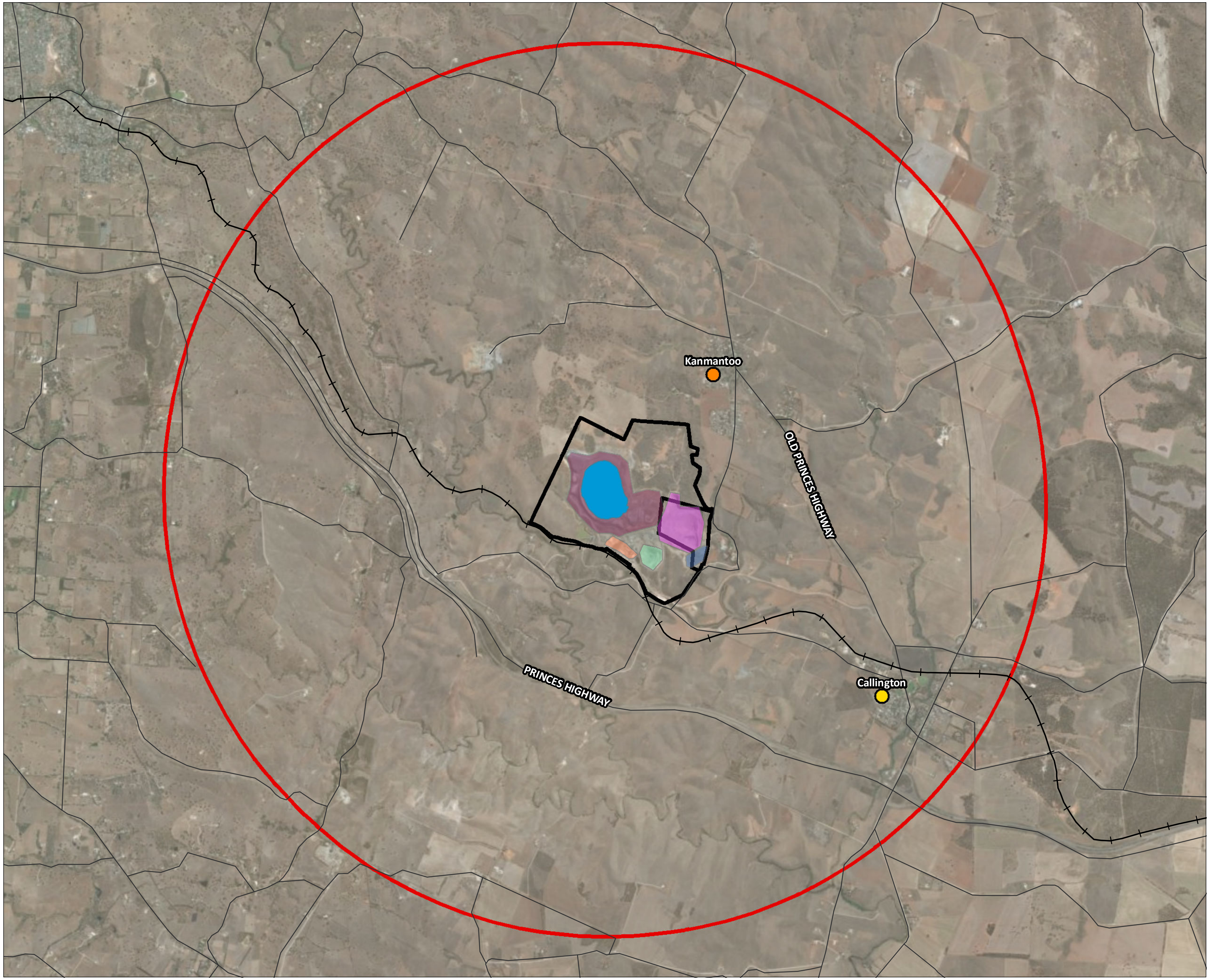
SITE LOCATION

FIGURE 1

Document Path: V:\05 Projects\Hillgrove Resources\57085 Kanmantoo TSF VIA\8 - ArcGIS\Maps\Final Report Maps\57085_01_Site Location.mxd

Image Reference: www.nearmap.com© - Imagery Date: 7 April 2019 and Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Legend:

- Project Area
- Mine Lease Boundary
- Railways
- Roads
- Tailings Storage Facility

Other Mine Components

- Emily Star Pit
- Main Pit
- Mine Buildings
- O'Neil Zone
- Waste Rock Storage

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Scale at A4 1:80,000	

0 1,000 2,000
metres

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PROJECT AREA

FIGURE 2

Document Path: V:\05 Projects\Hillgrove Resources\57085 Kanmantoo TSF VIA\8 - ArcGIS\Maps\Final Report Maps\57085_02_Project Area.mxd
Image Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

1.5.1 Theoretical Zone of Visual Influence

The TZVI is the area within which the development of the TSF is theoretically visible from a human receptor standing on the ground. The key factors in determining this are the visual capability of humans (human field of vision), the dimensions of the development, and the nature of the surrounding topography.

The human field of vision is defined by several areas, ranging from far peripheral to central vision. Human far peripheral vision is weak in distinguishing detail, colour and shape. Central vision is where detailed image processing and symbol recognition occur and is defined by a central cone of approximately 15 degrees (Marieb, 2014).

We have defined the limit of significant visibility as less than 5% of the central cone (0.75 degree). This is graphically presented in **plate 1**.

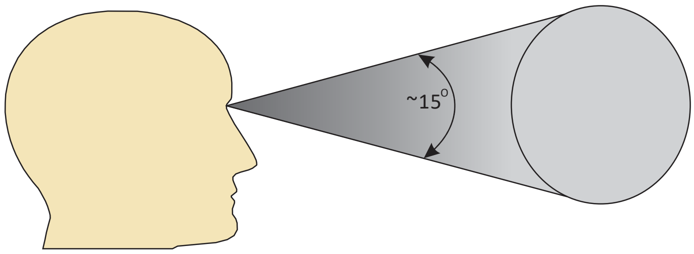
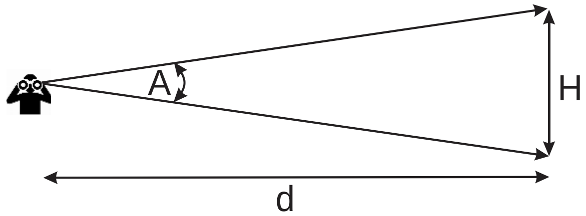


Plate 1: Human Central Field of Vision.

When both the linear size and angular size of an object are known, the distance to the object can be calculated using a standard method for the measurement of angular size (Maoz, 2016). The measurement of angular size equation and a graphical representation of the relationship between the variables are illustrated below in **Plate 2**.



$$d = \frac{360H}{2\pi A}$$

Where:

- A = Angular size of object
- H = Height of object
- d = Distance to object

Plate 2: Graphical Representation of the variables involved in the measurement of angular size.

The TZVI of the current TSF height and two TSF AutoCAD models is calculated by:

Angular size of object:

- 'A' – 5% of 15 degrees (human field of vision), 0.75 degree and use it with the angular size equation for the average final TSF heights (above the surrounding landscape/natural ground level); and

Height of object, 'H':

- 59 m (TSF height of 1,263 m RL (263 mAHD));
- 62 m (TSF height of 1,266 m RL (266 m AHD)); or
- 70 m (TSF height of 1,274 m RL (274 m AHD)).

Based on the above known variables the Distance to object, 'd' can be calculated and is approximately:

- 4.5 kms for the TSF height of 1,263 m RL (263 mAHD);
- 4.7 kms for the TSF height of 1,266 m RL (266 m AHD); and
- 5.3 kms for the TSF height of 1,274 m RL (274 m AHD).

Beyond the above distances the TSF is not significantly visible. **Plate 3** shows the angular size equation being calculated.

A = 0.75°
H = 59 m

$$d = \frac{360 * 59}{2\pi 0.75} = 4{,}500 \text{ m}$$

A = 0.75°
H = 62 m

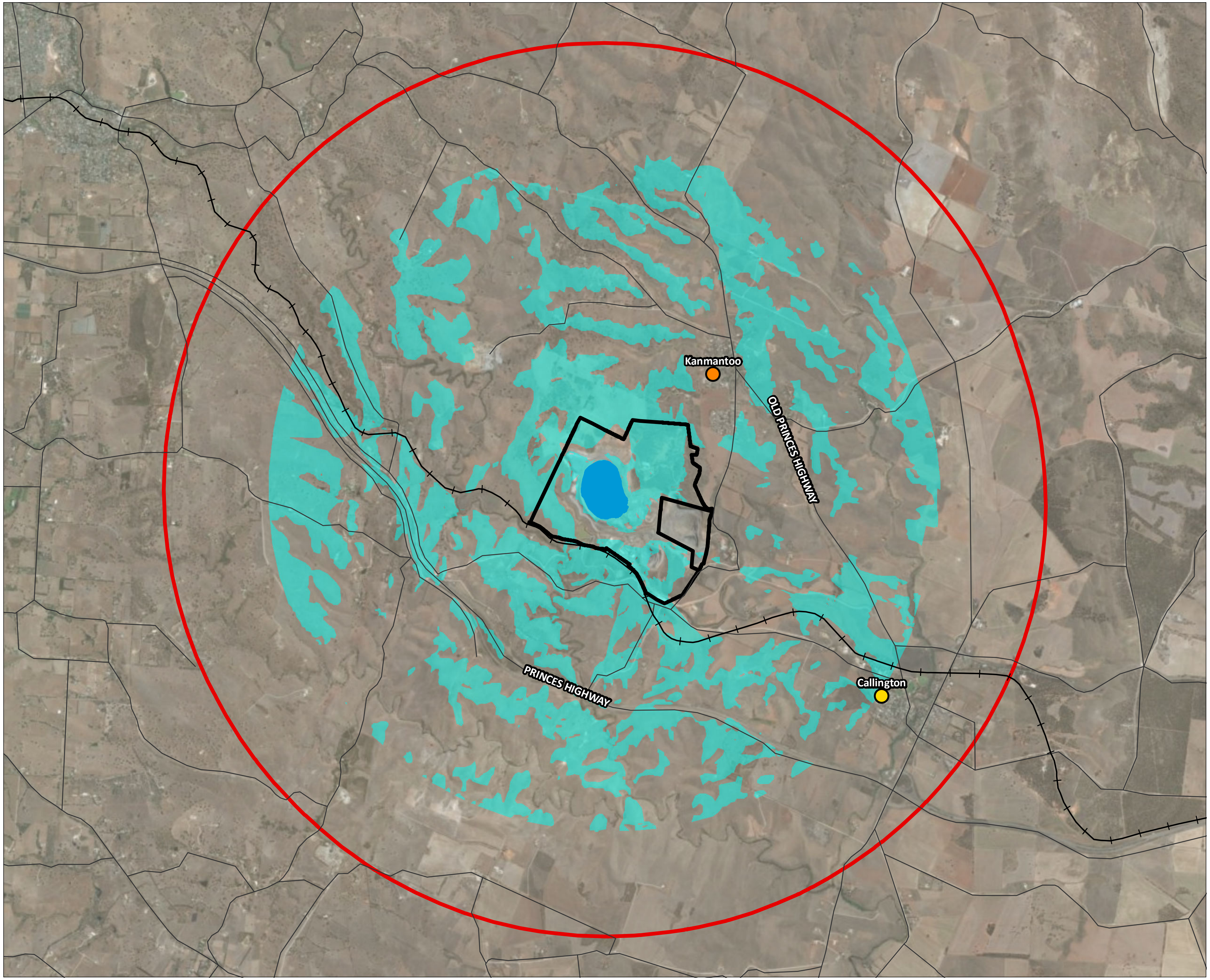
$$d = \frac{360 * 62}{2\pi 0.75} = 4{,}736 \text{ m}$$

A = 0.75°
H = 70 m

$$d = \frac{360 * 70}{2\pi 0.75} = 5{,}348 \text{ m}$$

Plate 3: Calculation of TZVI limits using angular size.

Utilising a digital elevation model (DEM) and the established TZVI for the current TSF height and two TSF AutoCAD models the viewshed modelling is performed for each TSF to determine areas with the TZVI where the TSF is visible, this is presented in **Figure 3A to Figure 3C**.



Legend:

- Project Area
- Mine Lease Boundary
- Railways
- Roads
- Tailings Storage Facility
- Theoretical Zone of Visual Influence - 1,263 m RL (Current)

Note: Due to an artifact of modelling, TZVI results are potentially unreliable within 400m of TSF.

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Client: Hillgrove Resources	
Version: FINAL	Date: 27-Aug-2019
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0 1,000 2,000
metres

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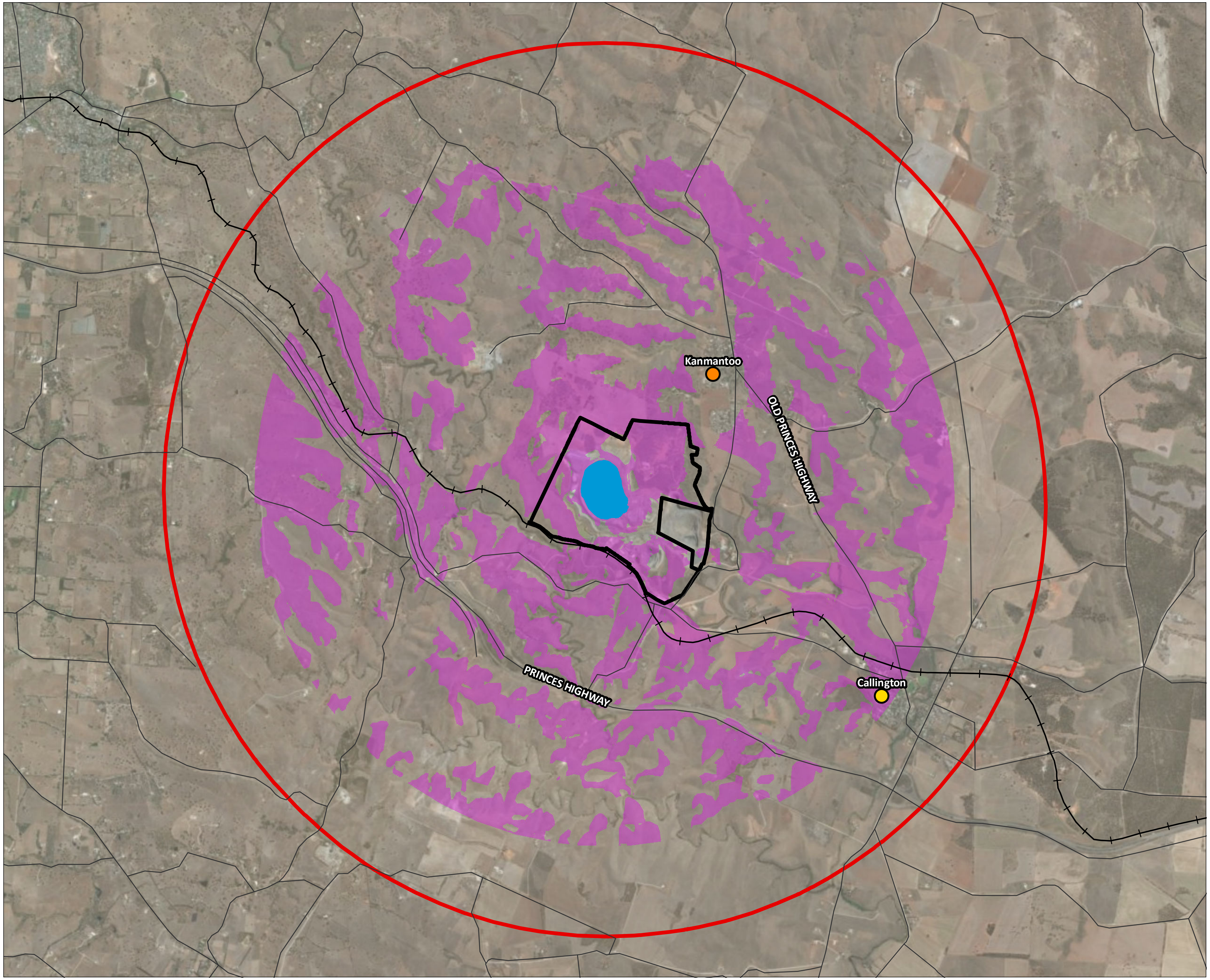
THEORETICAL ZONE OF VISUAL INFLUENCE (TSF Height of 1,263 m RL (263 m AHD))

FIGURE 3A

Document Path: V:\05 Projects\Hillgrove Resources\57085 Kanmantoo TSF VIA\8 - ArcGIS\Maps\Final Report Maps\57085_03A_TZVI-1263_RevA.mxd
Image Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend:

- Project Area
- Mine Lease Boundary
- Railways
- Roads
- Tailings Storage Facility
- Theoretical Zone of Visual Influence - 1,266 m RL (3m Lift)

Note: Due to an artifact of modelling, TZVI results are potentially unreliable within 400m of TSF.

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0 1,000 2,000
metres

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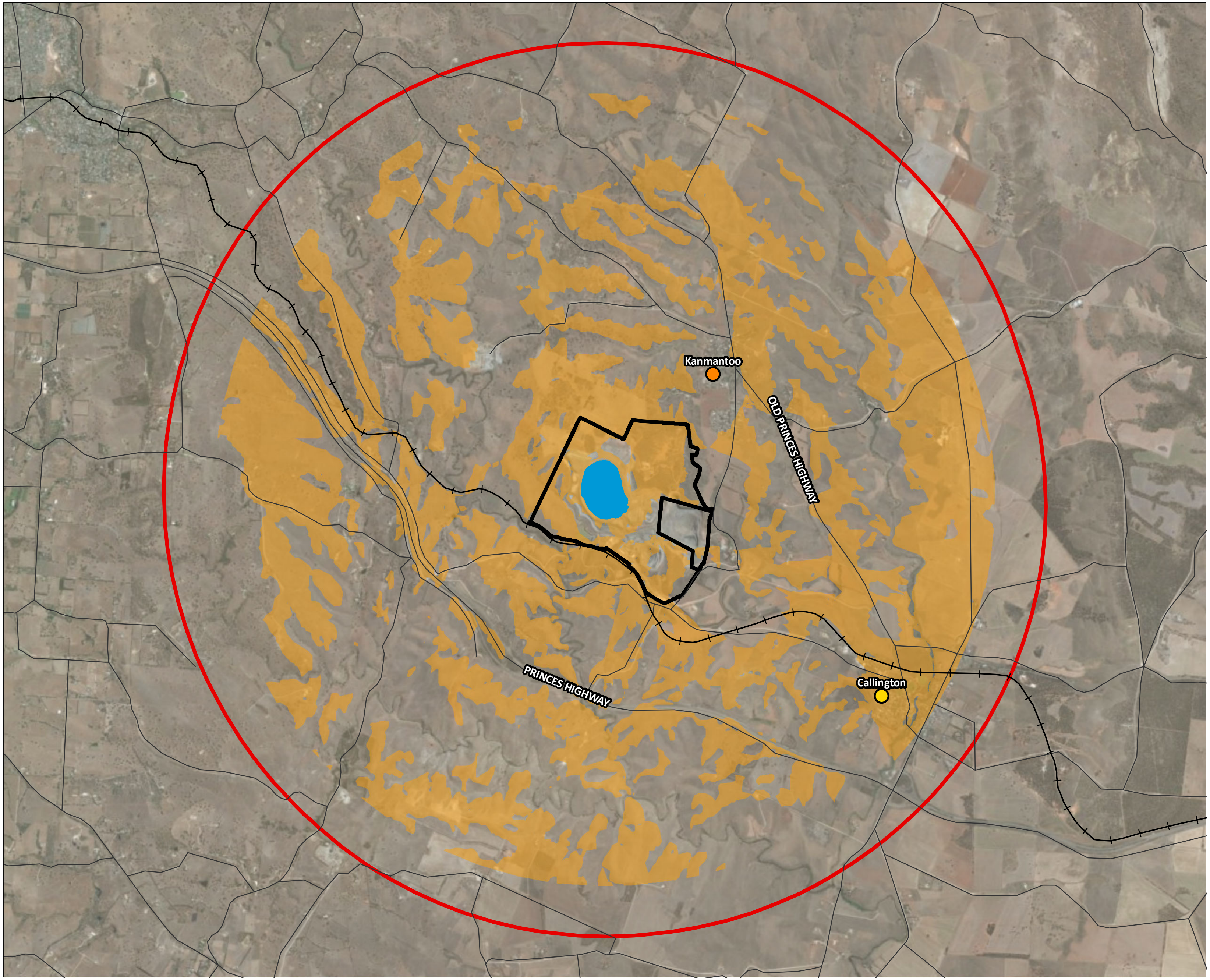
Kanmantoo Copper Mine, Kanmantoo, South Australia

THEORETICAL ZONE OF VISUAL INFLUENCE (TSF height of 1,266 m RL (266 m AHD))

FIGURE 3B



Legend:

- Project Area
- Mine Lease Boundary
- Railways
- Roads
- Tailings Storage Facility
- Theoretical Zone of Visual Influence - 1,274 m RL (11m Lift)

Note: Due to an artifact of modelling, TZVI results are potentially unreliable within 400m of TSF.

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Client: Hillgrove Resources	
Version: FINAL	Date: 27-Aug-2019
Drawn By: JC/ TB	Checked By: DB
Scale at A4 1:80,000	

0 1,000 2,000
metres

Coor. Sys. GDA 1994 MGA Zone 54

Kanmantoo Copper Mine, Kanmantoo, South Australia

THEORETICAL ZONE OF VISUAL INFLUENCE (TSF height of 1,274 m RL (274 m AHD))

FIGURE 3C

Document Path: V:\05 Projects\Hillgrove Resources\57085 Kanmantoo TSF VIA\8 - ArcGIS\Maps\Final Report Maps\57085_03C_TZVI-1274_RevA.mxd
Image Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

1.6 Legislative Context and Guidelines

The VIA was completed in general accordance following frameworks.

Federal Government – Legislative Context

There is no Federal legislation that provides specific regulation regarding visual amenity however impacts to visual amenity can be considered an 'environmental' impact under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. Under Section 528 of the *EPBC Act*, the term 'Environment' is defined as:

(a) ecosystems and their constituent parts, including people and communities; and

(b) natural and physical resources; and

(c) the qualities and characteristics of locations, places and areas; and

(d) Heritage values of places; and

(e) the social, economic and cultural aspects of a thing mentioned in paragraph (a), (b), or (c).

Therefore, under this definition, impacts to visual amenity can be considered an 'environmental' impact, as it falls under the definition in (c).

State Government – Legislative Context

The South Australia Environment Protection Act 1993 (SA EP) does not directly contain a framework to account for potential impacts to visual amenity when considering proposals. It states that the Authority can give notice to the owner to alter proposed variations if the proposed variation will 'result in any adverse effects on adjoining land or on the amenity value of the adjoining land' SA EP (1993).

There are no guidelines specific to visual impact within current South Australian legislation, however aspects of guidance from other states are considered applicable to this VIA.

Firstly, the Government of Western Australia, Environmental Protection Authority Statement of Environmental Principles, Factors and Objectives (WA EPA 2018), states that environmental assessment should aim:

- For Landforms: "To maintain the variety and integrity of distinctive physical landforms so that environmental values are protected"; and
- For Social Surroundings: "To protect social surroundings from significant harm".

In addition, Wind Farm Development Guidelines prepared by the Central Local Government Region of South Australia (CLGR) 2014 are relevant to the project. Best practice information within the Wind Farm Development Guidelines relating to visual impacts states that 'the degree of visual impact depends on the extent of the change to the landscape caused by the development', taking into account:

- *The overall visibility of the development;*
- *The locations and distances from which the development can be viewed;*
- *The significance of the landscape and proximity to sensitive areas;*
- *Landscape values associated with nearby public parks, conservation areas or Ramsar wetlands;*
- *Landscape values associated with nearby land, specified areas of landscape and environmental significance, specified coastal locations and areas identified to accommodate future urban growth; and*
- *The sensitivity of the landscape features to change.*

Local Council – Development Plans

The project area intersects with three Local Government Areas:

- Mount Barker District Council;
- Alexandrina Council; and
- The Rural City of Murray Bridge.

The Site falls within the Mount Barker District Council[7] and is zoned as Industry. The objective of the Industry Zone are:

- Accommodate industrial development that is compatible with mining activities and the adjoining rural environment;
- A zone in which stormwater is carefully managed to prevent pollution of surrounding watercourses; and
- Development that contributes to the desired character of the zone.

The following is noted that under the Principles of Development Control, Form and Character, section 8:

- Development should be designed and sited to minimise negative impacts using measures such as:

(a) *establishing landscaped buffers between the proposed development and sensitive uses*

(b) *incorporating sound attenuation into site and building design including the use of mounding or professionally designed solid structures to address noise impacts*

(c) *orientating buildings to act as buffers between the source of the impact and sensitive uses*

(d) *using appropriate technology to mitigate impacts on sensitive uses*

(e) *confining the hours of operation to times which are least likely to create nuisance*

(f) *siting development and activities more than 10 metres from the boundary of the allotment generally to the west of Éclair Mine Road or Mine Road (excluding the boundary abutting Mineral Lease 5776).*

Additionally, the Site is covered by the Kanmantoo Buffer Policy Area 1. The desired character areas:

- *Re-vegetation in the policy area will include plantings that are of indigenous provenance, comprising both tree and understorey species. Plantings should be undertaken so as to protect and restore the area.*
- *Plantings are to be undertaken in a manner that will reinforce and encourage collaborative civic activities.*

Other Guidelines and Publications

As there are no recognised or standard visual assessment methodologies at federal, state or local government levels, this VIA has been designed to meet 'best practice' by utilising the following documents and JBS&G developed techniques:

- Guidance Note for Landscape and Visual Assessment (2018), Australian Institute of Landscape Architects;

[7]Government of South Australia (2017) Department of Planning, Transport and Infrastructure, Mount Barker District Council Development Plan (Consolidated – 8 August 2017) https://www.dpti.sa.gov.au/__data/assets/pdf_file/0009/249993/Mount_Barker_Council_Development_Plan.pdf viewed 01/08/19

- NSW Government, Roads and Maritime Service (2018) Guideline for Landscape Character and Visual Impact Assessment, Environmental impact assessment practice note EIA-N04;
- Routledge (2013) Landscape Institute and the Institute of Environmental Management & Assessment, Guidelines for Landscape and Visual Impact Assessment, 3rd Edition;
- Guidelines for Landscape and Visual Impact Assessment (Third edition) (2013), Landscape Institute;
- Swanwick, C (2013), Guidelines for Landscape and Visual Impact Assessment. 3rd ed. United Kingdom: Landscape Institute and Institute of Environmental Management and Assessment;
- Environment Protection and Heritage Council (2010) Draft National Wind Farm Development Guidelines;
- Photography and Photomontage in Landscape and Visual Impact Assessment (2011), Landscape Institute Advice Note 01/11;
- Visual Landscape Planning in Western Australia (2007), A manual for evaluation, assessment, siting and design, Western Australian Planning Commission; and
- Lothian, A (2000), Landscape Quality Assessment of South Australia. PhD Thesis Adelaide University.

1.7 Limitations of the Software Program and Data

The following limitations and assumptions are considered as part of the VIA:

- The TSF model heights and inputs were provided by Hillgrove;
- The VIA focuses on the vertical change associated with the TSF, as it is understood the change in horizontal component of the TSF is insignificant;
- The VIA considers the additional visual impact based on the two different TSF AutoCAD models provided by Hillgrove;
- It is noted that the DEM used was produced from a number of sources/ inputs. JBS&G has processed this data to an appropriate spatial resolution of 5 m, but notes that there may be inherent errors including limited ground control points and different dates of raw data capture that cannot be accounted for;
- Rapid changes in the DEM terrain are smaller than scale (e.g. some rises) and will likely be smoothed over as an average elevation;
- Weather effects such as sunlight, dust, lighting and rain have not been considered;
- The VIA analyses and modelling does not consider the Site's existing photographic monitoring programme and/ or other mitigating factors including vegetation and/ or rehabilitation management;
- Due to the artifact of DEM and data modelled the TZVI results are potentially unreliable within 400 m of TSF; and
- Certain aspects of the model aim to quantify variables that are subjective in nature. While the modelling aims to be highly conservative, these variables could change with differing interpretation.

2. Literature Review

The following documents have been reviewed by JBS&G and summarised below.

2.1 Wax Design (2007) Hillgrove Resources Kanmantoo Copper Project, Visual Impact Assessment

The report was prepared to assess the potential visual impact of the proposed redevelopment of the site by evaluating the existing visual character and comparison of proposed extent of visual change. The VIA was based on a copper and gold mining operation which included ore processing for concentrate production. The mine had a life of eight years and included including an open cut pit, waste rock dump, TSF, buildings and other associated infrastructure.

An assessment of the existing visual impact found that the existing waste rock dump, TSF and to a lesser extent other mine infrastructure, have a visual effect to the north west, west, south west and south east. An assessment of the extent of change included a viewshed analysis that highlighted that the area contains high topographical relief which limit views to approximately three to four kms from the site. A digital terrain model was then created to identify potentially sensitive viewpoints and map the viewshed. It was found that the greatest extent of visual impact was in close proximity to the mine site and from elevated ridges due to the increased height of the waste rock dump and TSF.

Photomontages were undertaken at four viewpoints; Ironstone Range Road – south of Petwood, Princes Highway – north of Callington, Ironstone Range Road – south of Dawesley and Back Callington Road – north of St Ives.

It was found that the visual effect of the rock dump and TSF already exist to the viewpoints assessed and that the proposed redevelopment will result in a proportional increase in the existing visual effect. Through the removal of the ridge line of Macfarlane as part of the open pit development; however, the degree of impact can be reduced through implementation of mitigation measures.

2.2 Urbis Pty Ltd (2013), Kanmantoo Copper TSF Modification – Visual impact Assessment (Job Code: MD3294/ ENAUKESW05000CC (Ver: DRAFT V6)

The report assessed the visual impact of an increase in the Project's TSF height of 27 m from 1,238 m RL to 1,265 m RL as well as additional rock storage landforms. The assessment included a qualitative assessment of the landscape coupled with a quantitative assessment of visual prominence and relationship with viewshed (five km radius) based on visual simulations. Assessment of potential impact was based on photomontages undertaken at a total of eight viewpoints; four replica viewpoints assessed as part of the 2007 VIA as well at four additional residential and township viewpoints were included due to their perceived high sensitivity. A quantitative comparative assessment of the approved project and proposed project was undertaken to ascertain the magnitude of visual change.

Zone of visual influence analysis found that the proposed modification will result in a 26% increase in the viewshed . Analysis of photomontages found that the final landform of the TSF would be consistent with the existing landscape setting in terms of form, colour and texture however the increase in TSF visual prominence would result in a low to moderate overall increase in visual impact.

In addition, it was concluded that the effects of night lighting will be visible to a wider area, however the impact can be mitigated. With the implementation of mitigation measures, the residual visual impact of an increase in height of 27 m of the TSF was considered to be low to moderate.

2.3 Program for Environment Protection and Rehabilitation – Life of Mine (2014), ML6345 and ML6436 – Kanmantoo Copper Mine (Ver: V6)

The findings of the 2007 and 2013 VIA reports were summarised into the visual impact section of the PEPR report and numerous control measures were proposed to minimise the anticipated impact.

It was generally concluded that modification of the existing landscape will likely reduce local visual amenity with the greatest impact experienced by local residents. Local residents were identified as the most sensitive receptors as they occur in the closest proximity to the modification and are more sensitive to landscape modifications due to their awareness of the existing landscape.

It was however noted that views of the TSF will be limited to specific ridges only and will not pose a widespread contiguous impact. The highest degree of visual impact will occur in the western sub-regional area and the reduced visual amenity consequence is considered to be moderate and the resultant risk is medium.

Due to topographical relief, there will be no visual impact beyond 10 kms. In line with the mine's closure and rehabilitation requirements decommissioning, contouring where possible and revegetation will be undertaken to incorporate the landform into the existing topography.

3. The Existing Landscape

The Australian Government Department of the Environment and Energy defines a bioregion as a '*large, geographically distinct area of land with common characteristics such as geology, landform patterns, climate, ecological features and plant and animal communities*'[8].

The Project area (the area that falls within the TZVI, as presented in **Section 1.5**) encompasses one bioregion; the Kanmantoo Bioregion[9]. The visual character and scenic quality are underpinned by the broader landscape characteristic of the bioregion and are important factors in determining the landscape sensitivity, which is discussed further in **Section 0**.

The visual landscape within the vicinity of the Project can be described within the context of Sub-Bioregions which reflect a set of major environmental, geographical and biophysical influences which shape the landscape, as described below.

3.1 Fleurieu Sub-Bioregion

The site is situated entirely within the Kanmantoo Bioregion. The context of the site is better understood through the description of the Sub-Bioregion (the Fleurieu Sub-Bioregion) which he site is situated entirely within and is described as a low hills landscape comprised of hilly dissected tablelands.

Natural vegetation is dominated by eucalyptus woodlands with shrubby understories located on hard setting loams with red clayey subsoils.

The topography of the area is characterised by high topographic relief with complex multidirectional ridgelines and occasional wide valleys.

3.2 Directional Visual Landscapes

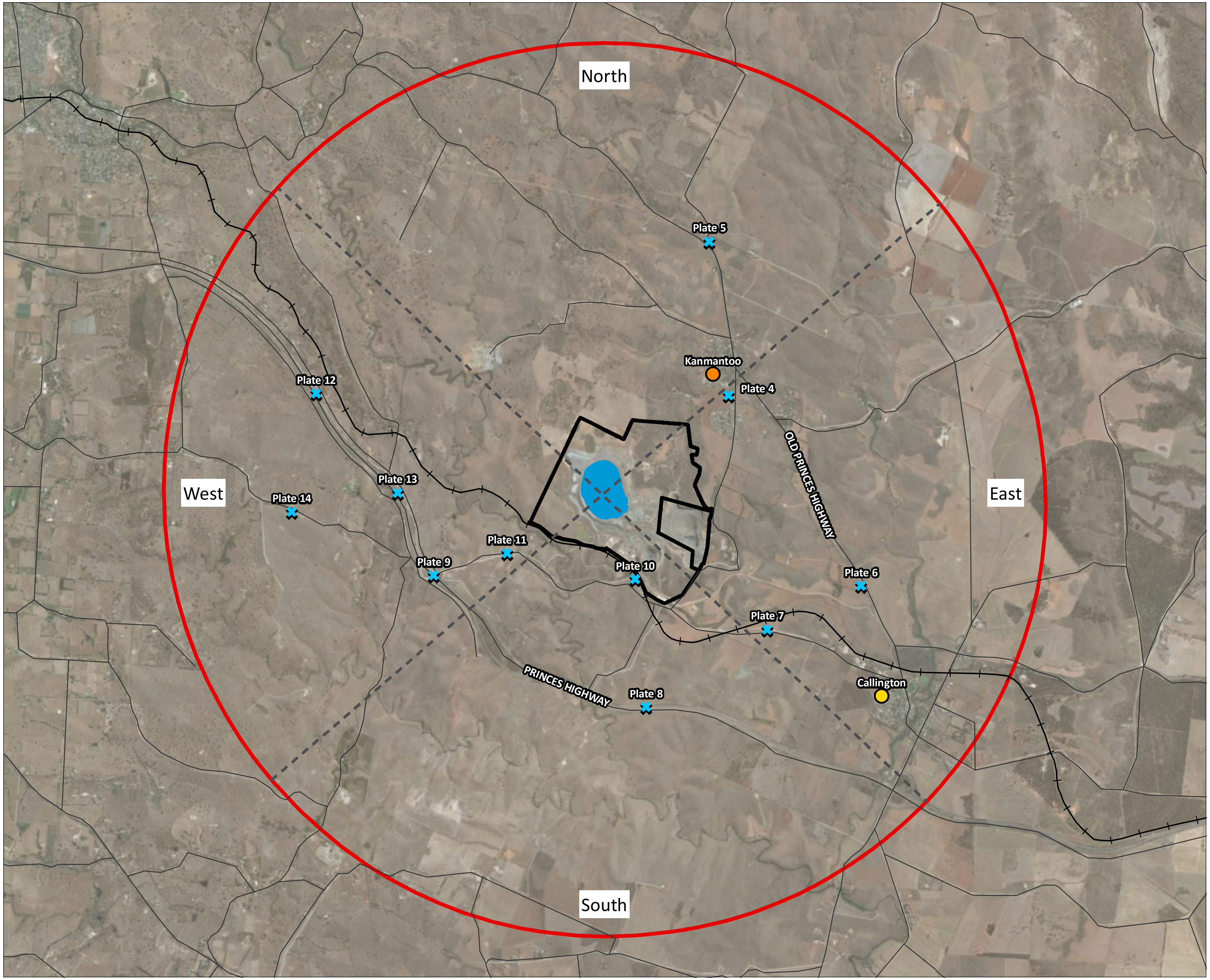
The TSF is nestled at a highpoint within an undulating landscape which is accessed by two major highways to the north (Old Princes Highway) and south (Princess Highway/ South Eastern Freeway). These two roads are the major sources of transient views within the Project area. Permanent and lasting views of higher impact are considered to be from residential properties surrounding the Site. In addition, the Project area is considered to be a highly modified agricultural landscape with a grassy understory, fragmented woodland vegetation which provides localised visual screening. Existing visual impacts on the landscape include transmission lines, train lines, quarries and other existing infrastructure.

To understand the viewshed surrounding the site, the Project area has been segregated into four directional views towards the site from the north, east, south, and west. Representative photos locations (discussed below) with each directional views of the landscape are presented in **Figure 4**.

---

[8] Australian Government (2019) Department of the Environment and Energy, Australia's bioregion framework https://www.environment.gov.au/land/nrs/science/ibra/australias-bioregion-framework accessed 29/07/19

[9] Government of South Australia (2019A) Department for Environment and Water, NatureMaps (version 3.4.1). Based on the Interim Biogeographic Regionalisation for Australia Sourced from Nature Maps from http://spatialwebapps.environment.sa.gov.au/naturemaps/?locale=en-us&viewer=naturemaps accessed 29/07/19



Legend:

- Project Area
- Mine Lease Boundary
- Railways
- Roads
- Tailings Storage Facility
- Representative Photo Location

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Version: FINAL	Date: 27-Aug-2019
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Scale at A4 1:80,000	

0 1,000 2,000
metres

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Kanmantoo Copper Mine, Kanmantoo, South Australia

PROJECT AREA DIRECTIONAL VIEW AND REPRESENTATIVE LANDSCAPE PHOTO LOCATIONS

FIGURE 4

Document Path: V:\05 Projects\Hillgrove Resources\57085 Kanmantoo TSF VIA\8 - ArcGIS\Maps\Final Report Maps\57085_04_Directional View and Landscape Photos.mxd
Image Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

3.2.1 North

The area north of the Project area is characterised by moderately high topographical relief with sporadic peaks particularly to the north west of the TSF. The landscape is generally of higher elevation on the western side of the Old Princess Highway and declines towards the east, this is in general accordance with the greater topological pattern of the Flinders Lofty Block. The area directly north of the site contains the highest degree of woody vegetation with fragmented areas of Eucalyptus woodland scattered on the peaks of hills and along creek lines surrounding the mine site, as depicted in **Plate 4** below.

Plate 4: View from 16 Mine Road looking south west. Source: Google[10] (2019).

The surrounding land is utilised for a combination of cropland and pastureland. The town of Kanmantoo is situated in one of the wide valleys associated with the broader topography profile. Views of the TSF from Kanmantoo are screened by hills between the receptor and TSF as well as the presence of vegetation on ridgelines. In addition, it is unlikely that views of the TSF from the Old Princess Highway will exist due to its situation in a valley adjacent to the ridgeline that obstructs potential views, as demonstrated in **Plate 5** below.

Plate 5: View from 1840 Old Princess Highway looking south. Source: Google (2019).

3.2.2 East

The area to the east of the Project area contains the largest area of low elevation, this is coupled with fragmented vegetation which provides a low degree of screening capacity. This is associated with a wide valley between two north/ south running ridgelines, and vegetation clearing associated with the agricultural landuse of the area. The Bremer River is situated at the base of the western ridgeline and Callington is situated in the valley low-point. As the Old Princess Highway extends in a northwest to southeast direction, views of the TSF can be gained in proximity to the intersection of the mine site access road, this is depicted in **Plate 6** below.

Plate 6: View from near the intersection of Old Princess Highway and the mine access road looking west. Google (2019).

[10] Google Street View (2019)

In addition, due to the lower topography to the east of the TSF, there is less capacity for landscape screening and therefore a greater opportunity for viewing locations. There are several views of the Site along Back Callington Road and the northern most portion of Callington Road, see **Plate 7** below.

Plate 7: View from 1011 Back Callington Road looking north west. Google (2019).

It is not anticipated that the site will be visible from receptors within Callington due to the high visual absorption capacity of other existing structures including buildings, infrastructure and vegetation.

3.2.3 South

South of the Project area there are several potential views of the TSF. This is due to the presence of highly undulating topography with narrow valleys containing numerous ancillary waterways to the two main creeks; Dawesley Creek and Mount Barker Creek. Due to the presence of narrow valleys, infrastructure is present along several ridgelines which host clear views of the mining operation. This is demonstrated in **Plate 8** and **Plate 9** below.

Plate 8: View from the South Eastern Freeway/ Princess Highway looking north west. Google (2019).

Plate 9: View from the South Eastern Freeway/ Princess Highway looking north east. Google (2019).

In addition, there is a trainline that ferries viewers in an east to west direction immediately south of the Site. The train line is situated on the outer boundary of the Site and therefore the visual envelope of the TSF will be within significant view. Typical views from the trainline are demonstrated in **Plate 10** below and are short duration and transient in nature.

Plate 10: View from the trainline adjacent to the mine substation looking north west. Google (2019).

There are several residences located on high points between the South Eastern Freeway and Dawesley Creek, these are scattered agricultural homesteads accessed with Back Callington Road and host almost unobstructed views of the TSF. An example of the type of views in the area described above are shown in **Plate 11**.

Plate 11: View from the western portion of Back Callington Road looking north east. Google (2019).

3.2.4 West

The landscape west of the site is characterised by undulating ridges which decrease in elevation from west to east with Dawesley Creek occurring in a valley. Topography ranges from a high point of 330 mAHD at the approximate intersection of Summit Road and Back Callington Road with several undulating ridgelines occurring until the lowest point of 170 mAHD at Dawesley Creek, after which the highest topographical feature further east is the TSF at 240 mAHD. Due to the ruggedness and steepness of slopes, the area west of the site contains a higher degree of vegetation cover than the areas east and south of site, this is depicted in **Plate 12** below.

Plate 12: View from Petwood Road looking south east. Google (2019).

Due to the increased elevation, there are more elevated vantage points west of the site which provide a view of the TSF. There are several locations along the South Eastern Freeway and Old Princess Highway where unobstructed views of the TSF can be gained, see **Plate 13** below, however roadside planting provides an effective screen along the majority of the road.

Plate 13: View from South Eastern Freeway/ Princess Highway looking east. Google (2019).

In addition, there are several residential receptors located on elevated peaks west of the site which are exposed to prolonged views of the TSF; however, these receptors are approximately 2.5 kms from the TSF and natural rolling hills and vegetation mitigate the presence of the TSF .

Lastly, prominence of the TSF in the landscape will be less apparent from several elevated western views as the TSF against a background of elevated hills, as shown in **Plate 14**. Due to the presence of a dark-toned horizon of ridgelines, the prominence and contrast of the TSF compared to the existing surrounding landscape will be naturally moderated.

Plate 14: View from 191 Back Callington Road looking north east. Google (2019).

3.3 Landscape Sensitivity

Visual absorption capacity is defined as the potential for the attributes of a scene to absorb visual change. Scenic quality is a subjective value based on the visual landscape type. This is influenced by its sensitivity and scenic quality.

A landscape with a high visual absorption capacity is considered to be less sensitive than a landscape with low visual absorption capacity. Visual absorption is provided by the natural features and other structures within the landscape. Elements such as presence of rugged terrain, height and density of vegetation, as well as other man-made structures will influence the visual absorption capacity.

As discussed in the directional visual landscape above, the sensitivity of the landscape is decreased due to landscape modification for agricultural use, vegetation removal and presence of manmade structures. In addition, the landform of the existing TSF is nestled within a rugged and undulating topographical landscape which enhances the visual absorption capacity through obstruction of views as well as provision of similar and non-contrasting landform.

3.4 Land Use

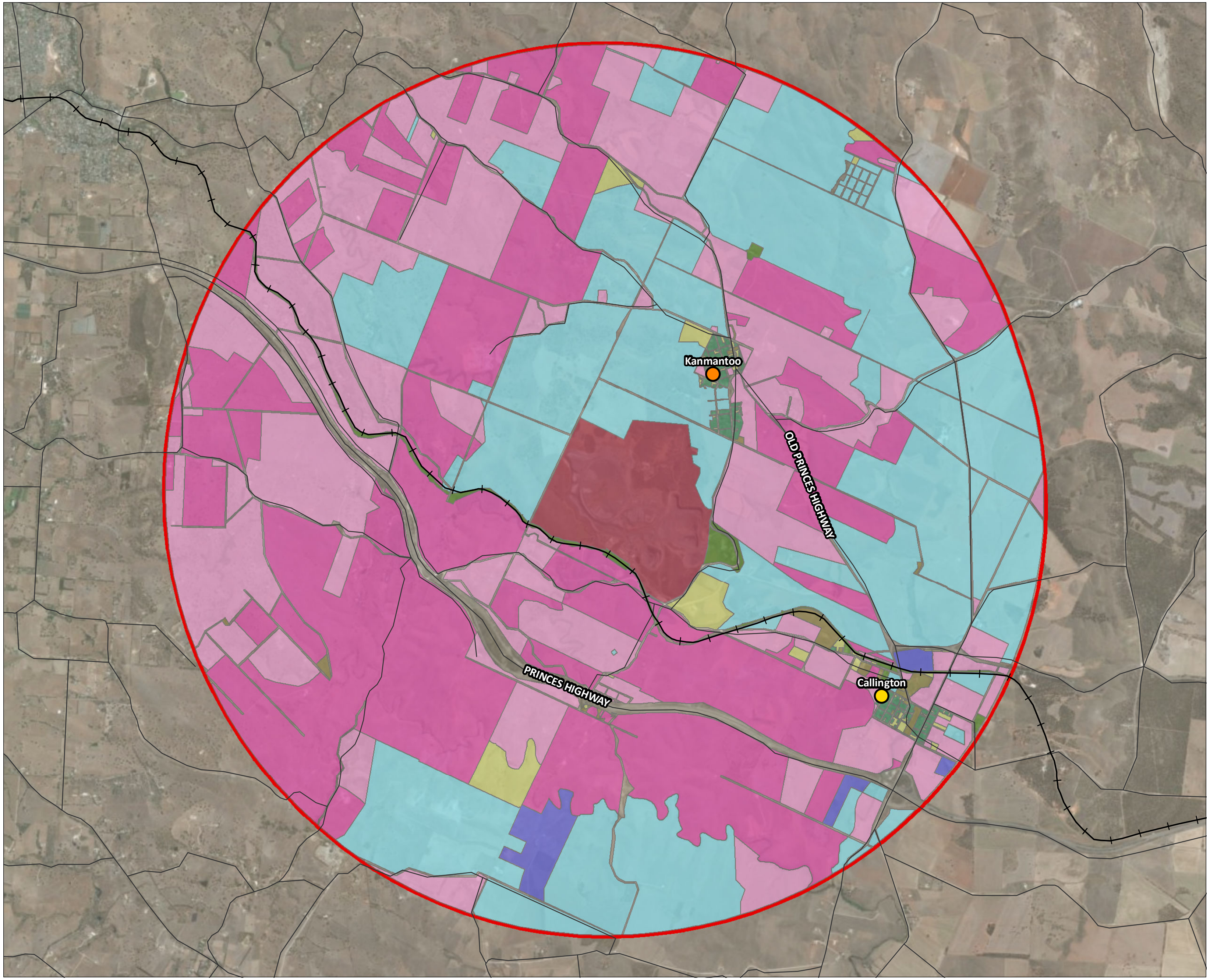
Within the Project area, defined as a 6 km radius around the Site (based on the calculation of the TZVI extent, as discussed in **Section 1.5**), the landscape is comprised of a highly modified agricultural landscape with limited vegetation cover with occasional tree grouping along creeks and valleys. The landscape is characterised by low grassland communities as result of extensive grazing within the region.

The sparsely populated agricultural land use within the Project area is demonstrated through the categories of landuse as shown in **Table 3.1** below and presented graphically in **Figure 5**.

Table 3.1: Land Use within the Project Area

Land Use Category[11]	Percentage of Project Area
Livestock	32 %
Agriculture	31 %
Rural residential	25 %
Roads	4.5 %
Extractive/mining industry	3.5 %
Vacant	1 %
Horticulture	1 %
Commercial/public	1 %
Utilities	0.6 %
Residential	0.5 %

[11] Government of South Australia (2019B) Land Use Generalised https://data.sa.gov.au/data/dataset/land-use-generalised accessed 01/08/19



Legend:

- Project Area
- Railways
- Roads

Generalised Land Use

- Livestock
- Agriculture
- Rural Residential
- Extractive/Mining Industry
- Vacant
- Horticulture
- Commercial/Public
- Utilities
- Residential

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Version: FINAL	Date: 27-Aug-2019
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0 1,000 2,000
metres

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Kanmantoo Copper Mine, Kanmantoo, South Australia

LAND USE WITHIN THE PROJECT AREA

FIGURE 5

Document Path: V:\05 Projects\Hillgrove Resources\57085 Kanmantoo TSF VIA\8 - ArcGIS\Maps\Final Report Maps\57085_05_Land Use.mxd
Image Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, data.sa.gov.au

4. Visual Impact Assessment Methodology

The VIA was undertaken in broad accordance with applicable Federal and State legislation, Council development plans and other guidelines presented in **Section 1.6.**

The VIA was completed by considering the previous VIAs (**Section 2**), and calculating the additional visual impact of the two TSF models (1,266 m RL and 1,274 m RL).

The VIA consists of two main components:

- A desktop assessment **(Section 4.1)** to determine the theoretical additional visual impact of the two TSF models; and
- A photomontage assessment **(Section 4.2)** to both verify and support the initial desktop results.

4.1 Phase 1: Desktop Assessment

The desktop assessment of this VIA was composed of the following components.

4.1.1 Analysis of Models

Hillgrove provided AutoCAD files of the TSF at 1,266 m RL and 1,274 m RL. These were processed by JBS&G and overlain on a DEM in order to conduct viewshed analyses.

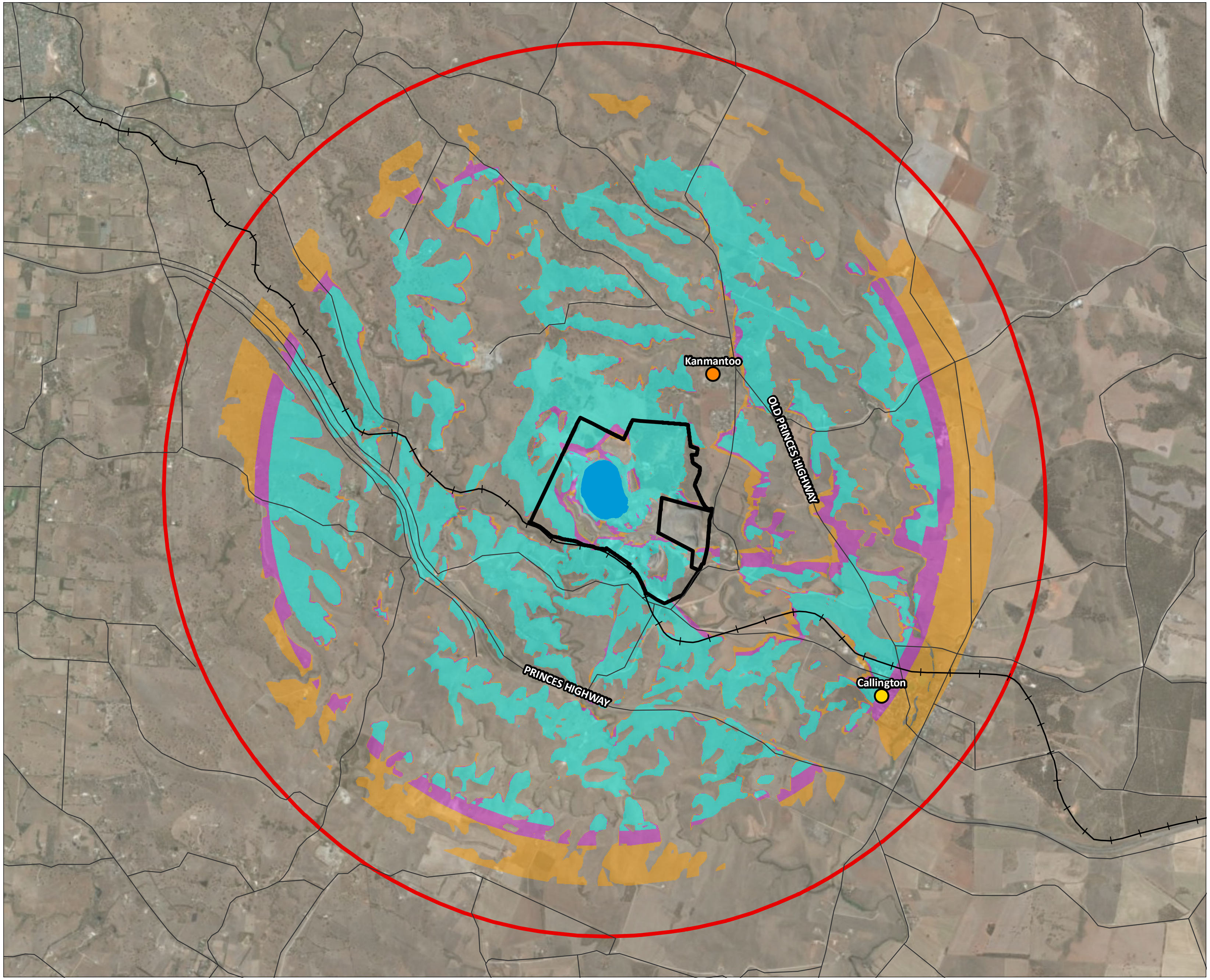
4.1.2 Comparative Viewshed Analyses

Viewshed analyses were performed for the TSF at 1263 m RL, 1266 m RL, and 1274 m RL. (The 1,263 m RL analysis was produced from the 1,266 m RL model).

Visual source points were evenly spaced at 50 m along the top edge of the TSF (**Section 1.5.1**). The TZVI was produced for each TSF lift, and compared to provide percentage differences as presented in **Table 4.1** below and graphically in **Figure 6**.

Table 4.1: TZVI Statistics

TSF Model	Approximate TSF Height (over surrounding landscape/natural ground level) (m)	Increase in TSF Height (m)	Increase in TSF Height (%)	Approximate Radius of TZVI (m)	Increase in Radius (%)	Area of TZVI (km^2)	Increase of Area Covered by TZVI (%)
TSF height of 1,263 m RL (263 m AHD) (current)	59 m	0 m	0.00 %	4,500 m	0 %	28.45 km^2	0 %
TSF height of 1,266 m RL (266 m AHD) (3 m lift)	62 m	3 m	5.08 %	4,700 m	6.67 %	34.30 km^2	20.5 %
TSF height of 1,274 m RL (274 m AHD) (11 m lift)	70 m	11 m	18.64 %	5,300 m	17.78 %	46.09 km^2	62.0 %



Legend:

- Project Area
- Mine Lease Boundary
- Railways
- Roads
- Tailings Storage Facility

Theoretical Zones of Visual Influence

- 1,263 m RL (Current)
- 1,266 m RL (3m Lift)
- 1,274 m RL (11m Lift)

Note: Due to an artifact of modelling, TZVI results are potentially unreliable within 400m of TSF.

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0 1,000 2,000
metres

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THEORETICAL ZONES OF VISUAL INFLUENCE - COMPARISON

FIGURE 6

Document Path: V:\05 Projects\Hillgrove Resources\57085 Kanmantoo TSF VIA\8 - ArcGIS\Maps\Final Report Maps\57085_06_TZVI Comparison.mxd
Image Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

4.1.3 Increase in Visible TSF (%)

At a chosen receptor location, the increase in visible TSF associated with each of the models (1,266 m RL and 1,274 m RL) was calculated.

The limit of the TSF currently visible at a chosen receptor location was determined by running diminishing viewshed analyses. Knowing the limit of visibility enables calculation of the amount of visible TSF.

The increase in the amount of the TSF that is visible to a receptor has been calculated to provide a measure of how much more of the TSF will be visible as the height is increased. This is important as receptors will not necessarily see the entire face of the TSF, but may only see the top portion due to topographical or other shielding. This percent increase in the amount of TSF that would be visible was calculated by dividing the number of metres of the TSF lift, 'L' by the number of metres of the TSF currently visible, 'V' resulting in percentage increase, 'i' as graphically presented in **Plate 15** below.

$$i = \left(\frac{\mathrm{L}}{\mathrm{V}}\right)100$$

Plate 15: Formula increase in visible portion of TSF (%)

The increase in visible portion of TSF (%) is a measure of the additional visible impact at a location. It is broken into four categories of impact, visible in **Table 4.2** below.

Table 4.2: Additional Visual Impact

Additional Impact	Increase in Visible Portion of TSF (%)	Description
Large	>76 %	The maximum visual impact associated with the TSF lifts. The amount of visible TSF is approximately double or more.
Medium	75% – 51 %	Decreasing impact, but the lift is still obvious. The visible portion of the TSF will appear to be 50 to 75 percent larger than it currently does.
Small	50% – 26 %	The visible portion of the TSF will appear to be 50 to 26 percent larger than it currently does. There will be a moderate additional impact.
Very Small	<25 %	Low additional visual impact. The visible portion of the TSF is not obvious, appearing up to 25% larger than it currently does.

4.1.4 Distance Analysis

Distance is a key determining factor of the degree of visual impact, as both apparent size (**Plate 1**) and visual contrast decrease exponentially with distance (Hecht, 2017). Receptor distance within the Project area has been broken into four categories of visual impact based on distance of the viewer from the TSF, as seen in **Table 4.3** below.

Table 4.3: Distance Group

Distance Group	Distance from Development (m)	Description
Adjacent	0 – 400 m	The maximum visual impact associated with distance. Developments dominate the visual field and dramatically alter the landscape. At 400 m a 70 m high object occupies approximately 10°, or roughly 66% of the central field of view.
Near	401 – 1,200 m	Decreasing effect, but developments are still very obvious in the visual field and alter the landscape. At 1,200 m a 70 m object occupies 3°, or roughly 22% of the central field of view.
Far	1,201 – 2,800 m	Moderate visual impact. Developments are easy to see and alter the landscape to a degree. At 2,800 m a 70 m object occupies 1.432°, or roughly 10% of the central field of view.
Distant	>2,801 m	Low visual impact. Developments are becoming less distinct and are not obvious in the visual field. At 5,348 m a 70 m object occupies 0.75°, or roughly 5% of the central field of view.

4.1.5 Receptor Identification

Stage 1

The previously completed VIAs (as discussed in **Section 2**) identified receptors surrounding the Site. The validity of these receptors was assessed and deemed appropriate for use in this VIA. Representative receptors were chosen to facilitate comparison of the existing and proposed TSF heights.

Stage 2

An additional desktop review of relevant government databases and previously completed VIAs was undertaken to identify additional receptors and potential receptors. This included using sensitive receptors published in the PEPR (2014) and desktop identification utilising Google Earth Pro (2019) and online databases. To ensure a thorough assessment of the landscape and inclusion of all potentially sensitive receptors, less (and non) visible sensitive receptors were captured by consulting the following sources of information and databases:

- Australian collaborative land use and management program;
- Land development zones;
- Land use generalised;
- Local, State and Government registered towns; and
- South Australian heritage places.

Stage 3

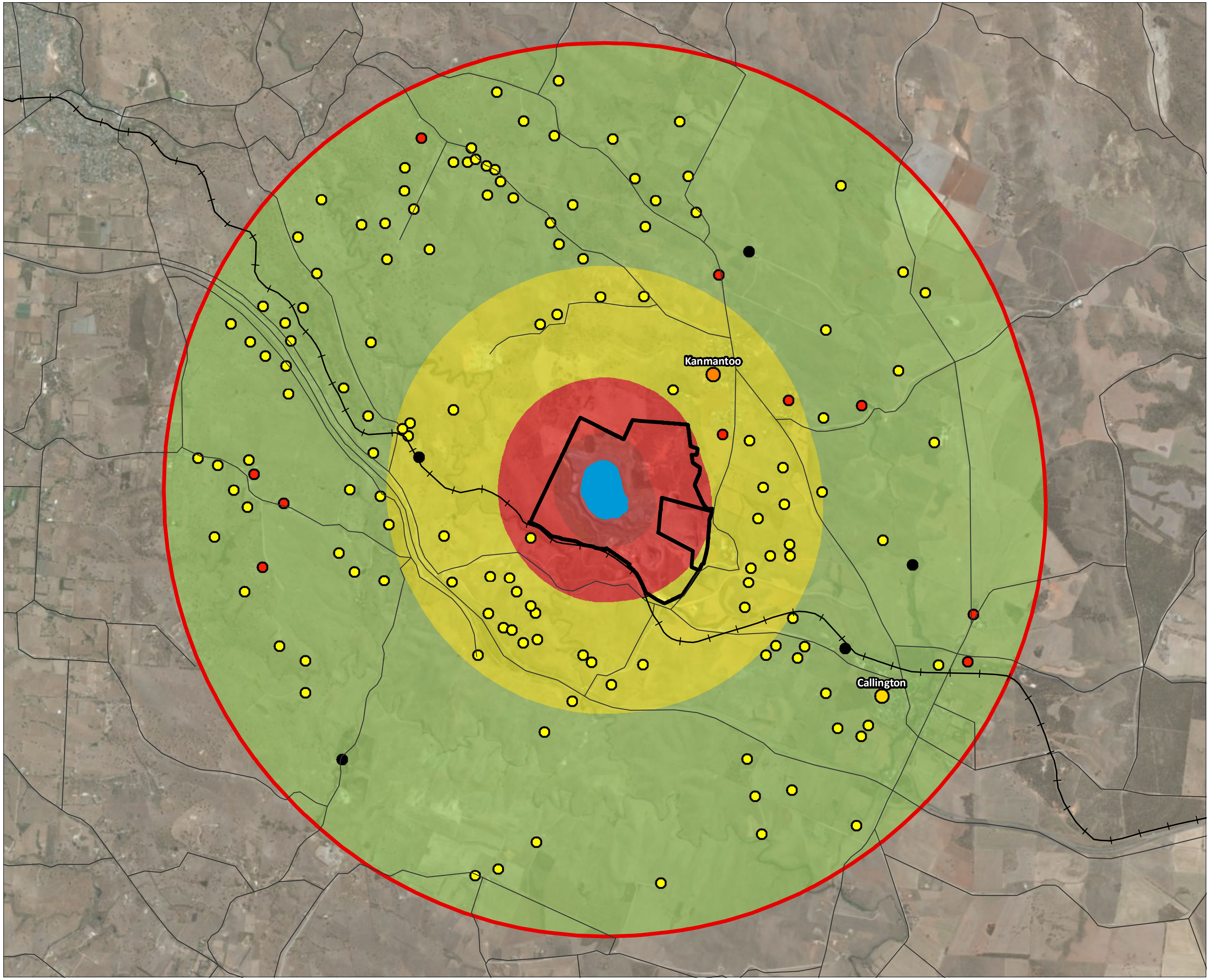
Final receptor selections were based on:

- Existing receptors;
- Distance to the TSF;
- Elevation;
- Extent of TSF visibility;
- Frequency of viewing; and
- Receptor type/ category.

Table 4.4 below shows a count of where the identified receptors are located in relation to the defined distance groups and within each TZVIs for the Current, 3 m and 11 m TSF. These are respectively presented graphically in **Figure 7** and **Figure 8**, and discussed in **Section 5.2**.

Table 4.4: Identified Receptors Within Distance Group and Each TSF TZVI

Distance Group	Count of Total Receptors (within Project Area)	Count of Receptors (within Current TSF TZVI)	Percent of Receptors (within Current TSF TZVI)	Count of Receptors (within 3 m Lift TSF TZVI)	Percent of Receptors (within 3 m Lift TSF TZVI)	Count of Receptors (within 11 m Lift TSF TZVI)	Percent of Receptors (within 11 m Lift TSF TZVI)
Adjacent	0	0	0 %	0	0 %	0	0 %
Near	1	0	0 %	0	0 %	0	0 %
Far	43	11	26 %	14	33 %	15	35 %
Distant	104	26	25 %	31	30 %	48	46 %
Total	**148**	**37**	**25 %**	**45**	**30 %**	**63**	**43 %**



Legend:

- Project Area
- Mine Lease Boundary
- Tailings Storage Facility
- Railways
- Roads

Identified Receptors - JBS&G 2019

- Callington
- Kanmantoo
- Commercial
- Residence
- Residences

Distance Group

- Adjacent
- Near
- Far
- Distant

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metres

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IDENTIFIED RECEPTORS WITHIN THE PROJECT AREA

FIGURE 7

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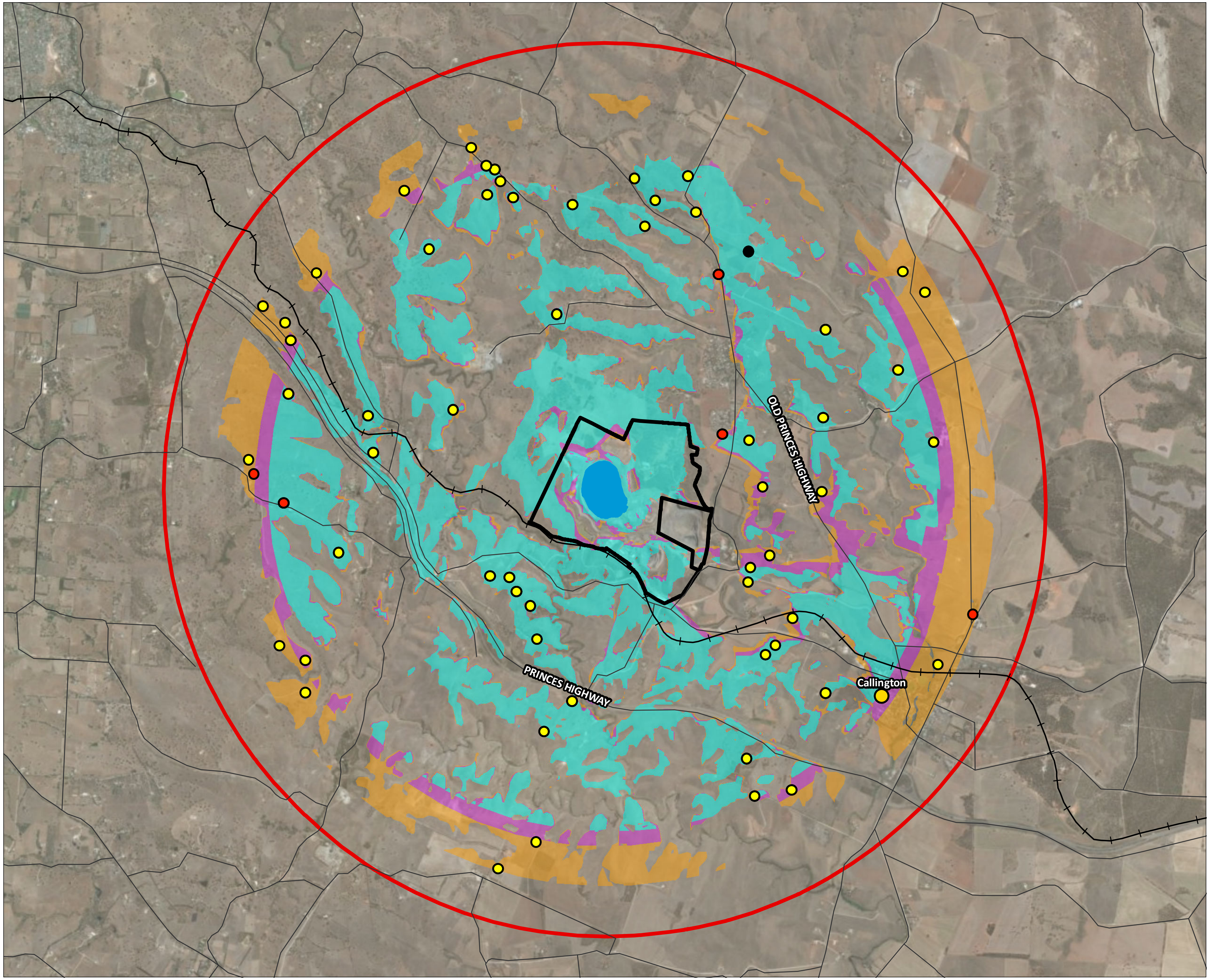
Image Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend:
- Project Area
- Mine Lease Boundary
- Tailings Storage Facility
- Railways
- Roads

Identified Receptors - JBS&G 2019
- Callington
- Commercial
- Residence
- Residences

Theoretical Zones of Visual Influence
- 1,263 m RL (Current)
- 1,266 m RL (3m Lift)
- 1,274 m RL (11m Lift)

Note: Due to an artifact of modelling, TZVI results are potentially unreliable within 400m of TSF.

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Client: Hillgrove Resources	
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0 1,000 2,000
metres

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RESPECTIVE IDENTIFIED RECEPTORS WITHIN EACH TSF TZVI

FIGURE 8

Document Path: V:\05 Projects\Hillgrove Resources\57085 Kanmantoo TSF VIA\8 - ArcGIS\Maps\Final Report Maps\57085_08_Identified Receptors_within_TZVIs.mxd
Image Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

4.1.6 Theoretical Visual Impact Matrix

Following viewshed analysis, the visual impact of the TSF lifts can be calculated by utilising the Visual Impact Matrix. Combining the distance groups (**Table 4.1**) and Increase in visible portion of TSF (5) (**Plate 15**) results in a visual impact rating. The matrix is visible below in **Table 4.5.**

Table 4.5: Visual Impact Matrix

		Increase of Visible TSF			
		Large	Medium	Small	Very Small
Distance Group	Adjacent	High	Moderate	Moderate to Low	Low
	Near	High	Moderate	Moderate to Low	Low
	Far	Moderate	Moderate to Low	Low	Low
	Distant	Moderate to Low	Moderate to Low	Low	Very Low

The definitions of the visual impact scores can are provided below:

- High: The lift is very obvious in the visual field and alters the landscape;
- Moderate: The lift is obvious, but no longer dominates the landscape;
- Moderate to Low: The lift can be seen in the visual field and alters the landscape to a degree;
- Low: The lift is becoming less distinct, and is not obvious in the visual field; and
- Very Low: Limited/no visual effect on the landscape, visible as a very minor feature in some locations.

4.2 Phase 2: Photomontage Assessment

Following the desktop assessment, a field assessment and collection of representative 360-degree photographs of the Project area landscape was completed for the development of photomontages to visually compare the existing and future landscape from the selected viewpoint locations.

4.2.1 Photomontage Methodology and Viewpoint Locations

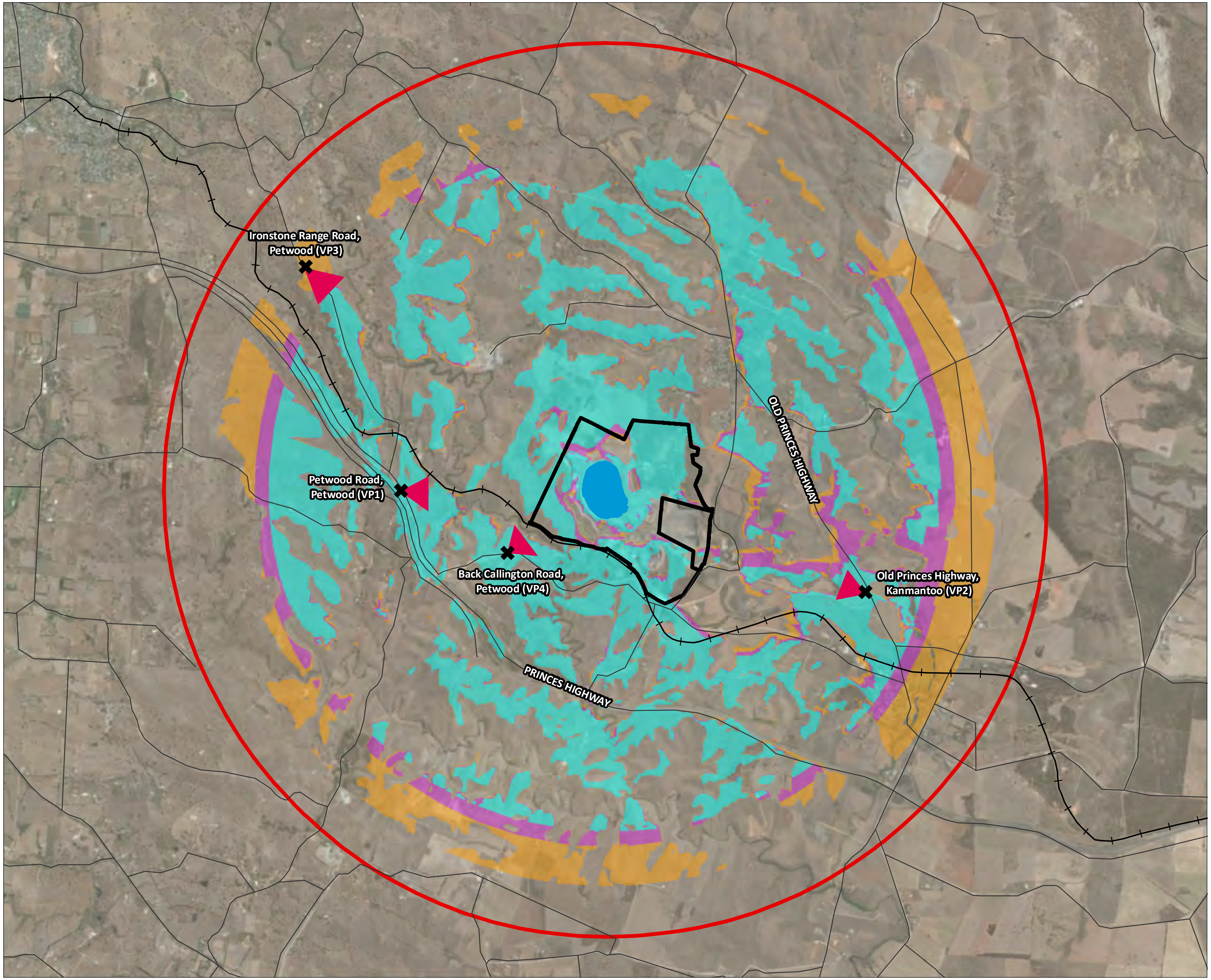
Representative 360-degree photographs (completed on the 4th August 2019) of the Project area's landscape (as discussed in **Section 2.4**) at replica (or as best as possible) viewpoint locations (kept to public viewing locations/ land), as presented in the PEPR[12] .

The replica viewpoint locations are:

- Viewpoint 1 – Petwood Road Petwood, looking east (VP1);
- Viewpoint 2 – Old Princes Highway Kanmantoo, looking west north west (VP2);
- Viewpoint 3 – Ironstone Range Road, Petwood, looking south east (VP3); and
- Viewpoint 4 – Back Callington Road, Petwood, looking north east (VP4).

The viewpoint locations with respect to the current TSF height and two TSF AutoCAD models is presented in **Figure 9**.

[12] Program for Environment Protection and Rehabilitation – Life of Mine (2014), ML6345 and ML6436 - Kanmantoo Copper Mine (Ver: V6)



Legend:

- Project Area
- Mine Lease Boundary
- Tailings Storage Facility
- Viewpoint Location
- Photomontage Direction of View
- Roads
- Railways

Theoretical Zones of Visual Influence

- 1,263 m RL (Current)
- 1,266 m RL (3m Lift)
- 1,274 m RL (11m Lift)

Note: Due to an artifact of modelling, TZVI results are potentially unreliable within 400m of TSF.

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Version: FINAL	Date: 27-Aug-2019
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Scale at A4 1:80,000	

0 1,000 2,000
metres

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Kanmantoo, South Australia

VIEWPOINT LOCATIONS

FIGURE 9

Document Path: V:\05 Projects\Hillgrove Resources\57085 Kanmantoo TSF VIA\8 - ArcGIS\Maps\Final Report Maps\57085_09_Photomontage Locations.mxd
Image Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Although the central cone of vision (discussed in **Section 1.5.1**) is only 15 degrees, it is noted that when viewing any particular location, a human does not keep their head and eyes fixed (Tilley, 1993). This leads to consideration of an area that is the aggregate of many different scenes processed as the field of view (Hecht, 2017).

Photomontages for each viewpoint location were developed through creating a digital representation of the existing landscape, topography, vegetation and urban form. A rendered model for each of the TSF's design is then overlaid and corrected to mask the TSF or parts of the TSF that are screened by vegetation and other elements within the foreground. This ensures that the TSF's appears in the correct location in the photomontage.

Photomontage outputs consist of the following:

- Current TSF at 1,263 m RL:
  - Baseline Image 1A: Representative base image (baseline) of the Project area's landscape;
  - Baseline Image 1B: Representative base image (baseline) and highlighted current TSF extent;
- TSF at 1,266 m RL (3m Lift):
  - Photomontage 1A: Representative base image (baseline) and TSF at 1,266 m RL modelled;
  - Photomontage 1B: Representative base image (baseline), highlighted current TSF extent and TSF at 1,266 m RL;
- TSF at 1,274 m RL (11m Lift):
  - Photomontage 2A: Representative base image (baseline) and TSF at 1,274 m RL modelled;
  - Photomontage 2B: Representative base image (baseline), highlighted current TSF extent, TSF at 1,266 m RL and TSF at 1,274 m RL; and
- Render of Rehabilitated Tailings Storage Facility at 1,274 m RL (11m Lift):
  - Photomontage 3: Representative base image (baseline) and render of rehabilitated TSF at 1,274 m RL.

The viewpoint locations and photomontages are analysed in **Section 3.2.2** to **Section 3.2.5**.

4.2.2 Viewpoint 1 Photomontage Analysis: Petwood Road, Petwood, looking east (VP1)

The Petwood Road, Petwood viewpoint location is located to the west of the TSF and within a landscape characterised by undulating ridges and valleys, which contains vegetation cover in the foreground and assist in creating a natural visual screen (mitigating measure) of the portion of the TSF which is currently visible.

The analysis on the Petwood Road, Petwood viewpoint location is discussed in **Table 4.6** below and photomontages are presented below.

Table 4.6: Viewpoint 1 Photomontage Analysis – Petwood Road, Petwood (VP1)

Component	Characteristic
Photomontage Location	Petwood Road, Petwood
Eastings (MGA Zone 54)	314,084
Northings (MGA Zone 54)	6,115,454
Elevation	246 m
Date and Time of Baseline Image	4th August 2019 at 10:00 AM
Direction of View	Looking east
Distance to TSF (approximate)	2.9 kms
Directional Visual Landscape (**Section 2.5**)	West
TSF height of 1,263 m RL (263 m AHD) (current)	
Portion (m) of TSF visible (approximate)	23 m
Distance from TSF (**Table 3.3**)	Far
TSF height of 1,266 m RL (266m AHD) (3m lift)	
Increase in visible portion of TSF (**Table 3.2**)	Very small
Distance from TSF (**Table 3.3**)	Far
Visual Impact Rating (**Table 3.5**)	Low
TSF height of 1,274 m RL (274m AHD) (11m lift)	
Increase in visible portion of TSF (**Table 3.2**)	Small
Distance from TSF (**Table 3.3**)	Far
Visual Impact Rating (**Table 3.5**)	Low

The increase in visibility for the TSF height of 1,266 m RL (266m AHD) (3m lift) is *very small* and will not be obvious. The increase in visibility for the TSF height of 1,274 m RL (274m AHD) (11m lift) is *small* and provides a moderate impact. The viewpoint location is located more than 2.8 kms from the TSF and is considered *distant*.

The mitigating effects of the landscape character and vegetation provide a natural visual screen and the overall visual impact on the Petwood Road, Petwood viewpoint location is considered to have a *low* visual impact.

Viewpoint 1 Photomontage: Petwood Road, Petwood, looking east (VP1)

Current Tailings Storage Facility 1,263 m RL (Current)

Baseline Image 1A: Current Tailings Storage Facility 1,263 m RL (Current)

Baseline Image 1B: Current Tailings Storage Facility Highlighted 1,263 m RL (Current)

Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 1: Petwood Road, Petwood	Looking east	4th August 2019 at 10:00 AM

Viewpoint 1 Photomontage: Petwood Road, Petwood, looking east (VP1)

Tailings Storage Facility at 1,266 m RL (3m Lift)

Photomontage 1A: Tailings Storage Facility at 1,266 m RL (3m Lift)

Photomontage 1B: Tailings Storage Facility Highlighted at 1,266 m RL (3m Lift)

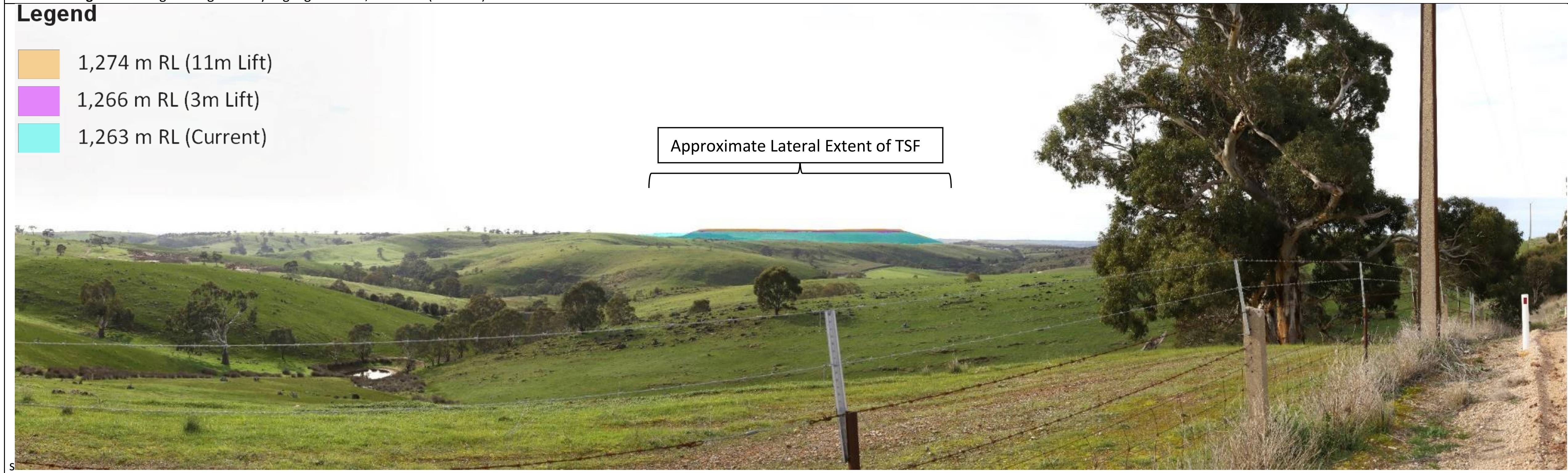
Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 1: Petwood Road, Petwood	Looking east	4th August 2019 at 10:00 AM

Viewpoint 1 Photomontage: Petwood Road, Petwood, looking east (VP1)

Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 2A: Tailings Storage Facility at 1,274 m RL (11m Lift)

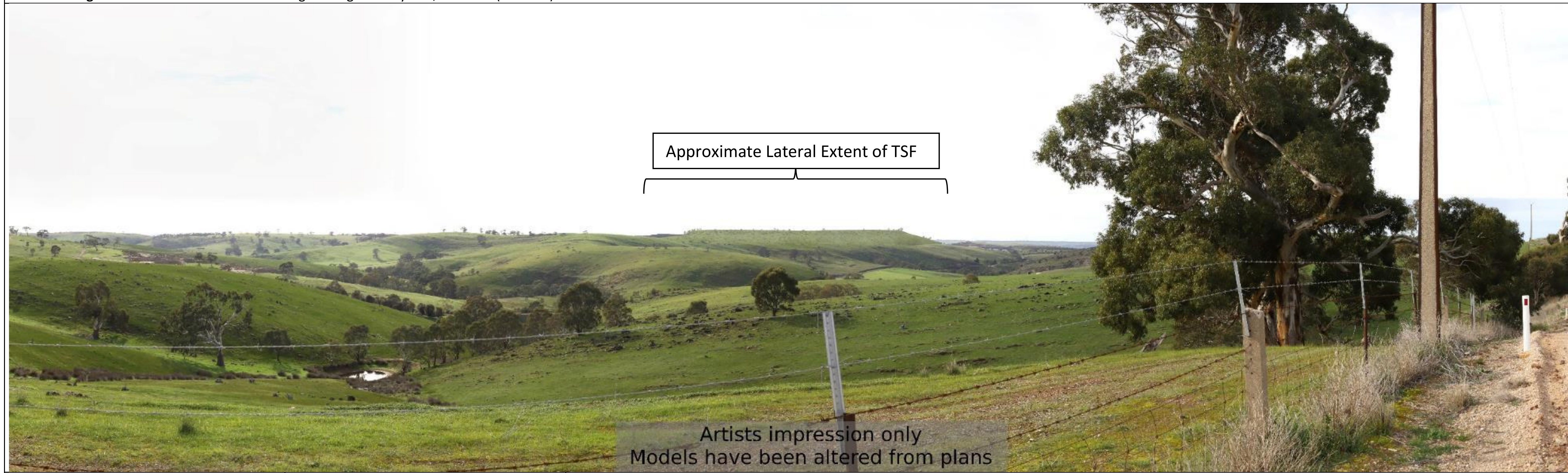
Photomontage 2B: Tailings Storage Facility Highlighted at 1,274 m RL (11m Lift)



Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 1: Petwood Road, Petwood	Looking east	4th August 2019 at 10:00 AM

Viewpoint 1 Photomontage: Petwood Road, Petwood, looking east (VP1)

Render of Rehabilitated Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 3: Render of Rehabilitated Tailings Storage Facility at 1,274 m RL (11m Lift)		
		
Viewpoint Location	**Direction of View**	**Date and Time of Baseline Image**
Viewpoint 1: Petwood Road, Petwood	Looking east	4th August 2019 at 10:00 AM

4.2.3 Viewpoint 2 Photomontage Analysis: Old Princes Highway, Kanmantoo, looking west north west (VP2)

The Old Princes Highway, Kanmantoo viewpoint location is located to the east of the TSF and within a landscape characterised by areas of low elevation and contains vegetation in the foreground which provides natural visual screen (mitigating measure) of the portion of the TSF which is currently visible.

The analysis on the Old Princes Highway, Kanmantoo viewpoint location is discussed in **Table 4.7** below and photomontages are presented below.

Table 4.7: Viewpoint 2 Photomontage Analysis – Old Princes Highway, Kanmantoo (VP2)

Component	Characteristic
Photomontage Location	Old Princes Highway, Kanmantoo
Eastings (MGA Zone 54)	320,751
Northings (MGA Zone 54)	6,114,001
Elevation	114 m
Date and Time of Baseline Image	4th August 2019 at 11:06 AM
Direction of View	Looking west north west
Distance to TSF (approximate)	4.16 kms
Directional Visual Landscape (**Section 2.5**)	East
TSF height of 1,263 m RL (263 m AHD) (current)	
Portion (m) of TSF visible (approximate)	50 m
Distance from TSF (**Table 3.3**)	Distant
TSF height of 1,266 m RL (266m AHD) (3m lift)	
Increase in visible portion of TSF (**Table 3.2**)	Very Small
Distance from TSF (**Table 3.3**)	Distant
Visual Impact Rating (**Table 3.5**)	Very Low
TSF height of 1,274 m RL (274m AHD) (11m lift)	
Increase in visible portion of TSF (**Table 3.2**)	Very Small
Distance from TSF (**Table 3.3**)	Distant
Visual Impact Rating (**Table 3.5**)	Very Low

The increase in visibility for the TSF height of 1,266 m RL (266m AHD) (3m lift) and TSF height of 1,274 m RL (274m AHD) (11m lift) is *very small* and will not be obvious. The viewpoint location is located more than 2.8 kms from the TSF and is considered *distant*.

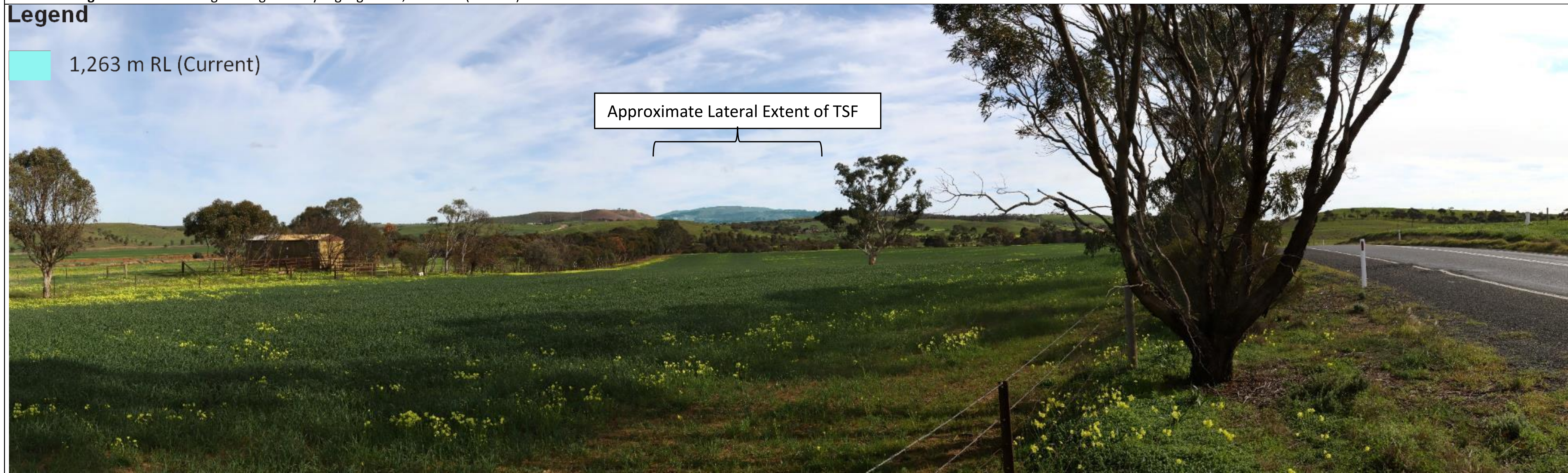
The mitigating effects of the landscape character and vegetation provide a natural visual screen and the overall visual impact on the Old Princes Highway, Kanmantoo viewpoint location is considered to have a *very low* visual impact.

Viewpoint 2 Photomontage: Old Princes Highway, Kanmantoo, looking west north west (VP2)

Current Tailings Storage Facility 1,263 m RL (Current)

Baseline Image 1A: Current Tailings Storage Facility 1,263 m RL (Current)

Baseline Image 1B: Current Tailings Storage Facility Highlighted 1,263 m RL (Current)



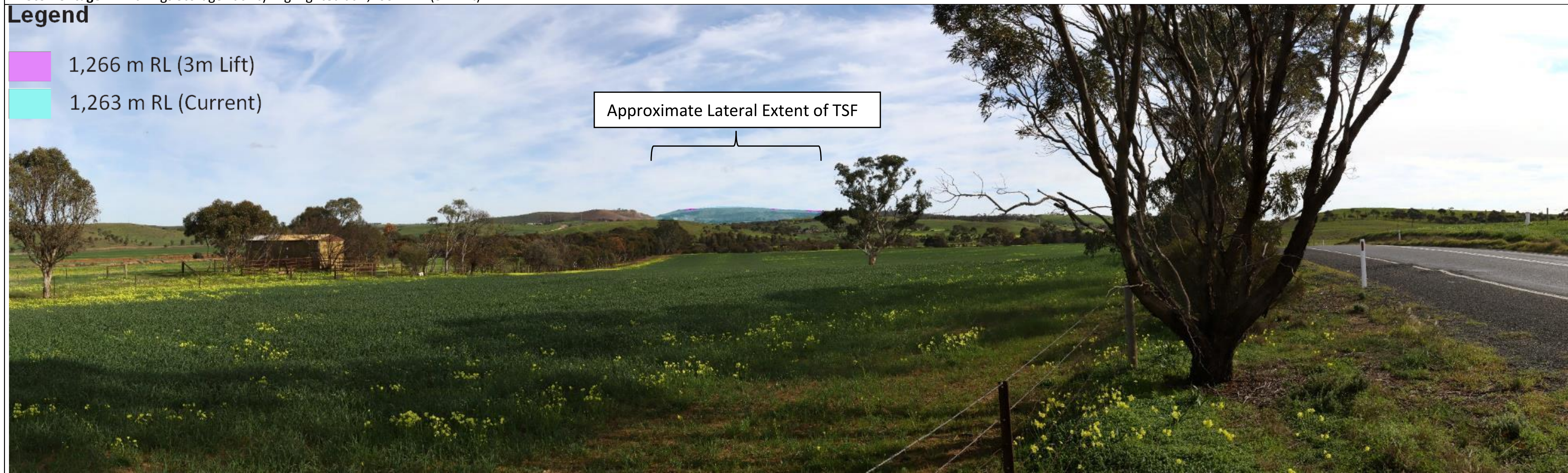
Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 2: Old Princes Highway, Kanmantoo	Looking west north west	4th August 2019 at 11:06 AM

Viewpoint 2 Photomontage: Old Princes Highway, Kanmantoo, looking west north west (VP2)

Tailings Storage Facility at 1,266 m RL (3m Lift)

Photomontage 1A: Tailings Storage Facility at 1,266 m RL (3m Lift)

Photomontage 1B: Tailings Storage Facility Highlighted at 1,266 m RL (3m Lift)



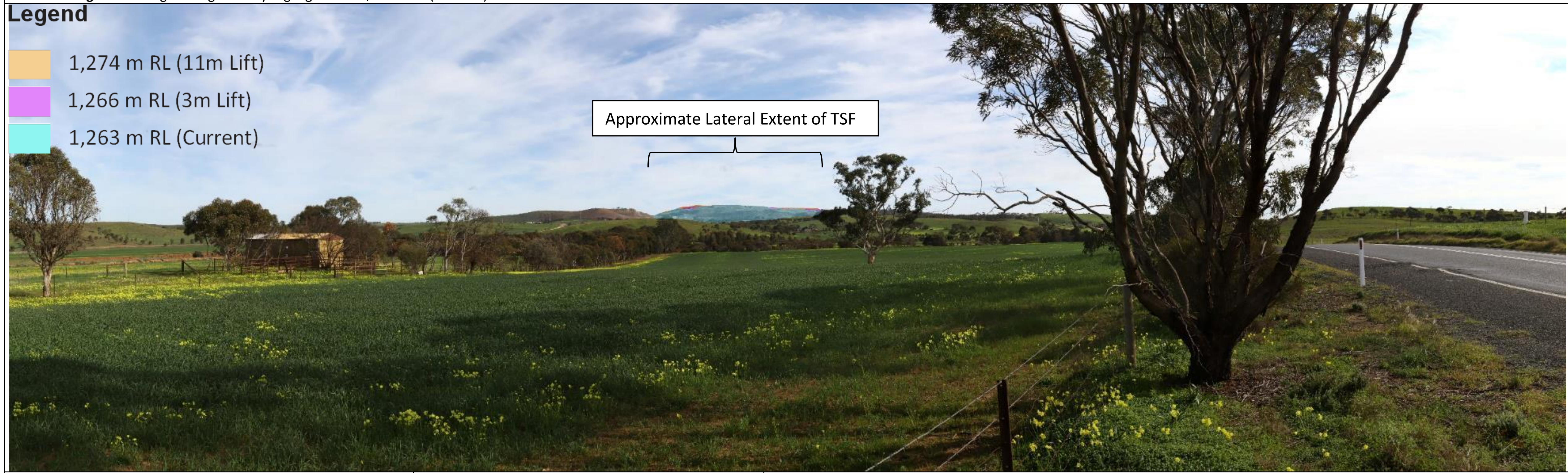
Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 2: Old Princes Highway, Kanmantoo	Looking west north west	4th August 2019 at 11:06 AM

Viewpoint 2 Photomontage: Old Princes Highway, Kanmantoo, looking west north west (VP2)

Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 2A: Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 2B: Tailings Storage Facility Highlighted at 1,274 m RL (11m Lift)

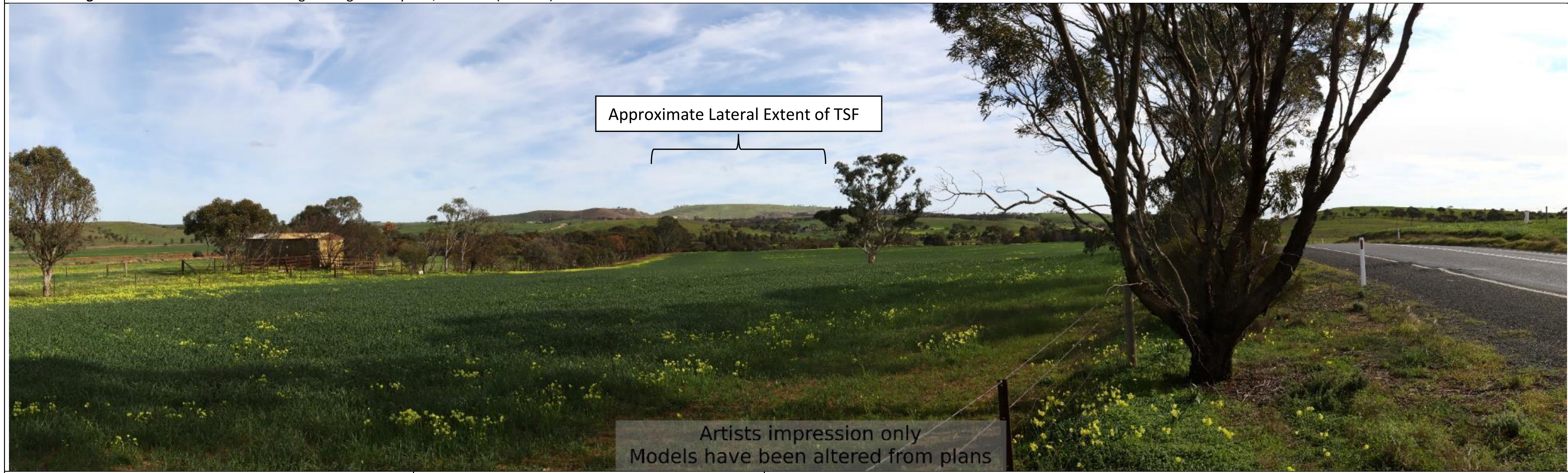


Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 2: Old Princes Highway, Kanmantoo	Looking west north west	4th August 2019 at 11:06 AM

Viewpoint 2 Photomontage: Old Princes Highway, Kanmantoo, looking west north west (VP2)

Render of Rehabilitated Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 3: Render of Rehabilitated Tailings Storage Facility at 1,274 m RL (11m Lift)



Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 2: Old Princes Highway, Kanmantoo	Looking west north west	4th August 2019 at 11:06 AM

4.2.4 Viewpoint 3 Photomontage Analysis: Ironstone Range Road, Petwood, looking south east (VP3)

The Ironstone Range Road, Petwood viewpoint location is located to the west of the TSF and within a landscape characterised by undulating ridges and valleys, which contains vegetation cover in the foreground and assist in creating a natural visual screen (mitigating measure) of the portion of the TSF which is currently visible.

The analysis on the Ironstone Range Road, Petwood viewpoint location is discussed in **Table 4.8** below and photomontages are presented below.

Table 4.8: Viewpoint 3 Photomontage Analysis – Ironstone Range Road, Petwood (VP3)

Component	Characteristic
Photomontage Location	Ironstone Range Road, Petwood
Eastings (MGA Zone 54)	312,716
Northings (MGA Zone 54)	6,118,670
Elevation	348 m
Date and Time of Baseline Image	4th August 2019 at 9:32 AM
Direction of View	Looking south east
Distance to TSF (approximate)	5.3 kms
Directional Visual Landscape (**Section 2.5**)	West
TSF height of 1,263 m RL (263 m AHD) (current)	
Portion (m) of TSF visible (approximate)	<1 m
Distance from TSF (**Table 3.3**)	Distant
TSF height of 1,266 m RL (266m AHD) (3m lift)	
Increase in visible portion of TSF (**Table 3.2**)	Very small
Distance from TSF (**Table 3.3**)	Distant
Visual Impact Rating (**Table 3.5**)	Very low
TSF height of 1,274 m RL (274m AHD) (11m lift)	
Increase in visible portion of TSF (**Table 3.2**)	Large
Distance from TSF (**Table 3.3**)	Distant
Visual Impact Rating (**Table 3.5**)	Moderate to Low

The increase in visibility for the TSF height of 1,266 m RL (266m AHD) (3m lift) is *very small* and will not be obvious. The increase in visibility for the TSF height of 1,274 m RL (274m AHD) (11m lift) is *large* and the visible amount of TSF is approximately double. The viewpoint location is located more than 2.8 kms from the TSF and is considered *distant*.

The mitigating effects of the landscape character and vegetation provide a natural visual screen and the overall visual impact on the Ironstone Range Road, Petwood viewpoint location is considered to have a *very low* to *moderate to low* visual impact. Distance is a key determining factor of the degree of visual impact and the photomontages present that the visual contrast decrease with distance.

Viewpoint 3 Photomontage: Ironstone Range Road, Petwood, looking south east (VP3)

Current Tailings Storage Facility 1,263 m RL (Current)

Baseline Image 1A: Current Tailings Storage Facility 1,263 m RL (Current)

Baseline Image 1B: Current Tailings Storage Facility Highlighted 1,263 m RL (Current)

Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 3: Ironstone Range Road, Petwood	Looking south east	4th August 2019 at 9:32 AM

Viewpoint 3 Photomontage: Ironstone Range Road, Petwood, looking south east (VP3)

Tailings Storage Facility at 1,266 m RL (3m Lift)

Photomontage 1A: Tailings Storage Facility at 1,266 m RL (3m Lift)

Photomontage 1B: Tailings Storage Facility Highlighted at 1,266 m RL (3m Lift)

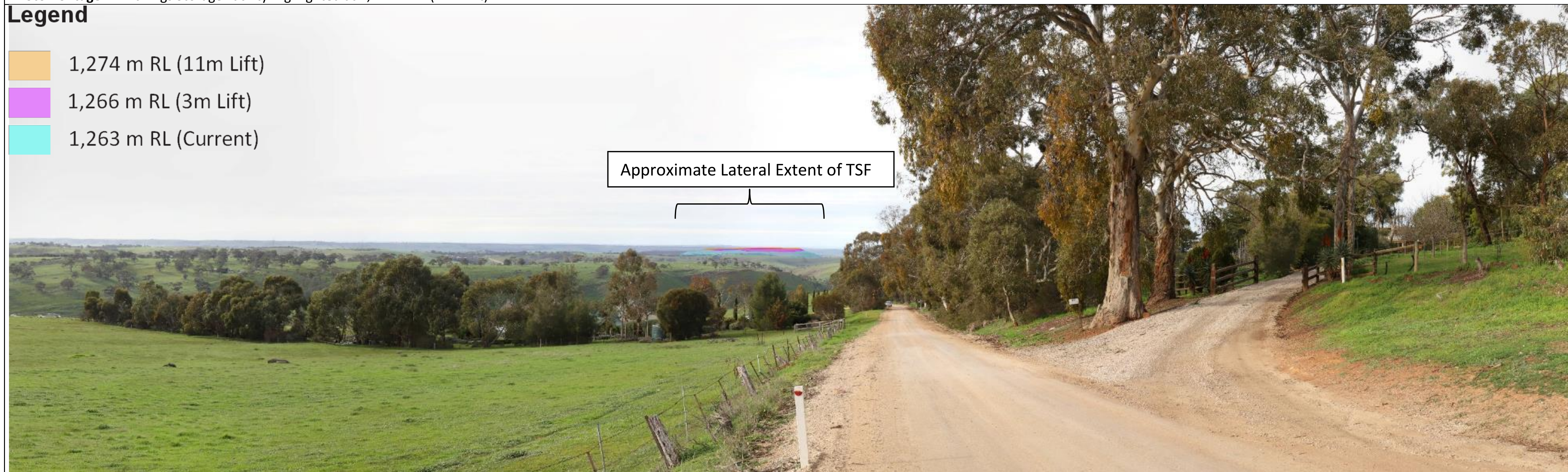
Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 3: Ironstone Range Road, Petwood	Looking south east	4th August 2019 at 9:32 AM

Viewpoint 3 Photomontage: Ironstone Range Road, Petwood, looking south east

(VP3) Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 2A: Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 2B: Tailings Storage Facility Highlighted at 1,274 m RL (11m Lift)

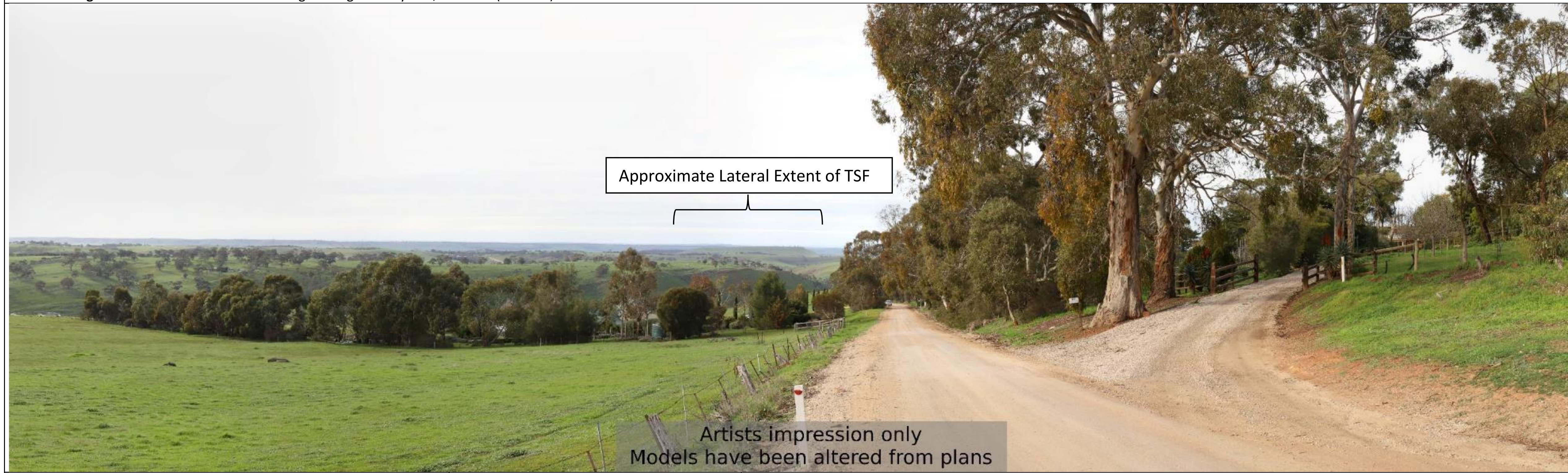


Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 3: Ironstone Range Road, Petwood	Looking south east	4th August 2019 at 9:32 AM

Viewpoint 3 Photomontage: Ironstone Range Road, Petwood, looking south east (VP3)

Render of Rehabilitated Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 3: Render of Rehabilitated Tailings Storage Facility at 1,274 m RL (11m Lift)



Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 3: Ironstone Range Road, Petwood	Looking south east	4th August 2019 at 9:32 AM

4.2.5 Viewpoint 4 Photomontage Analysis: Back Callington Road, Petwood, looking north east (VP4)

The Back Callington Road, Petwood viewpoint location is located to the west/ south of the TSF and within a landscape characterised by highly undulating to undulating ridges and valleys, which contains fragmented vegetation in the foreground and assist in creating a natural visual screen (mitigating measure) of the portion of the TSF which is currently visible.

The analysis on the Back Callington Road, Petwood viewpoint location is discussed in **Table 4.9** below and photomontages are presented below.

Table 4.9: Viewpoint 4 Photomontage Analysis – Back Callington Road, Petwood (VP4)

Component	Characteristic
Photomontage Location	Back Callington Road, Petwood
Eastings (MGA Zone 54)	315,617
Northings (MGA Zone 54)	6,114,562
Elevation	238 m
Date and Time of Baseline Image	4th August 2019 at 10:26 AM
Direction of View	Looking north east
Distance to TSF (approximate)	1.65 kms
Directional Visual Landscape (**Section 2.5**)	West/ South
TSF height of 1,263 m RL (263 m AHD) (current)	
Portion (m) of TSF visible (approximate)	60 m
Distance from TSF (**Table 3.3**)	Far
TSF height of 1,266 m RL (266m AHD) (3m lift)	
Increase in visible portion of TSF (**Table 3.2**)	Very Small
Distance from TSF (**Table 3.3**)	Far
Visual Impact Rating (**Table 3.5**)	Low
TSF height of 1,274 m RL (274m AHD) (11m lift)	
Increase in visible portion of TSF (**Table 3.2**)	Small
Distance from TSF (**Table 3.3**)	Far
Visual Impact Rating (**Table 3.5**)	Low

The increase in visibility for the TSF height of 1,266 m RL (266m AHD) (3m lift) is *very small* and will not be obvious. The increase in visibility for the TSF height of 1,274 m RL (274m AHD) (11m lift) is *small* and provides a moderate impact. The viewpoint location is located more than 1.2 kms from the TSF and is considered *far*.

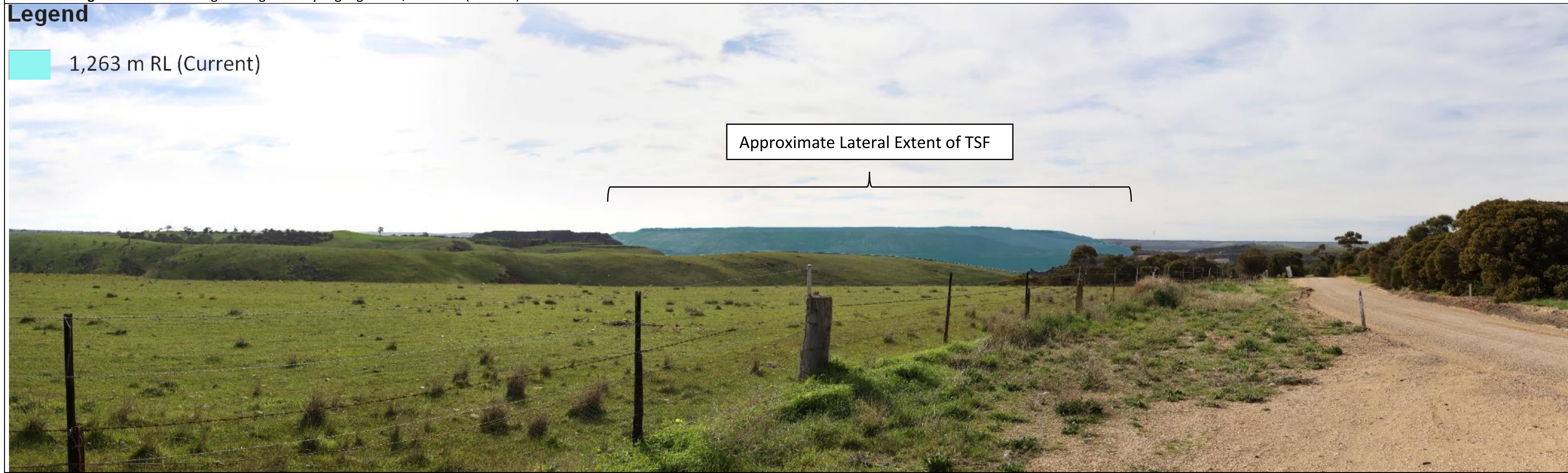
The mitigating effects of the landscape character and vegetation provide a natural visual screen and the overall visual impact on the Back Callington Road, Petwood viewpoint location is considered to have a *low* visual impact.

Viewpoint 4 Photomontage: Back Callington Road, Petwood, looking north east (VP4)

Current Tailings Storage Facility 1,263 m RL (Current)

Baseline Image 1A: Current Tailings Storage Facility 1,263 m RL (Current)

Baseline Image 1B: Current Tailings Storage Facility Highlighted 1,263 m RL (Current)



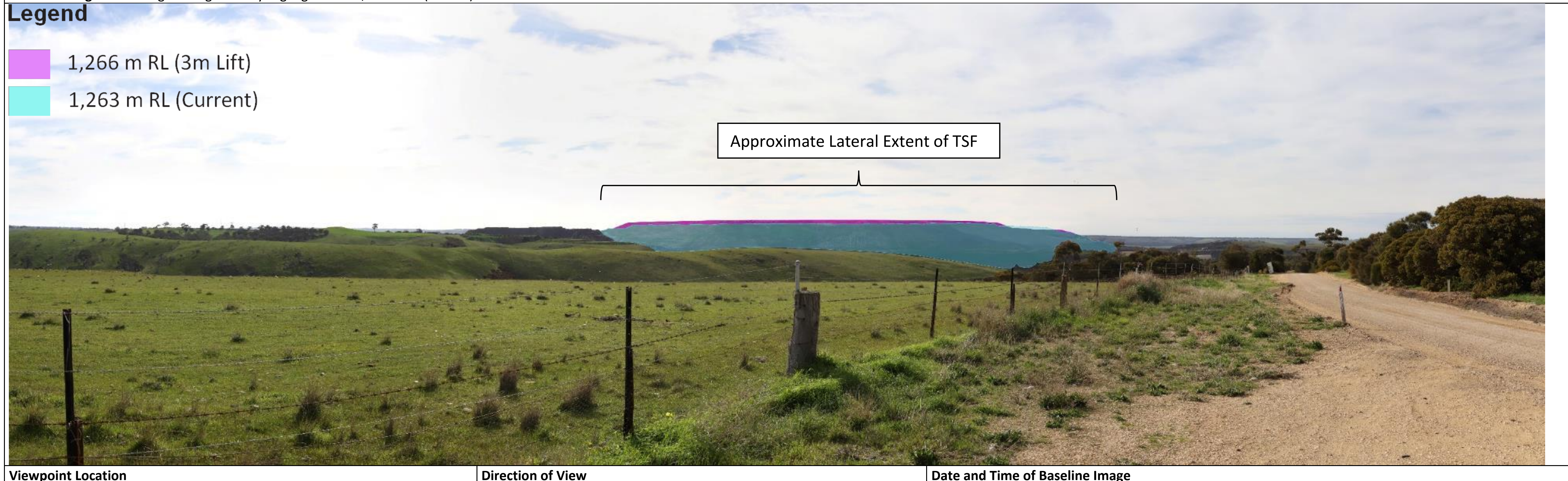
Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 4: Back Callington Road, Petwood	Looking north east	4th August 2019 at 10:26 AM

Viewpoint 4 Photomontage: Back Callington Road, Petwood, looking north east (VP4)

Tailings Storage Facility at 1,266 m RL (3m Lift)

Photomontage 1A: Tailings Storage Facility at 1,266 m RL (3m Lift)

Photomontage 1B: Tailings Storage Facility Highlighted at 1,266 m RL (3m Lift)



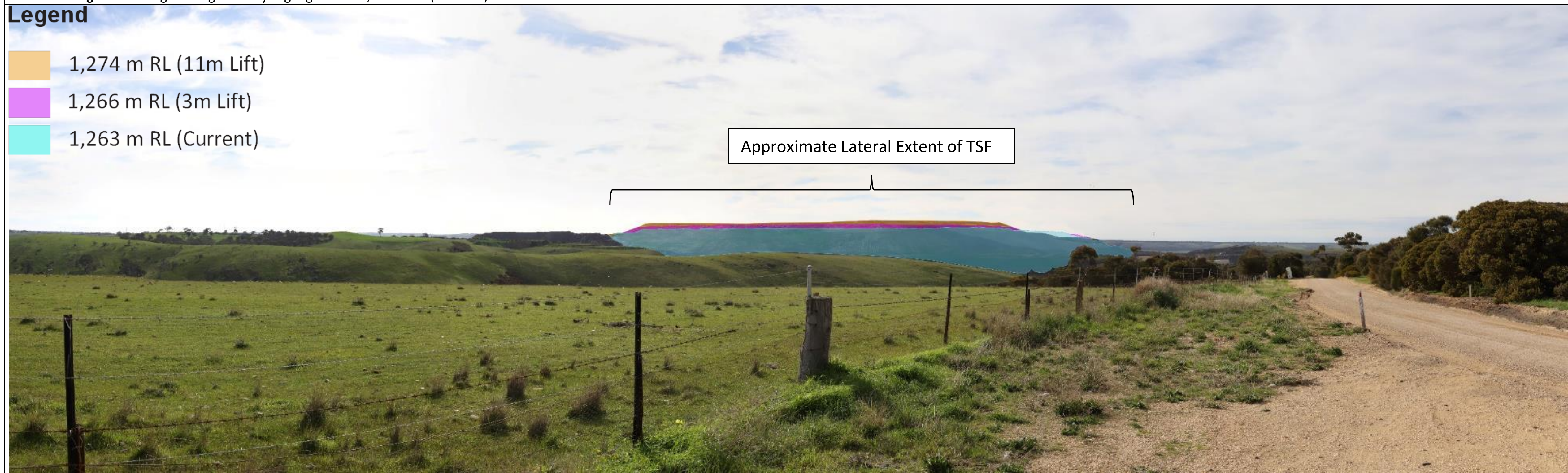
Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 4: Back Callington Road, Petwood	Looking north east	4th August 2019 at 10:26 AM

Viewpoint 4 Photomontage: Back Callington Road, Petwood, looking north east (VP4)

Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 2A: Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 2B: Tailings Storage Facility Highlighted at 1,274 m RL (11m Lift)

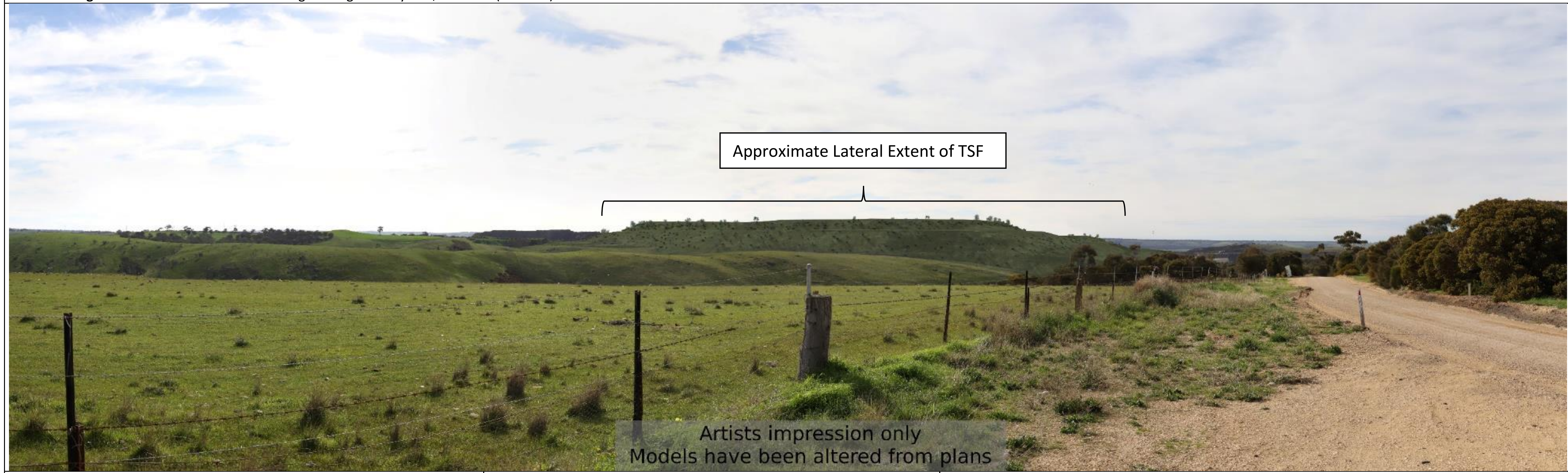


Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 4: Back Callington Road, Petwood	Looking north east	4th August 2019 at 10:26 AM

Viewpoint 4 Photomontage: Back Callington Road, Petwood, looking north east (VP4)

Render of Rehabilitated Tailings Storage Facility at 1,274 m RL (11m Lift)

Photomontage 3: Render of Rehabilitated Tailings Storage Facility at 1,274 m RL (11m Lift)



Viewpoint Location	Direction of View	Date and Time of Baseline Image
Viewpoint 4: Back Callington Road, Petwood	Looking north east	4th August 2019 at 10:26 AM

5. Discussion and Conclusion

5.1 Summary of Changes

Change to the current TSF height will result in the following approximate increase in the TSF height:

- The TSF height of 1,266 m RL (266m AHD) (3m lift) will increase the approximate height by 5.08 %; and
- The TSF height of 1,274 m RL (274m AHD) (11m lift) will increase the approximate height by 18.64 %.

The increase in the TSF height is not expected to significantly alter the current landscape within proximity to the Kanmantoo Site, which is already dominated by extractive/ mining industry land use (discussed in **Section 3.4**). From surrounding land use areas, the incremental increase in the proposed TSF lift is not expected to be significantly noticeable.

5.2 Summary of Receptors

As detailed in **Table 4.4**, the receptors that are closest to the TSF are likely to be more significantly impacted compared to those further away. Those within 400 m would be most impacted by the increase in the TSF height, however no sensitive receptors were identified within this distance and within the TZVI of the Current, 3 m and 11 m TSF. Within 401 – 1,200 m of the TSF one receptor was located, however this was not within the TZVI of the Current, 3 m and 11 m TSF. The largest number of receptors (104) were more than 2,801 m from the TSF, however a total count of 63 (43 %) of these receptors were within the TZVI of the 11 m TSF lift (discussed in **Section 4.1.5**) and are unlikely to be significantly impacted by the proposed TSF lift.

5.3 Implications of Landscape Change

The change to the current TSF height is not expected to significantly alter the character of the current landscape, bearing in mind that there is currently a TSF present and related mining activities in the area. Once works are complete, the rehabilitation of the final surface which will include shaping, placement of topsoil and planting of suitable vegetation will assist in reducing the visual impact of the TSF as a feature on the landscape. The final TSF landform will be designed to integrate within the landscape and reflect the surrounding landscape character and topography (discussed in **Section 2.3**).

The discussion and conclusion of this report should be read in conjunction with and with regard to the Limitations included in **Section 6**.

6. Limitations

This report has been prepared for use by the client who has commissioned the works in accordance with the project brief only, and has been based in part on information obtained from the client and other parties.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

JBS&G accepts no liability for use or interpretation by any person or body other than the client who commissioned the works. This report should not be reproduced without prior approval by the client, or amended in any way without prior approval by JBS&G, and should not be relied upon by other parties, who should make their own enquires.

Visual analysis and modelling is based on the AutoCAD data provided by the client. Conclusions arising from the review and assessment of this data are based on the analysis considered appropriate. The modelled visual appearance of the final development and associated landforms are indicative of the final appearance only.

This report does not provide a complete visual assessment of the site, and it is limited to the scope defined herein. Should information become available regarding conditions at the site including previously unknown sources of contamination, JBS&G reserves the right to review the report in the context of the additional information.

7. References

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Document Distribution

Rev No.	Copies	Recipient	Date
RevA – DRAFT	1 x Electronic PDF	Catherine Davis, Environment Manager, Hillgrove Resources Ltd	16 August 2019
Rev0 – FINAL	1 x Electronic PDF	Catherine Davis, Environment Manager, Hillgrove Resources Ltd	21 August 2019
Rev1 – FINAL	1 x Electronic PDF	Catherine Davis, Environment Manager, Hillgrove Resources Ltd	27 August 2019

Document Status

Rev No.	Author	Reviewer	Approved for Issue		
		Name	Name	Signature	Date
Rev1 – FINAL	Thomas Bratovic	David Blair	David Blair		27 August 2019

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Appendix C - Further Assessment and Consideration of Management of Seepage Water at the Kanmantoo Copper Mine (JBS&G, 2018)

4 September 2019

Catherine Davis
Environment Manager
Hillgrove Resources Ltd
Éclair Mine Road (cnr Back Callington Road)
Kanmantoo SA 5252
Via email: catherine.davis@hillgroveresources.com.au

INTERIM REPORT

Further Assessment and Consideration of Management of Seepage Water at the Kanmantoo Copper Mine

Dear Catherine,

1. Introduction

Following on from an investigation carried out in November 2018, JBS&G Australia Pty Ltd (JBS&G) was engaged by Hillgrove Resources Ltd (Hillgrove) to further investigate the nature and potential source of seepage water observed in a recently constructed cut-off drain at the north-eastern toe of the current tailings storage facility (TSF), which forms part of the Integrated Waste Landform (IWL), at the Kanmantoo Copper Mine (the site). In addition, Hillgrove has requested that JBS&G consider potential long-term passive options for managing this seepage water.

2. Background

During an inspection of the northern portion of the IWL by Hillgrove personnel on 25 September 2018, water ponding on top of the old (i.e. 1970s) tailings dam was identified at the base of the IWL in an area located approximately 500 m to the east-southeast of groundwater monitoring well KMB020. A review of old topographic records and aerial photographs by Hillgrove indicated that a portion of the IWL has been constructed directly on the old tailings dam (1970s), which had a capping layer of topsoil. Prior to Hillgrove acquiring the site there was a shallow “stock” pond in the paddock to the north of the initial IWL embankment which may have been spring fed. Available historical aerial photographs sourced from Google Earth and NearMap showing this area are indicated in **Figure 1.**

During construction of the northern TSF stage and the establishment of the IWL base (incorporating a minimum 5 m thick non-acid forming rock layer), the stock pond was buried. The top of the former stock pond prior to being buried beneath the northern wall of the IWL was reportedly at an elevation of approximately 199 m AHD, which is 1.2m higher in elevation than the reduced groundwater level gauged in KMB020 in August 2018 and the same elevation when compared to the August 2017 reduced groundwater level. This data suggests that the ponded water identified at the northeast toe of the IWL could be associated with spring discharge of groundwater triggered by the increasing groundwater elevation observed in this portion of the site since July 2012. It is noted that the November 2018 groundwater level gauging result for KMB020 indicated an apparent decline in the seasonal groundwater level when compared to November 2017. The other potential source of the ponded water considered in a November 2018 assessment was a potential breach of the TSF liners, and water ponding further to the north of the area in question (identified by Hillgrove personnel as the “north-western wetland”).

In November 2018 JBS&G was engaged by Hillgrove to undertake a geochemical assessment of surface water ponding near the north-eastern toe of the operational IWL. The outcomes of this assessment were reported in a letter report dated 4 December 2018. The key findings of this assessment were:

- Water from the north-western wetlands area had a different chemical composition to the other water samples and it was therefore considered unlikely to be contributing to the ponding of water at the toe of the current TSF;
- On the basis of the similar chemical signature of the two ponded water samples and the old tailings dam seepage dam sample (i.e. low pH and similar metal, sulphate and ammonia concentrations), it is highly likely that water originating from beneath the north-eastern toe of the IWL is interacting (coming into contact) with the tailings in the buried portion of the old tailings dam prior to ponding at surface adjacent to the toe of the current IWL;
- The origin of the water could not be definitively determined based on the chemical signatures of the water due to contamination of the water, most likely associated with interaction with the buried portion of the old tailings dam prior to surface discharge. There was however an absence of potential indicators that would suggest a breach of the TSF liners had occurred. This conclusion was based on observations made during sampling and/or recent groundwater compliance monitoring results, including the following:
    - The water quality results for monitoring bores KMB020, KMB022 and KMB023 (installed to assess potential impacts from a leaking TSF, should this occur) have not shown any potential impact from the current TSF operations;
    - The seepage interception pipework installed between the two liners of the TSF did not have any material flow observed at the time of sampling (i.e. there was insufficient or no flow to enable a sample to be collected); and
    - There has not been any observable increase in discharge over time from the two French Drains installed beneath the TSF liners since operation of the TSF commenced. Furthermore, these drains have been observed to be dry at various times during the ongoing groundwater monitoring program suggesting an absence of permanent water supply that would be expected if the TSF liner had been breached.
- Groundwater level data for monitoring well KMB020 (located to the north of the current IWL) has shown an increasing trend in groundwater levels (i.e. apparent groundwater mounding) since July 2012, shortly following the commencement of construction of the northern stage of the IWL. An observable increase in the seasonal groundwater level of approximately 3m occurred between June 2012 and June 2014, prior to the northern stage of the TSF becoming operational and receiving tailings from current mining operations. The increase in groundwater levels during this period is therefore not associated with seepage from the northern stage of the TSF and is most likely associated with a change in the groundwater recharge and/or discharge mechanisms in this portion of the site (e.g. covering the potential spring discharge area where there was a former stock water dam).
- In the absence of other potential indicators of a breach of the current TSF liners, it is considered most likely that the primary contributor to the ponded water is spring discharge of groundwater beneath the wall of the IWL associated with groundwater mounding in this area. Due to the absence of any material changes in the groundwater quality in monitoring

wells installed to assess potential seepage from the TSF, and the absence of any observable increase in flow from the French Drains installed beneath the TSF, the groundwater mounding is considered unlikely to be associated with a breach of the TSF liners. Whilst it is considered unlikely that the current TSF is a contributing source of the ponded water, it should be noted that there is no groundwater monitoring infrastructure installed in close proximity to the ponded water, or in the area between the lined TSF and the ponded water (i.e. within the wall of the IWL), to draw a more definitive conclusion. In order to draw a more definitive conclusion, additional monitoring infrastructure would be required in the area of concern.

Since the time of this initial geochemical assessment in November 2018 Hillgrove has undertaken works to actively manage the surface water ponding by installing a cut-off drain along the northern toe of the TSF to direct the water to a small dam. The captured water is then pumped in to the TSF on a daily basis. Hillgrove has undertaken some measurements of the amount of water transferred each day and from this it has been estimated that the seepage rate that is being intersected by the cut-off drain is approximately 0.8 L/s.

HISTORICAL AERIAL 2009

HISTORICAL AERIAL 2010

HISTORICAL AERIAL 2011

HISTORICAL AERIAL 2012

Legend:
- Original Spring
- Surface Water Location

JBS&G

Job No: 55572	
Client: Hillgrove Resources	
Version: DRAFT	Date: 09-Aug-2019
Drawn By: AS	Checked By: HF
Scale at A4	

0 30 60
metres

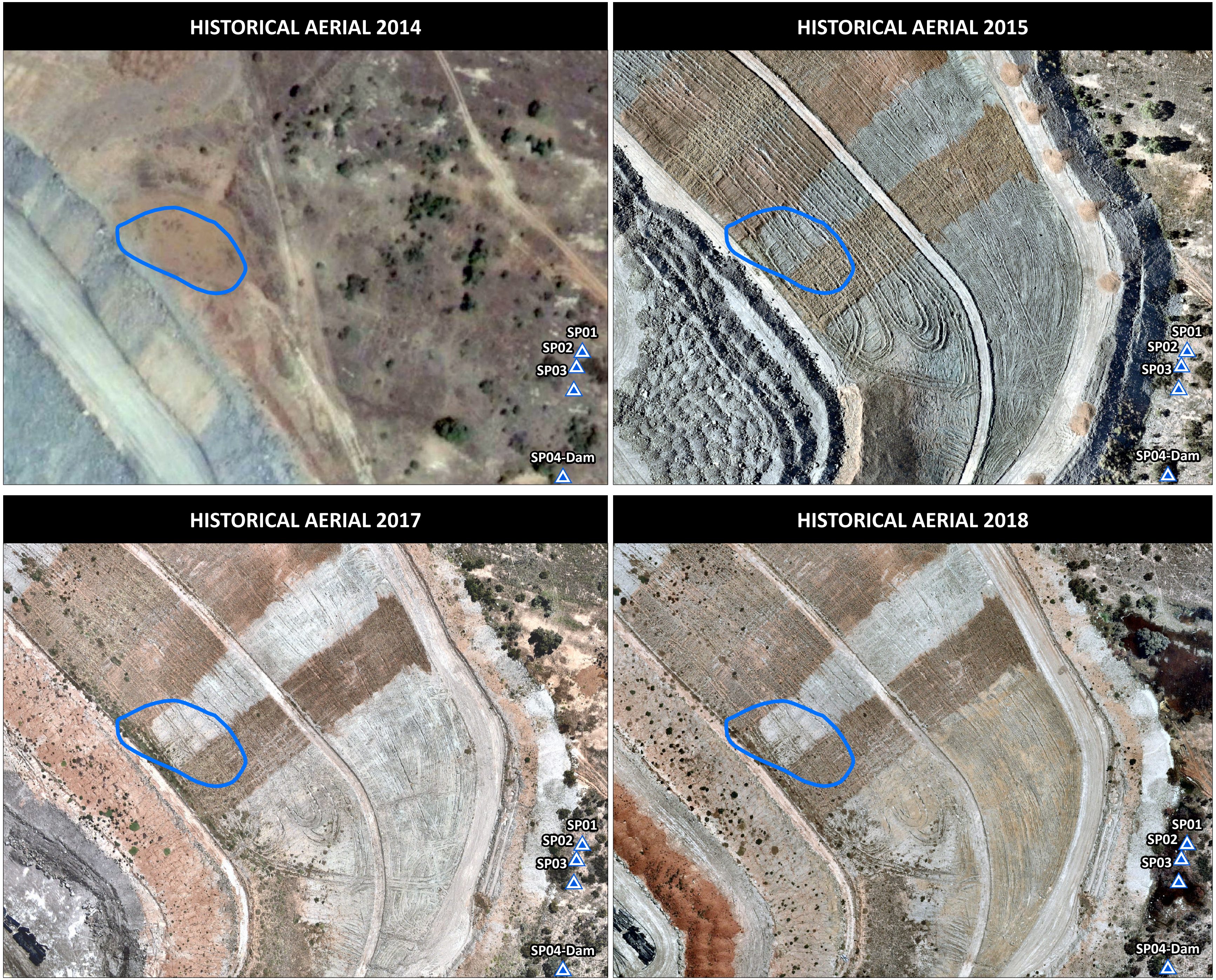
Coor. Sys. GDA 1994 MGA Zone 54

Kanmantoo, South Australia

HISTORICAL AERIALS 2009 - 2012

FIGURE 1

Document Path: C:\1. Arc Pro\1. ArcGIS Pro_190809\GMP_2019.aprx
Image Reference:
www.nearmap.com© - Imagery Date: 29 October 2015
Google Maps © 2016
South Australian Department of Environment, Water and Natural Resources (Mapland)
ESRI Topographic Basemap - Imagery Accessed: 23/12/19



Legend:

- Original Spring
- Surface Water Location

JBS&G

Job No: 55572	
Client: Hillgrove Resources	
Version: DRAFT	Date: 09-Aug-2019
Drawn By: AS	Checked By: HF
Scale at A4	

0 30 60

metres

Coor. Sys. GDA 1994 MGA Zone 54

Kanmantoo, South Australia

HISTORICAL AERIALS 2014 - 2018

FIGURE 1

Document Path: C:\1. Arc Pro\1. ArcGIS Pro_190809\GMP_2019.aprx
Image Reference:
www.nearmap.com© - Imagery Date: 29 October 2015
Google Maps © 2016
South Australian Department of Environment, Water and Natural Resources (Mapland)
ESRI Topographic Basemap - Imagery Accessed: 23/12/19

3. Scope of Work

The scope of work of the August 2019 assessment includes the following:

3.1 Geochemical Assessment

- Mobilisation to site;
- Preparation of a site-specific Health, Safety, and Environment (HSE) Plan and associated Safe Work Method Statement (SWMS);
- Site inspection/assessment with Principal JBS&G Staff;
- Collection and analysis of 4 primary samples for the following (Standard laboratory delivery);
  - Metals Suite (arsenic, barium, beryllium, boron, cadmium, chromium (total), cobalt, copper, lead, manganese, mercury (inorganic), nickel, selenium, vanadium and zinc);
  - Major Ions (sodium, magnesium, potassium, calcium, chloride, sulphate, bicarbonate and carbonate);
  - Nutrients [Ammonia as N, total nitrogen as N, nitrate+nitrite as N (oxidised nitrogen - NOx), and total phosphorus];
  - pH and EC; and
  - Collection of QAQC samples for analysis.
- Review and analysis of laboratory data, including comparison with November 2018 seepage assessment;
- Preparation of an interim short letter report in draft and, following receipt of collated comments from Hillgrove, will issue a final letter report.

3.2 Hydrogeological Review

- JBS&G will undertake a review of existing literature, including the groundwater modelling report that was recently completed by Mining One. JBS&G will also review other pertinent reports, within the constraints of the fee estimate provided;
- JBS&G will use available information to undertake an analysis of the hydrogeological context of the seepage. It is expected that this analysis will supplement the findings of the November 2018 geochemical assessment and further works as proposed above;
- JBS&G will consider whether alternative analytical techniques such isotope fractionation or carbon dating of the seepage water would provide and further clarity about the origin of the water;
- Access to some GIS data such as the Digital Elevation Model (most recent ground survey, including the tailings storage facilities) and, potentially the site geological model, may be of assistance. Some or all of this data may already be available as part of the Geochemical Assessment project;
- It is noted that modelling and detailed analysis is not proposed within this scope of work; and
- JBS&G will incorporate the findings of the review in to a short letter report.

3.3 Seepage Management

Hillgrove requires a long-term passive management option as ongoing transfer of the seepage water to the TSF can only be a temporary solution. It is understood that Hillgrove's preference is to manage the seepage water within the boundaries of the existing mining lease. JBS&G will undertake a water balance using the best available data to assess whether management of the water by evaporation is a feasible option.

4. Geochemical Assessment Results

All field works as described in **Section 3**, including collection of four surface water samples from the target area, were completed on 8 August 2019. The sampling locations are depicted in **Figure 2.**

4.1 Site Inspection

An inspection by JBS&G staff on 8 August 2019 was conducted of the recent earthworks in the area affected by the ponding water first observed in September 2018. The affected area has been significantly altered and engineered to both channel and contain the seepage water, as well as provide vehicle access through the affected area. Prior to construction of the seepage interception system, the water appeared only as a stagnant pond with no visible flow. Field measurement of the ponded water indicated low pH (~3.00 pH) and covered an area of approximately 4,500 m^2 at ~0.1 m depth at the toe of the north east portion of the TSF.

During the construction of the cut-off channel it was observed by site staff that, after breaking the silt rich crust of the top soil, multiple free flowing water seepage points were present in the exposed TSF toe. These seepage points were targeted with engineered drainage and channelling pathways into a common drainage point and pumping sump (see **Section 6** of this report for a site photograph of the described catchment system).

Three drainage points were present and free flowing at the time of sampling, approximately 5 m distance apart and identified as SP01 to SP03 (north to south represented). It was stated by site staff that the SP01 drainage point has a T-piece drainage system attached to it collecting several smaller seepages out of a main drain. The other drainage points, SP02 and SP03, represent single seepage points coming out of the TSF toe.

Samples were collected from the three drainage points, with an extra sample collected from the water within the small seepage interception dam. All sampling points were noted to be free flowing, appeared clear with low turbidity, and with apparent iron staining of the drainage channel aggregate adjacent to the sampling points. The samples, as presented in **Figure 2** are as follows:

- SP01 – northern drainage point, connected to T-piece collection point;
- SP02 – central drainage point;
- SP03 – southern drainage point; and
- SP04-DAM – pumping sump and seepage interception dam, sample taken approximately 1.0 m from inlet pipe.

Additionally, it is also noted that the sampling took place after a moderate rain event, during which approximately 10 – 15 mm fell within the previous 24 hours. This would have had an influence within the SP04-DAM sample. It was also noted that a secondary inlet pipe was located in the pumping sump, for the purpose of drainage of a southern area of ponded water.

4.2 Physicochemical Field Parameters

The field-measured physicochemical parameters for the surface water samples are provided in **Attachment A** and indicate the following:

- Dissolved Oxygen (DO) levels were comparable for the drainage points ranging from 1.26 to 1.72 ppm. The holding dam sample had a higher DO level (6.26 ppm), which is consistent with increased aeration of the water as it flows into the sump and potentially reflects mixing with rain water overnight;
- Electrical Conductivity (EC) – The EC levels of the drainage points were similar ranging from 5,350 to 5,380 µS/cm. The sump sample (SP04-DAM) was found to have a lower EC (3,940 µS/cm) indicating a dilution of water from overnight rain;
- The pH of the seepage water samples was comparable across the points ranging from 3.99 to 4.61 pH units, which indicates moderately acidic conditions. Similar to the EC, the pH of the sump sample (SPO4-DAM) appears to be diluted resulting in a slightly higher pH of 4.99;
- Oxidation Reduction Potential (ORP) was somewhat variable for the seepage samples ranging from 230 to 332 mV, which indicates oxidative conditions for these points. The sump sample (SP04-DAM) was also comparable to the drainage points, with a slightly lower ORP of 208 mV;
- Temperature ranges from 15.8 to 18.5°C for drainage points and a lower value of 11.2 °C for the sump sample. This difference would be due to exposure to ambient air temperatures for the sump, while the drainage waters have not been exposed to these lower temperatures, being from an 'subsurface/underground' source.

4.3 Laboratory Results

The tabulated laboratory analytical results are provided in **Attachment B.** A copy of the laboratory certificates is provided in **Attachment C.**

Laboratory results for the seepage water samples were compared with the ponded water from the November 2018 sampling event. The following differences were identified:

- pH is almost an order of magnitude higher, and less acidic, the average of the August 2019 samples was 3.91 pH units (SP01-SP03) compared to 3.05 pH units for the ponded water (01 and 02);
- EC (and thus TDS) is also lower in the August 2019 samples and trending towards fresher waters, with an EC of ~6,300 µS/cm for the 2019 seepage samples compared to ~8,500 µS/cm for the 2018 ponded water samples;
- Ammonia concentrations were somewhat higher at 6.53 mg/L for the seepage water samples compared to ponded water in November 2018 at 5.49 mg/L. This is consistent with greater volatilisation of ammonia from the surface ponding compared with the current seepage water collection system;
- The majority of heavy metal analytes within the 2019 seepage samples are lower than the 2018 ponded water samples, for example;
    - Boron – 0.38 mg/L (avg.) in 2019 compared to 0.66 mg/L (avg.) in the 2018 data;
    - Cobalt – 8.43 mg/L in 2019 compared to 16.8 mg/L (avg.) in the 2018 data;
    - Copper – 57.1 mg/L (avg.) in 2019 compared to 106 mg/L (avg.) in the 2018 data;
    - Manganese– 74.2 mg/L (avg.) in 2019 compared to 149 mg/L (avg.) in the 2018 data;

- Nickel – 4.8 mg/L (avg.) in 2019 compared to 9.88 mg/L (avg.) in the 2018 data;
- Zinc – 3.7 mg/L (avg.) in 2019 compared to 7.41 mg/L (avg.) in the 2018 data;

The change in metals concentrations within the 2019 data is considered to be directly related to the pH values, as more acidic waters (lower pH) will mobilised more metals from the contacted soils/rock material. This in turn is likely to be related to lower contact time between the source water and old tailings.

The ionic balance of all water samples tested showed a variation of less than 10% (ranging from 7.02 to 9.1%) indicating that anions and cations are balanced. This provides a high degree of confidence that all major anions and cations have been captured by the laboratory analysis and therefore valid comparisons can be made between the different water samples. A graphical representation of the ionic composition of the water samples this round as well as the original sampling round of the ponded water back in November 2018 (and groundwater sampled from KMB020 in November 2017) is provided below in **Figure 3**.

As stated in the previous 2018 seepage water document regarding the chemical composition of the waters, the north-western wetland water sample has a different chemical composition to the other samples retrieved. The salinity of the water is sodium chloride dominated rather than calcium sulphate dominated. Total alkalinity and pH was also significantly higher than other samples whilst the ammonia concentration was significantly lower, reflecting minimal impact on this water from mining activities.

With respect to the 2019 analysed samples (SP01 - SP03), these can be chemically compared to the 2018 ponded water samples, as presented in **Figure 3**. The cation and anion signature of the separate sampling events appears similar for these samples. The November 2018 and August 2019 event samples are different to the TSF decant and underdrainage samples.

The ammonia concentration of the 2019 drainage water samples (6.5 mg/L avg.), the 2018 ponded water samples (5.5 mg/L avg.) and the old tailings dam seepage dam sample (3.86 mg/L) are somewhat similar and lower than the ammonia concentrations in the decant and underdrainage samples from the operational TSF which ranged from 7.75 mg/L to 18.40 mg/L. This indicates that the water from the current TSF is not similar to the 2019 drainage water and the 2018 ponded water.

Legend:
- Original Spring
- Surface Water Location
- Proposed Groundwater Locations

JBS&G

Job No: 55572

Client: Hillgrove Resources

Version: DRAFT	Date 15-Aug-19
Drawn By: AS	Checked By: HF

Scale 1:1,000

0 15 30
metres

Coord. Sys. GDA 1994 MGA Zone 54

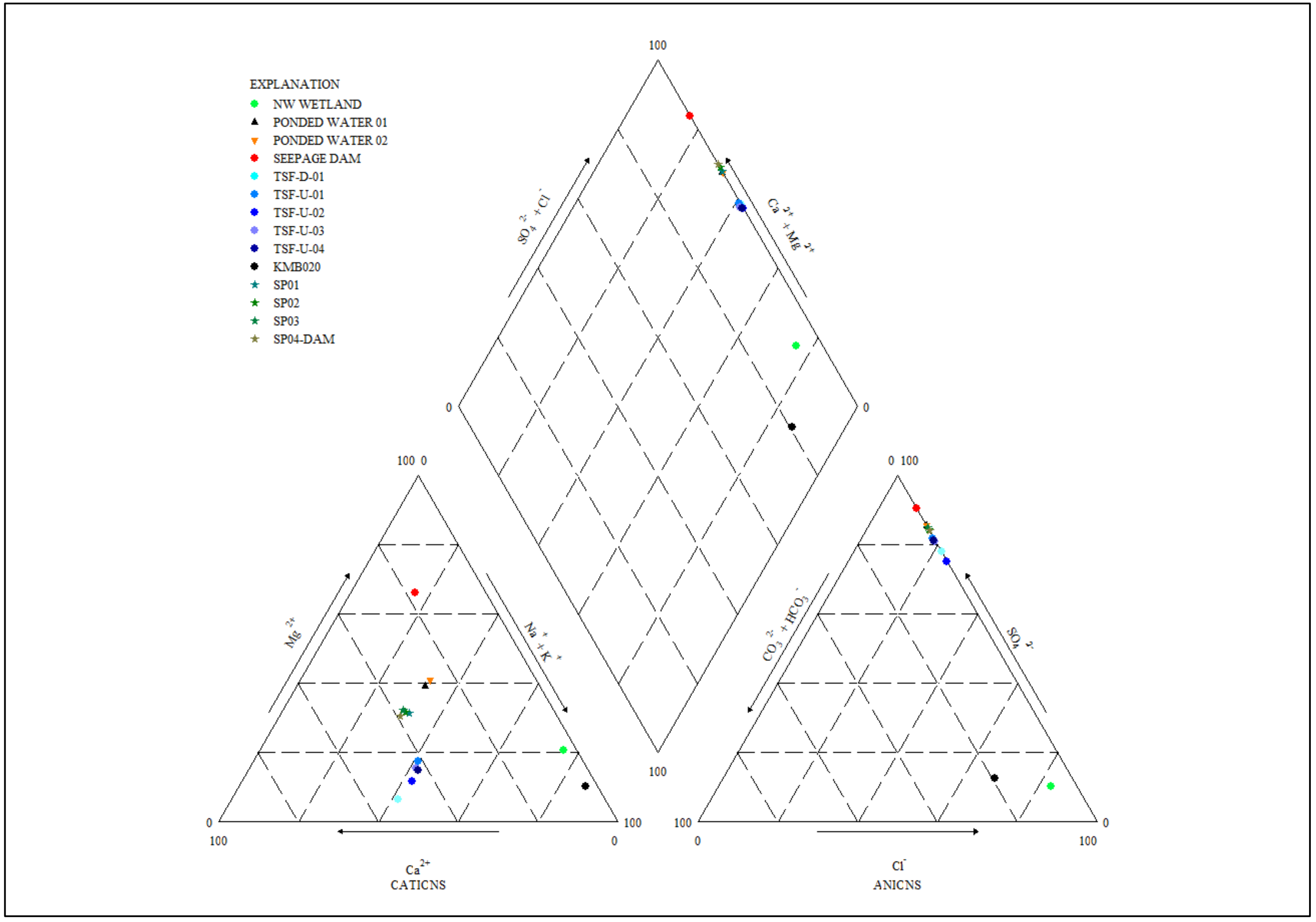
Kanmantoo, South Australia

PROPOSED GROUNDWATER MONITORING WELL LOCATIONS

FIGURE 2

File Name: C:\1. Arc Pro\1. ArcGIS Pro_190809\GMP_2019.aprx
Reference: www.nearmap.com - Imagery Date: 23/04/2019

Figure 3: Piper Diagram of Water Samples



5. Hydrogeological Review

JBS&G contacted commercial laboratories to consider whether alternative analytical techniques such as isotope fractionation or carbon dating of the seepage water would provide further clarity about the origin of the water. The advice obtained suggested that these techniques are not appropriate due to the suspected contamination of the source water by passing through the old tailings left behind from the 1970s operation, i.e. they are unlikely to provide any further clarity over and above the geochemical assessment already undertaken.

Installation of additional monitoring infrastructure as recommended in correspondence of 4 December 2018 and as further discussed in **Section 7** of this letter report would be beneficial in retrieving water samples closer to the suspected spring that previously fed the ‘old stock dam’.

Further information resulting from the analysis of the hydrogeological data, in particular the groundwater levels in the northern area of the site, will be included in the final report.

6. Seepage Water Management

Hillgrove is currently capturing the seepage water via a cut-off channel installed along the northern toe of the TSF to direct the water to a small dam as shown in **Figure 4.**

Figure 4 – Cut Off Channel and Seepage Interception Dam

The captured water is pumped in to the TSF on a daily basis. Hillgrove has undertaken some initial measurements of the amount of water transferred each day and from this it has been estimated that the seepage rate that is being intersected by the cut-off drain is approximately 0.8 L/s.

It is understood that Hillgrove requires a long-term passive management option to contain the seepage water and prevent the water impacting on the surrounding environment. The current transfer of the seepage water to the TSF is considered to be a temporary solution only given the TSF will ultimately be closed. It is understood that Hillgrove's preference is to manage the seepage water within the boundaries of the existing mining lease.

It should be noted, that it may be possible to install groundwater extraction wells in the future to pump groundwater from the inferred source location (with proposed locations presented in **Figure 2**), if the water is of suitable quality and quantity, to another location for use in the proposed pumped hydro-electricity scheme. This would likely result in the current observed seepage rate being reduced or halted altogether.

6.1 Seepage Water Balance

JBS&G has undertaken undertake a water balance using the best available data to assess whether management of the water by evaporation is a feasible option. The output of the balance using the following assumptions is provided in **Attachment D**. **Figure 5** provides a suggested dam size and approximate location for Hillgrove's consideration.

The key assumptions for the water balance are as follows:

- Seepage flow rate is 1.0 L/s (Hillgrove measurement is 0.8 L/s so this is conservative);
- Considers a 10-year rainfall period including two decile 9 years (high rainfall) and eight mean rainfall years during that period. This is considered conservative as the simple probability of two decile 9 rain years occurring within a 10-year period is 1 in 100. The balance does not include consideration of any decile 1 years (low rainfall) providing a further level of conservatism;
- Rainfall Data from the Bureau of Meteorology (BOM) Strathalbyn station (number 23747) has been used. This is considered to be most representative of local conditions;
- Mean evaporation data from the Turretfield, Rosedale BOM weather station (number 023343). Only limited weather stations have pan evaporation data. This weather station is considered to be most representative of local conditions as it is on the same isohyet as the site;
- To provide a degree of conservatism, and to reflect non-ideal evaporation conditions, the water balance uses 75% of the mean evaporation to calculate evaporation losses;
- A shallow evaporation pan with a maximum working depth of 1.0 m (will need at least 0.5 m of freeboard to allow for high wind conditions).

On this basis a 50 ML evaporation pan (225 m x 225 m x 1.0 m deep) accommodates a seepage rate of 1 L/s. Given that the water is contaminated and has a similar chemical signature to the old tailings dam seepage dam water, the pan will need to be appropriately engineered.

It should be noted that the water balance is very sensitive to the seepage rate and therefore ongoing monitoring should be undertaken to continually verify this rate to detect any changes (e.g. seasonal). The current seepage rate estimated by Hillgrove is 0.8 L/s, as highlighted in **Table 1**. The sensitivity to seepage rate is indicated in **Table 1.** The table also indicates the number of months to reach 80% and 100% respectively noting that at lower seepage rates the dam never fills completely. At higher rates the maximum volume indicates by how much the dam will overflow once maximum capacity is reached.

Table 1 – Water Balance Sensitivity Analysis

Flow Rate (L/s Seepage)	Months to 80%	Months to 100%	Max. Volume % Capacity
0.2	n/a	n/a	30%
0.4	n/a	n/a	36%
0.6	n/a	n/a	42%
0.8 (current estimated rate)	**n/a**	**n/a**	**50%**
1.0	n/a	n/a	57%
1.2	57	n/a	89%
1.4	21	45	182%
1.6	20	21	301%
1.8	19	20	421%
2.0	18	19	540%

Legend:
- Original Spring
- Proposed Evaporation Pond
- Surface Water Location

JBS&G

Job No: 55572

Client: Hillgrove Resources

Version: DRAFT	Date 20-Aug-19
Drawn By: AS	Checked By: HF

Scale 1:3,000

0 50 100
metres

Coord. Sys. GDA 1994 MGA Zone 54

Kanmantoo, South Australia

PROPOSED EVAPORATION DAM LOCATION

FIGURE 5

File Name: C:\1. Arc Pro\1. ArcGIS Pro_190809\GMP_2019.aprx
Reference: www.nearmap.com - Imagery Date: 23/04/2019

7. Discussion and Conclusions

Geochemical Assessment

Water sampled in November 2018 was ponded at the surface, the ponded area was expanding with time. Intervention by Hillgrove in the form of a cut-off drain has intercepted the seepage and is directing it to a small dam. It is transferred from there to the TSF on a daily basis.

Water sampled in August 2019 was retrieved from four locations, three samples from different areas of seepage at the toe of the IWL and a further sample from the seepage interception dam. It was observed that the water was running from the 'seeps' and that this water was clear. Some of the rock adjacent to the seeps was stained consistent with relatively high metal concentrations in the seepage water.

Assessment of the four most recent (August 2019) seepage water samples has verified the findings of the November 2018 assessment, i.e. the seepage water and the old tailings dam seepage dam samples have a similar chemical signature, based on low pH and similar metal (boron, cobalt, copper, manganese, nickel and zinc), sulphate and ammonia concentrations.

It is highly likely that water originating from beneath the north-eastern toe of the IWL is interacting (coming into contact) with the tailings in the buried portion of the old tailings dam prior to ponding at surface adjacent to the toe of the current IWL.

The origin of the water cannot be definitively determined based on the chemical signatures of the water due to contamination of the water most likely associated with interaction with the buried portion of the old tailings dam prior to surface discharge.

There are some differences between the November 2018 and August 2019 analytical results most notably:

- Higher pH,
- Higher ammonia; and
- Lower metal and sulphate concentrations (boron, cobalt, copper, manganese, nickel and zinc) in the more recent samples.

These differences are consistent with shorter contact time between the water and the old tailings, and greater volatilisation of ammonia from the surface ponding compared with the current seepage water collection system.

As per our previous advice of December 2018, in order to draw a more definitive conclusion, additional monitoring infrastructure would be required in the area of concern.

Figure 2 indicates potential monitoring locations that have been chosen to maximise the probability of intersecting the suspected source and pathway of the water, i.e. the suspected spring feeding the 'old stock dam' (as shown in **Figure 1**) and a location approximately halfway between that location and the current area of seepage. Access for a drill rig has also been considered in selecting these locations.

Hydrogeological Review

JBS&G contacted commercial laboratories to consider whether alternative analytical techniques such as isotope fractionation or carbon dating of the seepage water would provide further clarity about the origin of the water. The advice obtained suggested that these techniques are not appropriate due to the suspected contamination of the source water by passing through the old tailings, i.e. they are unlikely to provide any further clarity over and above the geochemical assessment already undertaken.

Further information resulting from the analysis of the hydrogeological data, in particular the unusual changes in groundwater levels in the northern area of the site, will be included in final report.

Seepage Water Management

JBS&G has undertaken an assessment that considers management of seepage water by evaporation. The assessment indicates that evaporation is a feasible option and that a 50 ML evaporation pan (225 m x 225 m x 1.0 m deep) accommodates a seepage rate of 1 L/s. Given that the water is contaminated and has a similar chemical signature to the old tailings dam seepage dam water, the pan will need to be appropriately engineered.

It should be noted that the water balance is very sensitive to the seepage rate and therefore ongoing monitoring should be undertaken to continually verify this rate to detect any changes (e.g. seasonal). To account for this sensitivity a conservative value for the seepage rate was adopted in the water balance (i.e. 1L/s in lieu of the estimated 0.8 L/s rate), in addition to the adoption of other conservative measures (e.g. use of 75% of mean evaporation). It is further noted that the observations of seepage rate have been measured during winter and there is the potential that the rate may be reduced during the summer period (i.e. adding a further level of conservatism).

Additionally, although this may be considered an active management solution, it may be possible to install groundwater extraction wells in the future to pump groundwater from the inferred source location, if the water is of suitable quality and quantity, to another location for use in the potential pumped hydro-electricity scheme. This would likely result in the current observed seepage rate being reduced or halted altogether.

8. Closure

Should you require clarification, please contact the undersigned on 08 8431 7113 or by email mcowin@jbsg.com.au.

Yours sincerely:

Michael Cowin
Senior Associate Environmental Scientist
JBS&G Australia Pty Ltd

Reviewed/Approved by:

Richard Fassbender
Principal Environmental Chemist
JBS&G Australia Pty Ltd

Attachments

Attachment A. Summary of Field-Measured Physicochemical Parameters
Attachment B. Summary of Laboratory Analytical Results
Attachment C. Laboratory Certificates
Attachment D. Water Balance Output

Attachment A Summary of Field-Measured Physicochemical Parameters

Summary of Field-Measured Physicochemical Parameters -
Seepage Water (Northern TSF Area)

Seepage Point ID	Dissolved Oxygen	Electrical Conductivity	pH	Redox	Temperature	Observations
	ppm	µS/cm	pH units	mV	°C	
SP01	1.26	-	4.61	230.0	16.4	Northern Seepage Point / drain, larger T-Piece collection point for this drainage point, moderate flow, clear
SP02	1.72	5,350	4.13	310	18.5	Middle Seepage Point / drain, moderate flow, clear
SP03	1.39	5,380	3.99	332	15.8	Southern Seepage Point / Drain, moderate flow, clear
SP04-DAM	6.26	3,940	4.99	208	11.2	Drainage Sump, moderately turbid, sample taken from north western point 1m from inlet pipe.

Attachment B Summary of Laboratory Analytical Results

TSF SEEPAGE WATER COMPARISON SUMMARY TABLE
Project Number: 55572
Project Name: TSF Seepage Water Investigation

			Metals & Metalloids																
			Aluminium	Aluminium (Filtered)	Arsenic (Total)	Barium	Beryllium	Boron	Cadmium	Cadmium (Filtered)	Chromium (Total)	Cobalt	Cobalt (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Manganese
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOR			0.01	0.01	0.001	0.001	0.001	0.05	0.0001	0.0001	0.001	0.001	0.001	0.001	0.001	0.05	0.05	0.001	0.001
Field ID	**Lab Report Number**	**Sample Date**																	
PIT WATER	EM1819495	29/11/2018	0.81	-	-	-	-	-	0.0019	-	-	2.26	-	0.213	-	117	-	-	16.3
SKM4	EM1819495	28/11/2018	0.06	-	-	-	-	-	0.0068	-	-	1.11	-	1.66	-	0.98	-	-	7.46
TSF-D-01	EM1818679	20/11/2018	-	-	<0.001	0.069	<0.001	0.08	<0.0001	-	<0.001	0.036	-	0.002	-	-	-	<0.001	1.4
TSF-U-01	EM1818679	20/11/2018	-	-	<0.001	0.024	<0.001	0.15	<0.0001	-	<0.001	0.022	-	0.006	-	-	-	<0.001	9.21
TSF-U-02	EM1818679	20/11/2018	-	-	0.001	0.015	0.001	0.14	0.0008	-	<0.001	0.554	-	14.1	-	-	-	<0.001	6.22
TSF-U-03	EM1818679	20/11/2018	-	-	<0.001	0.03	<0.001	0.18	<0.0001	-	<0.001	0.305	-	0.999	-	-	-	<0.001	15.3
TSF-U-04	EM1818679	20/11/2018	-	-	<0.001	0.021	<0.001	0.14	<0.0001	-	<0.001	0.019	-	0.121	-	-	-	<0.001	8.16
SEEPAGE DAM	EM1818679	20/11/2018	-	-	0.006	<0.001	0.005	0.83	0.0102	-	0.003	32.8	-	90.6	-	-	-	<0.001	151
NW WETLAND	EM1818679	20/11/2018	-	-	0.007	0.087	<0.001	1.78	<0.0001	-	0.001	0.002	-	0.014	-	-	-	<0.001	0.144
PONDED WATER 01	EM1818679	20/11/2018	-	-	0.006	0.005	0.046	0.62	0.0637	-	0.002	15.4	-	97.3	-	-	-	<0.001	136
PONDED WATER 02	EM1818679	20/11/2018	-	-	0.006	0.006	0.04	0.69	0.0614	-	0.002	18.2	-	115	-	-	-	<0.001	162
SP01	EM1912852	8/08/2019	28.7	-	0.003	0.006	0.025	0.4	0.0281	-	0.002	8.1	-	51.1	-	-	-	0.002	73.2
SP02	EM1912852	8/08/2019	29.2	-	0.002	0.01	0.024	0.37	0.0274	-	0.002	8.5	-	54	-	-	-	0.002	73.9
SP03	EM1912852	8/08/2019	32.3	-	0.002	0.007	0.025	0.36	0.0305	-	0.002	8.69	-	66.3	-	-	-	0.002	75.6
SP04-DAM	EM1912852	8/08/2019	7.88	-	0.002	0.209	0.007	0.26	0.0164	-	0.003	5.1	-	22.8	-	-	-	0.002	46.2

Data Comments

#1 Reported Analyte LOR is higher than Requested Analyte LOR

TSF SEEPAGE WATER COMPARISON SUMMARY TABLE
Project Number: 55572
Project Name: TSF Seepage Water Investigation

			Metals & Metalloids								Non-Metallic Inorganics				Nitrite and Nitrate as N (NOx)
			Manganese (Filtered)	Mercury (Inorganic)	Nickel	Nickel (Filtered)	Selenium (Total)	Vanadium	Zinc	Zinc (Filtered)	Ammonia (as N)	Phosphorus	Total Kjeldahl Nitrogen (as N)	Total Nitrogen (as N)	Nitrite + Nitrate as N
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOR			0.001	0.0001	0.001	0.001	0.01	0.01	0.005	0.005	0.01	0.01	0.1	0.1	0.01
Field ID	**Lab Report Number**	**Sample Date**													
PIT WATER	EM1819495	29/11/2018	-	-	1.39	-	-	-	1.04	-	97.2	0.15	104	177	73.4
SKM4	EM1819495	28/11/2018	-	-	0.783	-	-	-	0.44	-	0.47	0.27	1.3	2	0.68
TSF-D-01	EM1818679	20/11/2018	-	<0.0001	0.026	-	<0.01	<0.01	0.006	-	18.4	0.51	21.8	24.9	3.13
TSF-U-01	EM1818679	20/11/2018	-	<0.0001	0.002	-	<0.01	<0.01	<0.005	-	9.27	0.54	9.7	9.7	0.02
TSF-U-02	EM1818679	20/11/2018	-	<0.0001	0.196	-	<0.01	<0.01	1.44	-	10.8	0.65	13.3	13.3	<0.01
TSF-U-03	EM1818679	20/11/2018	-	<0.0001	0.076	-	<0.01	<0.01	0.063	-	9.18	0.5	9.2	9.2	<0.01
TSF-U-04	EM1818679	20/11/2018	-	<0.0001	0.006	-	<0.01	<0.01	0.006	-	7.75	0.47	7.8	7.8	<0.01
SEEPAGE DAM	EM1818679	20/11/2018	-	<0.0001	7.37	-	<0.01	<0.01	3.23	-	3.86	<0.01	3.9	3.9	<0.01
NW WETLAND	EM1818679	20/11/2018	-	<0.0001	0.004	-	<0.01	<0.01	0.006	-	0.1	0.19	1.8	1.8	<0.01
PONDED WATER 01	EM1818679	20/11/2018	-	<0.0001	9.06	-	<0.01	<0.01	6.83	-	5.5	0.23	6.5	6.5	<0.01
PONDED WATER 02	EM1818679	20/11/2018	-	<0.0001	10.7	-	0.01	<0.01	7.99	-	5.47	0.18	5.6	5.6	<0.01
SP01	EM1912852	8/08/2019	-	<0.0001	4.65	-	<0.01	<0.01	3.5	-	6.39	0.31	6.7	6.7	<0.01
SP02	EM1912852	8/08/2019	-	<0.0001	4.79	-	<0.01	<0.01	3.53	-	6.6	0.29	6.9	6.9	<0.01
SP03	EM1912852	8/08/2019	-	<0.0001	4.95	-	<0.01	<0.01	4.09	-	6.6	0.37	6.9	6.9	<0.01
SP04-DAM	EM1912852	8/08/2019	-	<0.0001	2.9	-	<0.01	<0.01	2.12	-	4.27	0.2	5	5	<0.01

Data Comments
#1 Reported Analyte LOR is higher than Requested Analyte LOR

TSF SEEPAGE WATER COMPARISON SUMMARY TABLE
Project Number: 55572
Project Name: TSF Seepage Water Investigation

			Sulfate (Turbidimetric) as SO4	Major Cations				Major Anions	Ionic Balance by PCT DA and Tu								
			Sulfate as SO4 - Turbidimetric (Filtered)	Calcium (Filtered)	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Chloride	Ionic Balance	Total Anions	Total Cations	Bicarbonate Alkalinity (as CaCO3)	Carbonate Alkalinity (as CaCO3)	EC_Lab	Hydroxide Alkalinity (as CaCO3)	pH_Lab	Total Alkalinity (as CaCO3)
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	%	meq/L	meq/L	mg/L	mg/L	µS/cm	mg/L	ph Units	mg/L
LOR			1	1	1	1	1	1	0.01	0.01	0.01	1	1	1	1	0.01	1
Field ID	**Lab Report Number**	**Sample Date**															
PIT WATER	EM1819495	29/11/2018	2910	204	389	302	1770	3300	9.55	154	127	2	<1	11,700	<1	5.48	2
SKM4	EM1819495	28/11/2018	1800	289	279	68	1020	1570	3.86	90.2	83.5	422	<1	7260	<1	8.17	422
TSF-D-01	EM1818679	20/11/2018	1910	500	37	289	291	399	3	51	48	<1	<1	4490	<1	4.67	<1
TSF-U-01	EM1818679	20/11/2018	2990	553	142	384	404	488	6.69	76.2	66.7	11	<1	6170	<1	5.39	11
TSF-U-02	EM1818679	20/11/2018	2290	591	92	383	406	558	0.83	63.4	64.5	2	<1	5480	<1	5.04	2
TSF-U-03	EM1818679	20/11/2018	2740	576	125	400	411	472	2.54	70.6	67.1	14	<1	5790	<1	5.18	14
TSF-U-04	EM1818679	20/11/2018	2900	556	118	397	407	494	6.59	74.5	65.3	11	<1	6020	<1	5.47	11
SEEPAGE DAM	EM1818679	20/11/2018	6320	520	1170	17	526	489	0.06	145	146	<1	<1	12,000	<1	2.43	<1
NW WETLAND	EM1818679	20/11/2018	672	81	312	115	2100	4040	5.67	139	124	549	<1	13,000	<1	8.13	549
PONDED WATER 01	EM1818679	20/11/2018	4750	555	462	199	607	592	8.64	116	97.2	<1	<1	8100	<1	3.08	<1
PONDED WATER 02	EM1818679	20/11/2018	5120	582	538	223	680	645	6.94	125	109	<1	<1	8830	<1	3.02	<1
SP01	EM1912852	8/08/2019	3700	576	300	218	451	516	7.62	91.6	78.6	<1	<1	6460	<1	4.09	<1
SP02	EM1912852	8/08/2019	3720	588	300	228	425	505	7.85	91.7	78.4	<1	<1	6240	<1	3.88	<1
SP03	EM1912852	8/08/2019	3830	610	316	233	442	504	7.02	94	81.6	<1	<1	6410	<1	3.76	<1
SP04-DAM	EM1912852	8/08/2019	2400	390	184	143	259	336	9.1	59.4	49.5	<1	<1	4350	<1	4.75	<1

Data Comments

#1 Reported Analyte LOR is higher than Requested Analyte LOR

Attachment C Laboratory Certificates

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EM1912852**

Client	: **JBS&G Australia Pty Ltd**	Laboratory	: Environmental Division Melbourne
Contact	: HAYDN FRANKLIN	Contact	: Kieren Burns
Address	: 38 DEQUETTEVILLE TCE KENT TOWN SA, AUSTRALIA 5067	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: hfranklin@jbsg.com.au	E-mail	: Kieren.Burns@alsglobal.com
Telephone	: ----	Telephone	: +61881625130
Facsimile	: ----	Facsimile	: +61-3-8549 9626
Project	: 55572	Page	: 1 of 3
Order number	: ----	Quote number	: EM2019JBSENV0004 (ADBQ/003/18 - PRIMARY WORK ONLY (SA OFFICES))
C-O-C number	: 5156	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: Hillgrove Seepage Sampling		
Sampler	: HF		

Dates

Date Samples Received	: 09-Aug-2019 10:35	Issue Date	: 10-Aug-2019
Client Requested Due Date	: 16-Aug-2019	Scheduled Reporting Date	: **16-Aug-2019**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 4.7°C - Ice present
Receipt Detail	:	No. of samples received / analysed	: 5 / 5

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please direct any queries related to sample condition / numbering / breakages to Client Services.**
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- **Analytical work for this work order will be conducted at ALS Springvale.**
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **WATER**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	WATER - EA005P pH (PCT)	WATER - EA010P Electrical Conductivity (PCT)	WATER - EG020T Total Metals by ICP/MS (including digestion)	WATER - EK055G Ammonia as N By Discrete Analyser	WATER - NT-01 & 02 Ca, Mg, Na, K, Cl, SO4, Alkalinity	WATER - NT-11 Total Nitrogen and Total Phosphorus	WATER - W-03T 15 Metals (Total) (NEPM)
EM1912852-001	08-Aug-2019 00:00	SP01	✓	✓	✓	✓	✓	✓	✓
EM1912852-002	08-Aug-2019 00:00	SP02	✓	✓	✓	✓	✓	✓	✓
EM1912852-003	08-Aug-2019 00:00	SP03	✓	✓	✓	✓	✓	✓	✓
EM1912852-004	08-Aug-2019 00:00	SP04-DAM	✓	✓	✓	✓	✓	✓	✓
EM1912852-005	08-Aug-2019 00:00	DUP01	✓	✓	✓	✓	✓	✓	✓

Proactive Holding Time Report

The following table summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Client Sample ID(s)	Container	Due for extraction	Due for analysis	Samples Received		Instructions Received	
				Date	Evaluation	Date	Evaluation
EA005-P: pH by PC Titrator							
DUP01	Clear Plastic Bottle - Natural	----	08-Aug-2019	09-Aug-2019	×	----	----
SP01	Clear Plastic Bottle - Natural	----	08-Aug-2019	09-Aug-2019	×	----	----
SP02	Clear Plastic Bottle - Natural	----	08-Aug-2019	09-Aug-2019	×	----	----
SP03	Clear Plastic Bottle - Natural	----	08-Aug-2019	09-Aug-2019	×	----	----
SP04-DAM	Clear Plastic Bottle - Natural	----	08-Aug-2019	09-Aug-2019	×	----	----

Requested Deliverables

ACCOUNTS PAYABLE		
- A4 - AU Tax Invoice (INV)	Email	adminnsw@jbsg.com.au
HAYDN FRANKLIN		
- *AU Certificate of Analysis - NATA (COA)	Email	hfranklin@jbsg.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	hfranklin@jbsg.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	hfranklin@jbsg.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	hfranklin@jbsg.com.au
- A4 - AU Tax Invoice (INV)	Email	hfranklin@jbsg.com.au
- Chain of Custody (CoC) (COC)	Email	hfranklin@jbsg.com.au
- EDI Format - ENMRG (ENMRG)	Email	hfranklin@jbsg.com.au
- EDI Format - ESDAT (ESDAT)	Email	hfranklin@jbsg.com.au
LAB RESULTS JBSG		
- *AU Certificate of Analysis - NATA (COA)	Email	labresults@jbsg.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	labresults@jbsg.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	labresults@jbsg.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	labresults@jbsg.com.au
- A4 - AU Tax Invoice (INV)	Email	labresults@jbsg.com.au
- Chain of Custody (CoC) (COC)	Email	labresults@jbsg.com.au
- EDI Format - ENMRG (ENMRG)	Email	labresults@jbsg.com.au
- EDI Format - ESDAT (ESDAT)	Email	labresults@jbsg.com.au
MIKE COWIN		
- *AU Certificate of Analysis - NATA (COA)	Email	mcowin@jbsg.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	mcowin@jbsg.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	mcowin@jbsg.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	mcowin@jbsg.com.au
- A4 - AU Tax Invoice (INV)	Email	mcowin@jbsg.com.au
- Chain of Custody (CoC) (COC)	Email	mcowin@jbsg.com.au
- EDI Format - ENMRG (ENMRG)	Email	mcowin@jbsg.com.au
- EDI Format - ESDAT (ESDAT)	Email	mcowin@jbsg.com.au
RICHARD FASSBENDER		
- *AU Certificate of Analysis - NATA (COA)	Email	rfassbender@jbsg.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	rfassbender@jbsg.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	rfassbender@jbsg.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	rfassbender@jbsg.com.au
- A4 - AU Tax Invoice (INV)	Email	rfassbender@jbsg.com.au
- Chain of Custody (CoC) (COC)	Email	rfassbender@jbsg.com.au
- EDI Format - ENMRG (ENMRG)	Email	rfassbender@jbsg.com.au
- EDI Format - ESDAT (ESDAT)	Email	rfassbender@jbsg.com.au

CERTIFICATE OF ANALYSIS

Work Order	: **EM1912852**	Page	: 1 of 4
Client	: **JBS&G Australia Pty Ltd**	Laboratory	: Environmental Division Melbourne
Contact	: HAYDN FRANKLIN	Contact	: Kieren Burns
Address	: 38 DEQUETTEVILLE TCE KENT TOWN SA, AUSTRALIA 5067	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: ----	Telephone	: +61881625130
Project	: 55572	Date Samples Received	: 09-Aug-2019 10:35
Order number	: ----	Date Analysis Commenced	: 12-Aug-2019
C-O-C number	: 5156	Issue Date	: 15-Aug-2019 12:55
Sampler	: HF		
Site	: Hillgrove Seepage Sampling		
Quote number	: ADBQ/003/18 - PRIMARY WORK ONLY (SA OFFICES)		
No. of samples received	: 5		
No. of samples analysed	: 5		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Arenie Vijayaratnam	Non-metals prep supervisor	Melbourne Inorganics, Springvale, VIC
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA010-P: Electrical Conductivity @ 25°C was analysed by manual method (EA010).
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- ED045G: The presence of thiocyanate can positively contribute to the chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	SP01	SP02	SP03	SP04-DAM	DUP01
			Client sampling date / time	08-Aug-2019 00:00	08-Aug-2019 00:00	08-Aug-2019 00:00	08-Aug-2019 00:00	08-Aug-2019 00:00
				EM1912852-001	EM1912852-002	EM1912852-003	EM1912852-004	EM1912852-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	4.09	3.88	3.76	4.75	3.97
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	6460	6240	6410	4350	6420
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	3700	3720	3830	2400	3500
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	516	505	504	336	500
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	576	588	610	390	599
Magnesium	7439-95-4	1	mg/L	300	300	316	184	304
Sodium	7440-23-5	1	mg/L	451	425	442	259	439
Potassium	7440-09-7	1	mg/L	218	228	233	143	231
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	28.7	29.2	32.3	7.88	29.0
Arsenic	7440-38-2	0.001	mg/L	0.003	0.002	0.002	0.002	0.002
Boron	7440-42-8	0.05	mg/L	0.40	0.37	0.36	0.26	0.36
Barium	7440-39-3	0.001	mg/L	0.006	0.010	0.007	0.209	0.015
Beryllium	7440-41-7	0.001	mg/L	0.025	0.024	0.025	0.007	0.023
Cadmium	7440-43-9	0.0001	mg/L	0.0281	0.0274	0.0305	0.0164	0.0269
Cobalt	7440-48-4	0.001	mg/L	8.10	8.50	8.69	5.10	8.67
Chromium	7440-47-3	0.001	mg/L	0.002	0.002	0.002	0.003	0.003
Copper	7440-50-8	0.001	mg/L	51.1	54.0	66.3	22.8	55.0
Manganese	7439-96-5	0.001	mg/L	73.2	73.9	75.6	46.2	75.7
Nickel	7440-02-0	0.001	mg/L	4.65	4.79	4.95	2.90	4.82
Lead	7439-92-1	0.001	mg/L	0.002	0.002	0.002	0.002	0.002
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	3.50	3.53	4.09	2.12	3.65
EG035T: Total Recoverable Mercury by FIMS								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SP01	SP02	SP03	SP04-DAM	DUP01
			Client sampling date / time	08-Aug-2019 00:00	08-Aug-2019 00:00	08-Aug-2019 00:00	08-Aug-2019 00:00	08-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EM1912852-001	EM1912852-002	EM1912852-003	EM1912852-004	EM1912852-005
				Result	Result	Result	Result	Result
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**6.39**	**6.60**	**6.60**	**4.27**	**6.62**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**6.7**	**6.9**	**6.9**	**5.0**	**6.9**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**6.7**	**6.9**	**6.9**	**5.0**	**6.9**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.31**	**0.29**	**0.37**	**0.20**	**0.27**
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**91.6**	**91.7**	**94.0**	**59.4**	**87.0**
ø Total Cations	----	0.01	meq/L	**78.6**	**78.4**	**81.6**	**49.5**	**79.9**
ø Ionic Balance	----	0.01	%	**7.62**	**7.85**	**7.02**	**9.10**	**4.23**

Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1912852**	Page	: 1 of 7
Client	: **JBS&G Australia Pty Ltd**	Laboratory	: Environmental Division Melbourne
Contact	: HAYDN FRANKLIN	Contact	: Kieren Burns
Address	: 38 DEQUETTEVILLE TCE KENT TOWN SA, AUSTRALIA 5067	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: ----	Telephone	: +61881625130
Project	: 55572	Date Samples Received	: 09-Aug-2019
Order number	: ----	Date Analysis Commenced	: 12-Aug-2019
C-O-C number	: 5156	Issue Date	: 15-Aug-2019
Sampler	: HF		
Site	: Hillgrove Seepage Sampling		
Quote number	: ADBQ/003/18 - PRIMARY WORK ONLY (SA OFFICES)		
No. of samples received	: 5		
No. of samples analysed	: 5		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Arenie Vijayaratnam	Non-metals prep supervisor	Melbourne Inorganics, Springvale, VIC
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005P: pH by PC Titrator (QC Lot: 2518359)									
EM1912852-002	SP02	EA005-P: pH Value	----	0.01	pH Unit	3.88	3.83	1.30	0% - 20%
EM1912835-006	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.31	6.99	4.48	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 2518357)									
EM1912811-008	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	3040	3000	1.32	0% - 20%
EM1912807-004	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	529	536	1.31	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 2518358)									
EM1912852-002	SP02	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.00	No Limit
EM1912835-006	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	60	59	0.00	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	60	59	0.00	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2518182)									
EM1912835-009	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	6	6	0.00	No Limit
EM1912818-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	178	178	0.00	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2518186)									
EM1912852-005	DUP01	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	3500	3680	4.86	0% - 20%
EM1912884-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	129	130	0.00	0% - 20%
ED045G: Chloride by Discrete Analyser (QC Lot: 2518185)									
EM1912852-001	SP01	ED045G: Chloride	16887-00-6	1	mg/L	516	508	1.59	0% - 20%
EM1912883-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	2700	2680	0.624	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 2521087)									

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED093F: Dissolved Major Cations (QC Lot: 2521087) - continued									
EM1912846-009	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	51	52	3.24	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	157	162	2.79	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	1310	1340	2.36	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	1	1	0.00	No Limit
EM1912956-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	85	85	0.00	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	49	50	0.00	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	47	47	0.00	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 2520813)									
EM1912839-003	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.007	0.007	0.00	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.337	0.340	0.782	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.001	0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.060	0.060	0.00	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	3.40	3.39	0.296	0% - 20%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.060	0.060	0.00	0% - 20%
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.189	0.191	0.928	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.02	0.02	0.00	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.05	0.05	0.00	No Limit
EM1912883-003	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.182	0.180	1.15	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.003	0.003	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.018	0.018	0.00	0% - 50%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.010	0.010	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.236	0.232	1.85	0% - 20%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.033	0.034	4.22	0% - 20%
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.096	0.096	0.00	0% - 50%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.07	0.07	0.00	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.11	0.11	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2521284)									

Laboratory Duplicate (DUP) Report

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2521284) - continued									
EM1912835-002	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EM1912835-011	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2521285)									
EM1912852-005	DUP01	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EM1912856-015	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 2519646)									
EM1912805-001	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.39	0.39	0.00	0% - 20%
EM1912846-005	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.01	0.01	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2519648)									
EM1912846-009	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.95	0.95	0.00	0% - 20%
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2519231)									
EM1912852-005	DUP01	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	6.9	6.7	3.06	0% - 20%
EM1912852-004	SP04-DAM	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	5.0	5.1	3.76	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2519229)									
EM1912711-002	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	85.6	86.0	0.421	0% - 20%
EM1912807-010	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.12	0.12	0.00	0% - 50%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2519232)									
EM1912852-004	SP04-DAM	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.20	0.20	0.00	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA010P: Conductivity by PC Titrator (QCLot: 2518357)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	100	85	119
ED037P: Alkalinity by PC Titrator (QCLot: 2518358)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	99.2	88	112
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2518182)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	103	86	115
				<1	100 mg/L	99.0	86	115
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2518186)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	106	86	115
				<1	100 mg/L	99.6	86	115
ED045G: Chloride by Discrete Analyser (QCLot: 2518185)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	104	86	120
				<1	1000 mg/L	104	86	120
ED093F: Dissolved Major Cations (QCLot: 2521087)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	112	92	113
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	109	87	114
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	104	88	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	99.8	87	112
EG020T: Total Metals by ICP-MS (QCLot: 2520813)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	105	80	120
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	100	90	110
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	104	88	113
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	0.1 mg/L	98.6	88	112
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	102	86	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	101	87	109
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	102	88	113
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	99.2	87	108
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	106	88	109
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	97.1	88	111
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	105	87	111
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	98.5	85	113
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	102	88	112
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	102	87	113
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	107	88	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2521284)								

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2521284) - continued								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	103	76	115
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2521285)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	107	76	115
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2519646)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	1 mg/L	108	87	117
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2519648)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	106	93	120
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2519231)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	5 mg/L	98.6	70	117
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2519229)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	2.21 mg/L	98.6	72	114
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2519232)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	2.21 mg/L	98.6	72	114

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2518182)							
EM1912829-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	100 mg/L	89.5	70	130
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2518186)							
EM1912855-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	100 mg/L	98.6	70	130
ED045G: Chloride by Discrete Analyser (QCLot: 2518185)							
EM1912852-002	SP02	ED045G: Chloride	16887-00-6	400 mg/L	98.9	70	130
EG020T: Total Metals by ICP-MS (QCLot: 2520813)							
EM1912839-003	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	96.7	82	118
		EG020A-T: Beryllium	7440-41-7	1 mg/L	103	79	121
		EG020A-T: Barium	7440-39-3	1 mg/L	95.5	80	114
		EG020A-T: Cadmium	7440-43-9	0.25 mg/L	93.0	75	129
		EG020A-T: Chromium	7440-47-3	1 mg/L	89.1	80	118
		EG020A-T: Cobalt	7440-48-4	1 mg/L	93.5	82	120
		EG020A-T: Copper	7440-50-8	1 mg/L	89.0	81	115
		EG020A-T: Lead	7439-92-1	1 mg/L	92.0	83	121
		EG020A-T: Manganese	7439-96-5	1 mg/L	80.6	73	123

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	High
EG020T: Total Metals by ICP-MS (QCLot: 2520813) - continued							
EM1912839-003	Anonymous	EG020A-T: Nickel	7440-02-0	1 mg/L	94.4	80	118
		EG020A-T: Vanadium	7440-62-2	1 mg/L	92.0	81	119
		EG020A-T: Zinc	7440-66-6	1 mg/L	90.9	74	116
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2521284)							
EM1912835-003	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	91.8	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2521285)							
EM1912856-007	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	97.4	70	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2519646)							
EM1912805-002	Anonymous	EK055G: Ammonia as N	7664-41-7	1 mg/L	107	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2519648)							
EM1912846-010	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	# Not Determined	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2519231)							
EM1912876-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	100	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2519229)							
EM1912711-005	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	87.9	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2519232)							
EM1912876-001	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	114	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1912852**	Page	: 1 of 8
Client	: **JBS&G Australia Pty Ltd**	Laboratory	: Environmental Division Melbourne
Contact	: HAYDN FRANKLIN	Telephone	: +61881625130
Project	: 55572	Date Samples Received	: 09-Aug-2019
Site	: Hillgrove Seepage Sampling	Issue Date	: 15-Aug-2019
Sampler	: HF	No. of samples received	: 5
Order number	: ----	No. of samples analysed	: 5

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Ar	EM1912846--010	Anonymous	**Nitrite + Nitrate as N**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural SP01, SP02, SP03, SP04-DAM, DUP01	----	----	----	12-Aug-2019	08-Aug-2019	**4**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
Container */ Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	**----**	----	----	**12-Aug-2019**	08-Aug-2019	✗
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	**----**	----	----	**12-Aug-2019**	05-Sep-2019	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	----	----	----	**12-Aug-2019**	22-Aug-2019	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	----	----	----	**12-Aug-2019**	05-Sep-2019	✓
ED045G: Chloride by Discrete Analyser							
Clear Plastic Bottle - Natural (ED045G) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	----	----	----	**12-Aug-2019**	05-Sep-2019	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural (ED093F) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	----	----	----	**13-Aug-2019**	15-Aug-2019	✓
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG020A-T) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	**13-Aug-2019**	04-Feb-2020	✓	**13-Aug-2019**	04-Feb-2020	✓
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG035T) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	----	----	----	**14-Aug-2019**	05-Sep-2019	✓
EK055G: Ammonia as N by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK055G) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	----	----	----	**13-Aug-2019**	05-Sep-2019	✓
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK059G) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	----	----	----	**13-Aug-2019**	05-Sep-2019	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK061G) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	**13-Aug-2019**	05-Sep-2019	✓	**13-Aug-2019**	05-Sep-2019	✓
EK067G: Total Phosphorus as P by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK067G) SP01, SP02, SP03, SP04-DAM, DUP01	**08-Aug-2019**	**13-Aug-2019**	05-Sep-2019	✓	**13-Aug-2019**	05-Sep-2019	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	9	**22.22**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	7	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	4	31	**12.90**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	4	40	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	3	25	**12.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	4	31	**12.90**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	40	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	25	**8.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	31	**6.45**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	40	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	25	**8.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	**Actual**	**Expected**	*Evaluation*	
Matrix Spikes (MS) - Continued							
Ammonia as N by Discrete analyser	EK055G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	31	**6.45**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	40	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	25	**8.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH by PC Titrator	EA005-P	WATER	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)

Analytical Methods	Method	Matrix	Method Descriptions
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO3-. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	* EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)

CHAIN OF CUSTODY DOCUMENTATION

JBS&G (Australia) Pty Ltd

Adelaide
38 Dequetteville Tce KENT TOWN SA 5067
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ACN 100 220 479 · ABN 62 100 220 479

JBS&G

CLIENT: JBS&G	LABORATORY: HF	LABORATORY BATCH NO.:
SITE/PROJECT NAME: Hillgrove Seepage Sampling	COC Reference #: 5156	SAMPLERS: HF
SEND REPORT TO: JBS&G Australia Pty Ltd	SEND INVOICE TO: JBS&G Australia Pty Ltd	PHONE: 08 8431 7113 FAX: 08 8431 7115
DATA NEEDED BY: **Standard TAT**	REPORT NEEDED BY: **Standard TAT**	REPORT FORMAT: HARD: NO FAX: NO E-MAIL: YES
SITE/PROJECT NUMBER: 55572	**QUOTE #:**	JBS&G OFFICE TO SEND RESULTS: South Australia

RELINQUISHED BY:		RECEIVED BY		
NAME: Haydn Franklin	DATE: 08/08/2019	NAME: Sam	DATE: 9/8/19	METHOD OF SHIPMENT: Overnight
OF: JBS&G (Australia) Pty Ltd	TIME:	OF: ALS	TIME: 10:55	CONSIGNMENT NOTE NO.
NAME: Richard Fassbender	DATE: 08/08/2019	NAME:	DATE:	TRANSPORT CO. NAME.
OF:	TIME:	OF:	TIME:	

P.O. NO.:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:
Please forward results and invoice to:
labresults@jbsg.com.au; mcowin@jbsg.com.au; hfranklin@jbsg.com.au; rfassbender@jbsg.com.au

FOR LAB USE ONLY
COOLER SEAL
Yes ...... No ......
Broken ...... Intact ......
COOLER TEMP: deg.C

ANALYSIS REQUIRED

ALS ID	SAMPLE ID	MATRIX	DATE	TIME	TYPE & PRESERVATIVE	NO.	pH field	NT-1 & NT-2 (Anions / Cations)	Metals (15) -NEPM	Nutrients	EC	pH											
1	SP01	Water	8/08/2019		P; N; PS	4		X	X	X	X	X			hold one plastic (P) for potential further samples								
2	SP02	Water	8/08/2019		P; N; PS	3		X	X	X	X	X											
3	SP03	Water	8/08/2019		P; N; PS	3		X	X	X	X	X											
4	SP04-DAM	Water	8/08/2019		P; N; PS	3		X	X	X	X	X											
5	DUP01	Water	8/08/2019		P; N; PS	3		X	X	X	X	X											
							TOTAL	5	5	5	5	5	0	0	1	0	0	0	0	0	0	0	0

***Container Type and Preservative Codes:**
P = Neutral Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Jar; S = Solvent Washed Glass Bottle; VC = HCL Preserved Vial; PC = HCL Preserved Plastic; PS = Sulfuric Acid Preserved Plastic; BS = Sulfuric Acid Preserved Glass Bottle; Z = Zinc Acetate Preserved Bottle; ST =Sodium Thiosuplhate Preserved Plastic, E = EDTA Preserved Bottles; ST = Sterile Bottle; O = Other.

NOTES
Metals = NEPM'15 + Aluminium
Nutrients = Ammonia as N, Total Nitrogen as N, Nitrate+Nitrite as N (oxidised nitrogen - NOx), and Total Phosphorus

*** Please send on SPLIT01 Samples onto Eurofins MGT with COC**

Environmental Division
Melbourne
Work Order Reference
EM1912852
Telephone : + 61-3-8549 9600

1

Sample Receipt Advice

Company name:	**JBS & G Australia (SA) P/L**
Contact name:	Mike Cowin
Project name:	HILLGROVE SEEPAGE SAMPLING
Project ID:	55572
COC number:	5156
Turn around time:	5 Day
Date/Time received:	Aug 8, 2019 3:30 PM
Eurofins reference:	**670280**

Sample information

- ☑ A detailed list of analytes logged into our LIMS, is included in the attached summary table.
- ☑ All samples have been received as described on the above COC.
- ☑ COC has been completed correctly.
- ☑ Attempt to chill was evident.
- ☑ Appropriately preserved sample containers have been used.
- ☑ All samples were received in good condition.
- ☑ Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
- ☑ Appropriate sample containers have been used.
- ☑ Sample containers for volatile analysis received with zero headspace.
- ☒ Split sample sent to requested external lab.
- ☒ Some samples have been subcontracted.
- N/A Custody Seals intact (if used).

Contact notes

If you have any questions with respect to these samples please contact:

Michael Cassidy on Phone : +61 3 8564 5000 or by e.mail: MichaelCassidy@eurofins.com

Results will be delivered electronically via e.mail to Mike Cowin - MCowin@jbsg.com.au.

eurofins | Environment Testing

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Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Perth
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Kewdale WA 6105
Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

Company Name: JBS & G Australia (SA) P/L
Address: 100 Hutt St
Adelaide
SA 5000

Order No.:
Report #: 670280
Phone: 08 8431 7113
Fax: 08 8431 7115

Received: Aug 8, 2019 3:30 PM
Due: Aug 15, 2019
Priority: 5 Day
Contact Name: Mike Cowin

Project Name: HILLGROVE SEEPAGE SAMPLING
Project ID: 55572

Eurofins Analytical Services Manager : Michael Cassidy

Sample Detail						Conductivity (at 25°C)	Nitrate & Nitrite (as N)	Nitrite (as N)	pH (at 25°C)	Phosphate total (as P)	Total Nitrogen (as N)	Major Anions	Major Cations	NEPM 1999 Metals : Metals M15
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217														
Brisbane Laboratory - NATA Site # 20794														
Perth Laboratory - NATA Site # 23736														
External Laboratory														
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**									
1	SPLIT01	Aug 08, 2019		Water	M19-Au11735	X	X	X	X	X	X	X	X	X
Test Counts						1	1	1	1	1	1	1	1	1

Certificate of Analysis

eurofins Environment Testing

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

JBS & G Australia (SA) P/L
100 Hutt St
Adelaide
SA 5000

Attention: **Mike Cowin**

Report	**670280-W**
Project name	HILLGROVE SEEPAGE SAMPLING
Project ID	55572
Received Date	Aug 08, 2019

Client Sample ID			**SPLIT01**
Sample Matrix			**Water**
Eurofins Sample No.			**M19-Au11735**
Date Sampled			**Aug 08, 2019**
Test/Reference	LOR	Unit	
Ammonia (as N)	0.01	mg/L	6.4
Chloride	1	mg/L	430
Chromium (hexavalent)	0.005	mg/L	< 0.005
Chromium (trivalent)	0.001	mg/L	< 0.005
Conductivity (at 25°C)	1	uS/cm	6400
Nitrate & Nitrite (as N)	0.05	mg/L	0.89
Nitrate (as N)	0.02	mg/L	0.88
Nitrite (as N)	0.02	mg/L	< 0.02
pH (at 25°C)	0.1	pH Units	3.8
Phosphate total (as P)	0.01	mg/L	0.29
Sulphate (as SO4)	5	mg/L	3500
Total Nitrogen (as N)	0.2	mg/L	8.9
Alkalinity (speciated)			
Bicarbonate Alkalinity (as CaCO3)	20	mg/L	< 20
Carbonate Alkalinity (as CaCO3)	10	mg/L	< 10
Heavy Metals			
Arsenic	0.001	mg/L	0.001
Barium	0.02	mg/L	< 0.02
Beryllium	0.001	mg/L	0.024
Boron	0.05	mg/L	0.40
Cadmium	0.0002	mg/L	0.019
Chromium	0.001	mg/L	0.002
Cobalt	0.001	mg/L	9.1
Copper	0.001	mg/L	62
Lead	0.001	mg/L	0.002
Manganese	0.005	mg/L	87
Mercury	0.0001	mg/L	< 0.0001
Nickel	0.001	mg/L	5.1
Vanadium	0.005	mg/L	< 0.005
Zinc	0.005	mg/L	3.8
Alkali Metals			
Calcium	0.5	mg/L	610
Magnesium	0.5	mg/L	320
Potassium	0.5	mg/L	230
Sodium	0.5	mg/L	470

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Major Cations			
Ammonia (as N)	Melbourne	Aug 09, 2019	28 Days
- Method: LTM-INO-4200 Ammonia by Discrete Analyser			
Alkali Metals	Melbourne	Aug 09, 2019	180 Days
- Method: LTM-MET-3010 Alkali Metals S Si and P by ICP-AES			
Major Anions			
Chloride	Melbourne	Aug 09, 2019	28 Days
- Method: LTM-INO-4090 Chloride by Discrete Analyser			
Nitrate (as N)	Melbourne	Aug 09, 2019	28 Days
- Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA			
Sulphate (as SO4)	Melbourne	Aug 09, 2019	28 Days
- Method: LTM-INO-4110 Sulfate by Discrete Analyser			
Alkalinity (speciated)	Melbourne	Aug 09, 2019	14 Days
- Method: LTM-INO-4250 Alkalinity by Electrometric Titration			
Chromium (hexavalent)	Melbourne	Aug 09, 2019	28 Days
- Method: Cr (VI) by MGT 1170A			
Heavy Metals	Melbourne	Aug 12, 2019	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Conductivity (at 25°C)	Melbourne	Aug 09, 2019	28 Days
- Method: LTM-INO-4030 Conductivity			
Nitrate & Nitrite (as N)	Melbourne	Aug 09, 2019	28 Days
- Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA			
Nitrite (as N)	Melbourne	Aug 09, 2019	2 Days
- Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA			
pH (at 25°C)	Melbourne	Aug 09, 2019	0 Hours
- Method: LTM-GEN-7090 pH in water by ISE			
Phosphate total (as P)	Melbourne	Aug 09, 2019	28 Days
- Method: APHA 4500-P E. Phosphorus			

Company Name:	JBS & G Australia (SA) P/L	**Order No.:**		**Received:**	Aug 8, 2019 3:30 PM
Address:	100 Hutt St Adelaide SA 5000	**Report #:**	670280	**Due:**	Aug 15, 2019
		Phone:	08 8431 7113	**Priority:**	5 Day
		Fax:	08 8431 7115	**Contact Name:**	Mike Cowin
Project Name:	HILLGROVE SEEPAGE SAMPLING				
Project ID:	55572				

Eurofins Analytical Services Manager : Michael Cassidy

Sample Detail						Conductivity (at 25°C)	Nitrate & Nitrite (as N)	Nitrite (as N)	pH (at 25°C)	Phosphate total (as P)	Total Nitrogen (as N)	Major Anions	Major Cations	NEPM 1999 Metals : Metals M15
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217														
Brisbane Laboratory - NATA Site # 20794														
Perth Laboratory - NATA Site # 23736														
External Laboratory														
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**									
1	SPLIT01	Aug 08, 2019		Water	M19-Au11735	X	X	X	X	X	X	X	X	X
Test Counts						1	1	1	1	1	1	1	1	1

Environment Testing

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**ug/L:** micrograms per litre
ppm: Parts per million	**ppb:** Parts per billion	**%:** Percentage
org/100mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Ammonia (as N)	mg/L	< 0.01			0.01	Pass	
Chloride	mg/L	< 1			1	Pass	
Chromium (hexavalent)	mg/L	< 0.005			0.005	Pass	
Nitrate & Nitrite (as N)	mg/L	< 0.05			0.05	Pass	
Nitrate (as N)	mg/L	< 0.02			0.02	Pass	
Nitrite (as N)	mg/L	< 0.02			0.02	Pass	
Phosphate total (as P)	mg/L	< 0.01			0.01	Pass	
Sulphate (as SO4)	mg/L	< 5			5	Pass	
Total Nitrogen (as N)	mg/L	< 0.2			0.2	Pass	
Method Blank							
Heavy Metals							
Arsenic	mg/L	< 0.001			0.001	Pass	
Barium	mg/L	< 0.02			0.02	Pass	
Beryllium	mg/L	< 0.001			0.001	Pass	
Boron	mg/L	< 0.05			0.05	Pass	
Cadmium	mg/L	< 0.0002			0.0002	Pass	
Chromium	mg/L	< 0.001			0.001	Pass	
Cobalt	mg/L	< 0.001			0.001	Pass	
Copper	mg/L	< 0.001			0.001	Pass	
Lead	mg/L	< 0.001			0.001	Pass	
Manganese	mg/L	< 0.005			0.005	Pass	
Mercury	mg/L	< 0.0001			0.0001	Pass	
Nickel	mg/L	< 0.001			0.001	Pass	
Vanadium	mg/L	< 0.005			0.005	Pass	
Zinc	mg/L	< 0.005			0.005	Pass	
Method Blank							
Alkali Metals							
Calcium	mg/L	< 0.5			0.5	Pass	
Magnesium	mg/L	< 0.5			0.5	Pass	
Potassium	mg/L	< 0.5			0.5	Pass	
Sodium	mg/L	< 0.5			0.5	Pass	
LCS - % Recovery							
Ammonia (as N)	%	96			70-130	Pass	
Chloride	%	103			70-130	Pass	
Chromium (hexavalent)	%	115			70-130	Pass	
Nitrate & Nitrite (as N)	%	97			70-130	Pass	
Nitrate (as N)	%	97			70-130	Pass	
Nitrite (as N)	%	113			70-130	Pass	
Phosphate total (as P)	%	99			70-130	Pass	
Sulphate (as SO4)	%	120			70-130	Pass	
Total Nitrogen (as N)	%	114			70-130	Pass	
LCS - % Recovery							
Alkalinity (speciated)							
Carbonate Alkalinity (as CaCO3)	%	95			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic	%	102			80-120	Pass	
Barium	%	102			80-120	Pass	
Beryllium	%	108			80-120	Pass	
Boron	%	107			80-120	Pass	
Cadmium	%	106			80-120	Pass	

eurofins | Environment Testing

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Chromium			%	106			80-120	Pass	
Cobalt			%	106			80-120	Pass	
Copper			%	105			80-120	Pass	
Lead			%	106			80-120	Pass	
Manganese			%	106			80-120	Pass	
Mercury			%	101			75-125	Pass	
Nickel			%	108			80-120	Pass	
Vanadium			%	105			80-120	Pass	
Zinc			%	107			80-120	Pass	
LCS - % Recovery									
Alkali Metals									
Calcium			%	102			70-130	Pass	
Magnesium			%	101			70-130	Pass	
Potassium			%	107			70-130	Pass	
Sodium			%	96			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
				Result 1					
Ammonia (as N)	M19-Au15027	NCP	%	97			70-130	Pass	
Chloride	S19-Au09736	NCP	%	107			70-130	Pass	
Chromium (hexavalent)	M19-Au12421	NCP	%	94			70-130	Pass	
Nitrate & Nitrite (as N)	M19-Au15027	NCP	%	92			70-130	Pass	
Nitrate (as N)	M19-Au15027	NCP	%	92			70-130	Pass	
Nitrite (as N)	M19-Au15027	NCP	%	104			70-130	Pass	
Phosphate total (as P)	M19-Au12731	NCP	%	88			70-130	Pass	
Sulphate (as SO4)	S19-Au09726	NCP	%	109			70-130	Pass	
Total Nitrogen (as N)	M19-Au16361	NCP	%	77			70-130	Pass	
Spike - % Recovery									
Alkalinity (speciated)				Result 1					
Bicarbonate Alkalinity (as CaCO3)	B19-Au10805	NCP	%	116			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic	M19-Au13824	NCP	%	91			75-125	Pass	
Barium	M19-Au13824	NCP	%	92			75-125	Pass	
Beryllium	M19-Au13824	NCP	%	97			75-125	Pass	
Boron	M19-Au13824	NCP	%	93			75-125	Pass	
Cadmium	M19-Au13824	NCP	%	102			75-125	Pass	
Chromium	M19-Au13824	NCP	%	95			75-125	Pass	
Cobalt	M19-Au11658	NCP	%	95			75-125	Pass	
Copper	M19-Au11658	NCP	%	96			75-125	Pass	
Lead	M19-Au13824	NCP	%	97			75-125	Pass	
Manganese	M19-Au11658	NCP	%	96			75-125	Pass	
Mercury	M19-Au13824	NCP	%	92			70-130	Pass	
Nickel	M19-Au11658	NCP	%	90			75-125	Pass	
Vanadium	M19-Au13824	NCP	%	95			75-125	Pass	
Zinc	M19-Au13824	NCP	%	94			75-125	Pass	
Spike - % Recovery									
Alkali Metals				Result 1					
Calcium	B19-Au10804	NCP	%	108			70-130	Pass	
Magnesium	B19-Au10804	NCP	%	107			70-130	Pass	
Potassium	B19-Au10804	NCP	%	112			70-130	Pass	
Sodium	B19-Au10804	NCP	%	106			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
				Result 1	Result 2	RPD			
Ammonia (as N)	M19-Au14077	NCP	mg/L	84	84	<1	30%	Pass	
Chloride	M19-Au14964	NCP	mg/L	14	12	13	30%	Pass	
Chromium (hexavalent)	M19-Au12421	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Conductivity (at 25°C)	M19-Au08392	NCP	uS/cm	27000	27000	<1	30%	Pass	
Nitrate & Nitrite (as N)	M19-Au14077	NCP	mg/L	< 1	< 1	<1	30%	Pass	
Nitrate (as N)	M19-Au14077	NCP	mg/L	< 0.4	< 0.4	<1	30%	Pass	
Nitrite (as N)	M19-Au14077	NCP	mg/L	< 0.4	< 0.4	<1	30%	Pass	
pH (at 25°C)	M19-Au08392	NCP	pH Units	6.7	6.7	pass	30%	Pass	
Phosphate total (as P)	M19-Au12726	NCP	mg/L	0.09	0.09	<1	30%	Pass	
Sulphate (as SO4)	M19-Au14964	NCP	mg/L	600	620	2.0	30%	Pass	
Total Nitrogen (as N)	M19-Au19254	NCP	mg/L	2.8	2.6	6.0	30%	Pass	
Duplicate									
Alkalinity (speciated)				Result 1	Result 2	RPD			
Bicarbonate Alkalinity (as CaCO3)	M19-Au12151	NCP	mg/L	53	53	<1	30%	Pass	
Carbonate Alkalinity (as CaCO3)	M19-Au12151	NCP	mg/L	< 10	< 10	<1	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic	M19-Au07028	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Barium	M19-Au13824	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
Beryllium	M19-Au13824	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Boron	M19-Au13824	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Cadmium	M19-Au07028	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Chromium	M19-Au07028	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Cobalt	M19-Au11658	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Copper	M19-Au11658	NCP	mg/L	0.004	0.004	2.0	30%	Pass	
Lead	M19-Au07028	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Manganese	M19-Au11658	NCP	mg/L	0.011	0.011	2.0	30%	Pass	
Mercury	M19-Au07028	NCP	mg/L	< 0.0005	< 0.0005	<1	30%	Pass	
Nickel	M19-Au11658	NCP	mg/L	0.001	0.002	13	30%	Pass	
Vanadium	M19-Au13824	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Zinc	M19-Au07028	NCP	mg/L	0.059	0.063	6.0	30%	Pass	
Duplicate									
Alkali Metals				Result 1	Result 2	RPD			
Calcium	B19-Au10804	NCP	mg/L	73	70	4.0	30%	Pass	
Magnesium	B19-Au10804	NCP	mg/L	310	300	3.0	30%	Pass	
Potassium	B19-Au10804	NCP	mg/L	32	31	2.0	30%	Pass	
Sodium	B19-Au10804	NCP	mg/L	2500	2500	4.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By

Michael Cassidy	Analytical Services Manager
Emily Rosenberg	Senior Analyst-Metal (VIC)
Julie Kay	Senior Analyst-Inorganic (VIC)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

CHAIN OF CUSTODY DOCUMENTATION

JBS&G (Australia) Pty Ltd

Adelaide
38 Dequetteville Tce KENT TOWN SA 5067
T: + 61 8 8431 7113 · F: + 61 8 8431 7115
ACN 100 220 479 · ABN 62 100 220 479

JBS&G

CLIENT: JBS&G	LABORATORY: MGT	LABORATORY BATCH NO.:
SITE/PROJECT NAME: Hillgrove Seepage Sampling	COC Reference #: 5156	SAMPLERS: HF
SEND REPORT TO: JBS&G Australia Pty Ltd	SEND INVOICE TO: JBS&G Australia Pty Ltd	PHONE: 08 8431 7113 FAX: 08 8431 7115
DATA NEEDED BY: **Standard TAT**	REPORT NEEDED BY: **Standard TAT**	REPORT FORMAT: HARD: NO FAX: NO E-MAIL: YES
SITE/PROJECT NUMBER: 55572	**QUOTE #:**	JBS&G OFFICE TO SEND RESULTS: South Australia

RELINQUISHED BY:		RECEIVED BY		
NAME: Haydn Franklin	DATE: 08/08/2019	NAME: Pateimal	DATE: 08/08	METHOD OF SHIPMENT: Overnight
OF: JBS&G (Australia) Pty Ltd	TIME:	OF: Eurofins	TIME: 3:30pm	CONSIGNMENT NOTE NO.
NAME: Richard Fassbender	DATE: 08/08/2019	NAME:	DATE:	TRANSPORT CO. NAME.
OF:	TIME:	OF:	TIME:	

P.O. NO.:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:
Please forward results and invoice to:
labresults@jbsg.com.au; mcowin@jbsg.com.au; hfranklin@jbsg.com.au; rfassbender@jbsg.com.au

FOR LAB USE ONLY
COOLER SEAL
Yes ...... No ......
Broken ...... Intact ....
COOLER TEMP: deg.C

ANALYSIS REQUIRED

SAMPLE ID	MATRIX	DATE	TIME	TYPE & PRESERVATIVE	NO.	pH field	NT-1 & NT-2 (Anions / Cations)	Metals (15) -NEPM	Nutrients	EC	pH											
SPLIT01	Water	8/08/2019		P; N; PS	3		X	X	X	X	X											
						TOTAL	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

(SAMPLE DATA: SAMPLE ID, MATRIX, DATE, TIME; CONTAINER DATA: TYPE & PRESERVATIVE, NO., pH field)

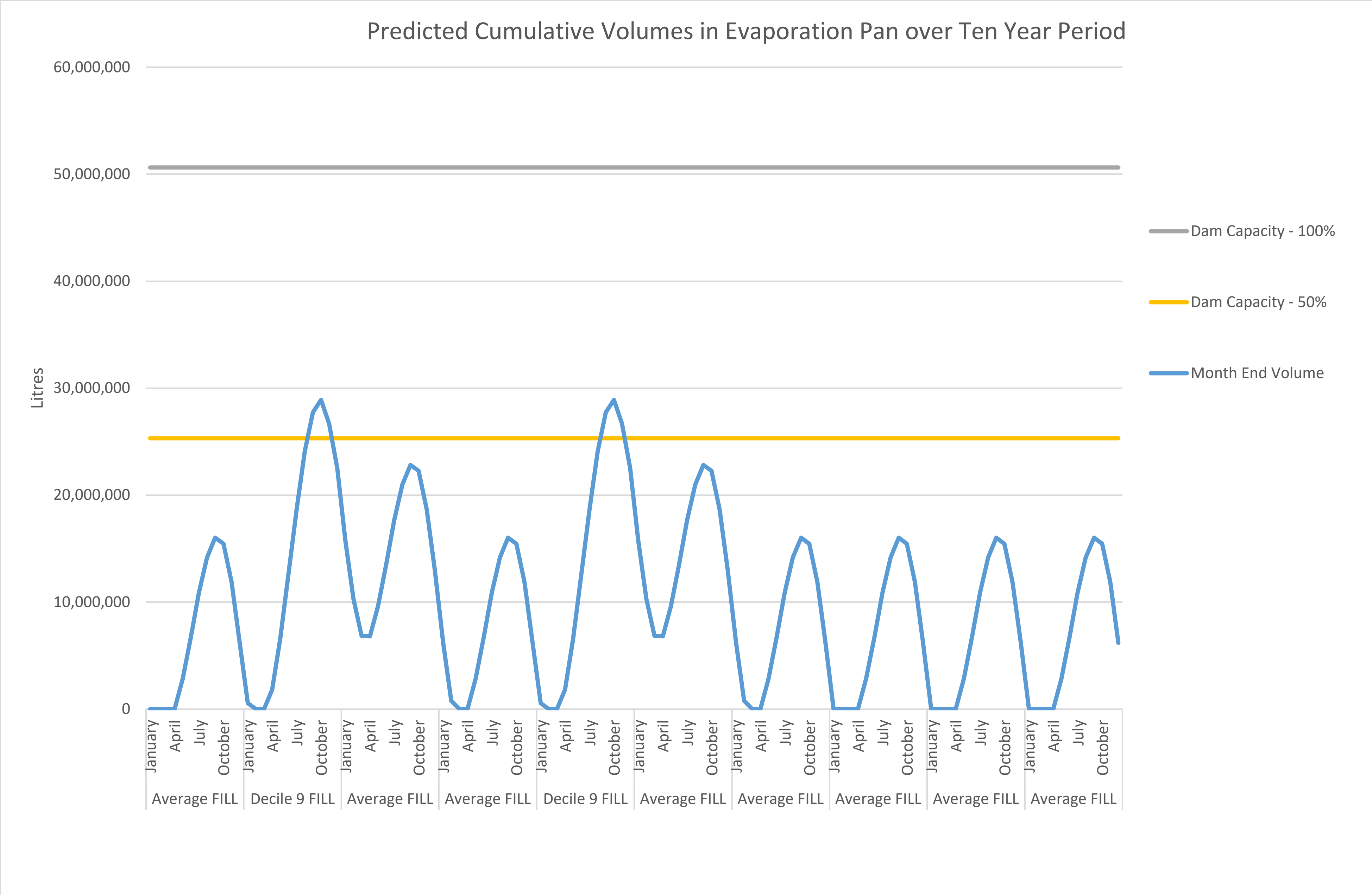
***Container Type and Preservative Codes:**
P = Neutral Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Jar; S = Solvent Washed Glass Bottle; VC = HCL Preserved Vial; PC = HCL Preserved Plastic; PS = Sulfuric Acid Preserved Plastic; BS = Sulfuric Acid Preserved Glass Bottle; Z = Zinc Acetate Preserved Bottle; ST =Sodium Thiosuplhate Preserved Plastic, E = EDTA Preserved Bottles; ST = Sterile Bottle; O = Other.

'NOTES
Metals = NEPM 15 + Aluminium
Nutrients = Ammonia as N, Total Nitrogen as N, Nitrate+Nitrite as N (oxidised nitrogen - NOx), and Total Phosphorus

*** Please send on SPLIT01 Samples onto Eurofins MGT with COC**

#670280
Pateimal

Attachment D Water Balance Output


Predicted Cumulative Volumes in Evaporation Pan over Ten Year Period
Litres
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
January
April
July
October
Average FILL
Decile 9 FILL
Average FILL
Average FILL
Decile 9 FILL
Average FILL
Average FILL
Average FILL
Average FILL
Average FILL
Dam Capacity - 100%
Dam Capacity - 50%
Month End Volume

Appendix D - Independent TSF Raise Design and Closure Review for Hillgrove Resources – Kanmantoo Copper Mine (Williams, 2019)

INDEPENDENT TSF RAISE DESIGN AND CLOSURE REVIEW

FOR

HILLGROVE RESOURCES – KANMANTOO COPPER MINE

Report prepared by

Professor David J Williams
BE (Hons I) Civil Eng, PhD, FIEAust, MAusIMM, CPEng, RPEQ
C/- School of Civil Engineering
The University of Queensland, Brisbane QLD 4072

Phone: (07) 3365 3642
Email: D.Williams@uq.edu.au

17 October 2019

TABLE OF CONTENTS

1 INTRODUCTION

Professor David Williams was commissioned by Bruce Hutchison, Principal Engineer, Kanmantoo Copper Mine, to undertake an independent review of three aspects of the Kanmantoo tailings storage facility (TSF) and integrated waste landform (IWL) closure works:

1. Design review for TSF upstream Stages 8 and 9 by up to 11 m (up to RL 1,274 m) that Kanmantoo's Consultant PSM are undertaking. The TSF has been raised upstream from RL 1,252 to 1,263 m using waste rock (comprising potentially acid forming [PAF] rock with a downstream cover of non-acid forming [NAF] rock).
2. Review of the store and release cover over the IWL and its performance monitoring and modelling results.
3. Review of the IWL cover erosion modelling.

A site visit took place 23-24 July 2019, accompanied by Bruce Hutchison and John Crocker, to inspect the site and view the progress of rehabilitation, the cover moisture monitoring data, and have discussions with site personnel. Also included in the review is relevant experience from elsewhere.

It is understood that the review will be submitted to the South Australian Department of Energy and Mining (DEM) before the formal Program for Environment Protection and Rehabilitation (PEPR) Report submission. The agreed post-mining land use is restricted primary production or industrial, although native habitat may be proposed for parts of the site.

2 REVIEW OF SUPPLIED REPORTS

2.1 Supplied Reports

The following supplied reports were reviewed:

1. TSF upstream Stages 8 and 9:
   a. Kanmantoo TSF CPTu and Vane Shear Testing by PSM, dated 10 October 2018 (2018_10 CPTu testing_PSM1734-191L.pdf).
   b. Kanmantoo TSF Stability Analysis and Water Balance Assessment by PSM, dated 23 November 2018 (2018_11_23 Rapid Build and Drainage Assessment PSM1734-190L.pdf).
   c. Kanmantoo TSF Stages 8 and 9 Design Report by PSM, dated 3 September 2019 (PSM1734-203R DRAFT.pdf).
2. Store and release cover over IWL:
   a. IWL Cover Design Summary Report by Hillgrove Resources, dated 15 February 2019 (190215 IWL cover design summary report 2019 v001.pdf).
   b. Geochemical Assessment of Surface Waters at Kanmantoo Copper Mine by JBS&G, dated 4 December 2018 (L01_Geochemical Assessment of Ponded Water at Kanmantoo_Rev 0.pdf).
   c. Soil Moisture Monitoring Report for Kanmantoo Copper Mine by Hillgrove Resources, dated 10 September 2019 (2019 09 10_Soil Moisture Monitoring Report 10Sep19.pdf).
   d. IWL Cover Design Summary Report by USEL, and Hillgrove Resources, dated September 2019 (190916 IWL cover design summary report 2019 v002c).
3. IWL cover erosion modelling:
   a. Interim Landform Evolution Modelling for Kanamntoo IWL Memo by Landloch, dated 7 December 2017 (2241.17a_Memorandum_Kanmantoo Erosion Modelling Dec2017.pdf).
   b. Landform Evolution Modelling for Kanmantoo IWL Report by Landloch, dated February 2019 (2241.17a_Landform Evolution Modelling_Report_Rev3_Final.pdf).
   c. Kanmantoo Erodibility Testing and Modelling Report by Landloch, dated August 2019 (2241.19a_Erodibility Testing and Modelling_Report_Rev2)

The key points from these reports are summarised in the following Sections, with comments by Professor Williams highlighted in ***bold italics***.

2.2 TSF Upstream Stages 8 and 9

2.1.1 CPTu and Vane Shear Testing by PSM

- The CPTu testing of the tailings around the perimeter of the TSF reported by PSM on 10 October 2018, indicated these tailings to be silty sand or sandy silt-sized, with a low relative density of about 40%. These tailings would be expected to have medium to high frictional strength and a low apparent cohesion, and to be of medium stiffness on loading. The phreatic surface was located at a depth of about 10 m close to the embankment and less than hydrostatic, due to a downward gradient towards the TSF underdrainage. CPTu dissipation tests indicated a hydraulic conductivity of 10^{-5} to 10^{-6} m/s (increasing with consolidation), capable of producing drainage in the range from 1 to 10 ML/day. ***PSM did not offer in this report further interpretation of the CPTu data, such as Soil Behaviour Type, estimated friction angle, estimated stiffness, or liquefaction susceptibility. The fact that the tailings are well-drained towards the underdrainage would mitigate their liquefaction potential.***
- The shear vane was difficult to insert and the tailings were found to drain readily on shear vane testing, making vane shear testing for undrained shear strengths inappropriate.

2.1.2 Initial Stability Analysis and Water Balance Assessment by PSM

- PSM reported on 23 November 2018 that the TSF upstream Stage 8, constructed upstream (the previous construction was downstream) on a double, high density polyethylene (HDPE) liner and underdrainage at RL 1,250 m, was initially to involve two x 4 m lifts of PAF waste rock to RL 1,260 m, to form a raise 70 m wide at the base and 30 m wide at the crest, with 1.5(horizontal):1(vertical) side slopes.
- The raise was then to be flattened to 3H:1V side slopes and raised a further 3 m to RL 1,263 m.
- The geotechnical design parameters selected were friction angles of 32° (***conservative compared to a measured value of 34° from direct shear strength testing***), 38° (***presumed and very conservative***), and 20° (***likely presumed, but considered reasonable***), for the tailings, PAF waste rock and liner, respectively. The foundation was ***presumed*** to have a cohesion of 5 kPa and a friction angle of 35°***, which are considered reasonable***. The level of the phreatic surface was inferred from CPTu pore water pressures to be located at 10 m depth, and was conservatively assumed to be hydrostatic, when in fact it is less than hydrostatic due to the downward gradient to the underdrainage.

- Geotechnical stability analyses carried out using Slide gave high calculated static Factors of Safety (FoS), ***very much higher than the value of 1.5 required by ANCOLD (2012)***[1], apart from those for surficial slip, which indicated marginal stability. ***In reality, there will be some suction generating apparent cohesion towards the surface, which would reduce the potential for surficial slip.***
- Flow meters on the outlet pipes at the base of TSF into the Return Water Dam (RWD) indicate average flow rates of 1.5 ML/day from the TSF decant and a ***high*** 3.5 ML/day from the installed underdrainage.
- The tailings, with a specific gravity of 2.96, are deposited at 62% solids by mass (dry density of 1.05 t/m^3), settle to an estimated dry density of 1.26 t/m^3 based on the amount of supernatant water produced, and achieve an estimated average final dry density of 1.70 t/m^3 and average degree of saturated of about 75% based on the total tonnage deposited and LiDAR surveys of the volume.
- It is expected that the permeable tailings will drain down within months on the cessation of tailings deposition, with a corresponding reduction in outflows to ***about 0.1 ML/day*** (about 1 L/s) within about 5 years.

2.1.3 Revised Stages 8 and 9 Design Report by PSM

- The revised design of TSF upstream Stages 8 and 9 TSF reported by PSM on 3 September 2019, increased storage capacity was provided within the same footprint to accommodate the tailings produced from processing the remaining ore stockpile (involving an additional 3 m raise to RL 1,266 m), and the possibility to accommodate the tailings from the Old Tailings Dam (OTD; involving a further 8 m raise in two x 4 m lifts to RL 1,274 m).
- The initial raising to RL 1,260 m was constructed upstream at angle of repose slopes of 1.3H:1V (37°) rather than 1.5H:1V, although the outer slope is to be flattened to 3H:1V and the inner slope will be covered and supported by deposited tailings.
- A store and release final cover is proposed to handle incident rainfall, rather than a dome cover as previously proposed.
- In addition to the previous geotechnical stability analyses, earthquake loading and the potential for liquefaction of the tailings were considered:
    - Operating Basis Earthquake (OBE) site-corrected peak ground acceleration (PGA) = 0.1g.
    - Operational Maximum Design Earthquake (MDE) PGA = 0.117g.
    - Post-closure Maximum Credible earthquake (MCE) PGA = 0.174g.
    - The likelihood of the tailings liquefying under the more extreme MDE and MCE were considered by PSM to be LOW.

[1] ANCOLD. (2012). Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure. Australian National Committee on Large Dams.

- ***Conditions necessary for the earthquake-induced liquefaction of tailings are:***
    - ***Fine-grained sandy or silty sand-sized tailings, which exist in the Kanmantoo TSF.***
    - ***Loose (contractive, brittle) state, which exists in the Kanmantoo TSF.***
    - ***Near-saturated, which does not apply above about 10 m depth towards the IWL embankment.***
    - ***Earthquake magnitude > about 5.5 and peak ground acceleration > about 0.13g, which the operating earthquake loadings do not exceed.***
- ***Triggers for static or flow liquefaction are:***
    - ***Loss of containment due to dam instability, which is unlikely at Kanmantoo.***
    - ***Overtopping and erosion of dam, which is unlikely at Kanmantoo.***
    - ***Pore water pressure increase due to dam raise, which is unlikely at Kanmantoo, given that the tailings underlying the raise are well-drained.***
    - ***Rise in the phreatic surface due to heavy rainfall or fresh tailings, which is unlikely at Kanmantoo, given the dry climate and free-draining tailings upper beach.***
- ***The interpreted CPTu data showed some of the tailings to be potentially liquefiable. However, under operating conditions, the tailings underlying the upstream raises are well-drained, and the PGA is below the typical threshold for liquefaction of about 0.13g, corresponding to an earthquake magnitude of about 5.5; hence liquefaction would not be expected. Static liquefaction is also unlikely since the upper 10 m depth of the tailings underlying the upstream Stages 8 and 9 are unsaturated. Post-closure, the tailings are expected to drain down further, and hence would not be expected to liquefy under the MCE.***
- The maximum earthquake-induced settlement was estimated by PSM to be about 180 mm ***or a minor 0.2% of the maximum embankment height of 91 m*** for no liquefaction of the tailings, and 700 mm***, or 0.8%,*** assuming liquefaction of the upper 30 m depth of tailings***, which is considered unlikely***. In neither case is there a potential for loss of tailings.
- Geotechnical stability analyses were carried out by PSM using Slide:
    - The calculated FoS values for the downstream slopes were generally in accordance with the minimum values suggested by ANCOLD (2012) of > 1.5 for static loading and > 1.0 for earthquake loading, apart from those for surficial slip.

  - However, there were some localised sections of the downstream slopes that did not meet the ANCOLD (2012) requirements, such as:
    - The eastern side of Section 1, due to over-steepening to accommodate the haul road. This slope is showing no signs of distress and could, with difficulty, be flattened post-closure to improve geotechnical stability.
    - The south-west side of Section 3, due to the steep outer slope to accommodate the Raw Water Storage (RWS), although this would be mitigated by the three-dimensional geometry of this section, with flatter slopes either side.
  - The calculated FoS values for the upstream slopes are generally marginally higher than unity, apart from those for surficial slip. ***This is expected since they are at the angle of repose of the waste rock at approximately 37^{o}. However, the selected friction angle of the waste rock of 38^{o} is considered very conservative. A more reasonable value would be 6^{o} higher than the angle of repose[2], or 43^{o}, which would increase the FoS by up to 20% for the portion of the slip surface passing through the PAF waste rock. Further, geotechnical stability will improve markedly as tailings are deposited against the upstream slopes, raising the FoS to well above the minimum values suggested ANCOLD (2012).***
  - ***Overall, the downstream and upstream slopes of TSF upstream Stages 8 and 9 are considered to have adequate geotechnical stability.***
- The design capacities of the TSF water reclamation system are:
  - A central decant and pipe with a design capacity of up to 13 ML/day.
  - An underdrainage and pipe with a design capacity of up to 2.6 ML/day.
  - A RWD with a combined inflow capacity of 15.6 ML/day.
- The measured TSF flows are:
  - Average decant flow of 1.1 ML/day – Less than expected.
  - Average underdrainage flow of about 3.5 ML/day, based on a final estimated average tailings dry density of 1.67 t/m^{3} – More than expected***, although the effectiveness of the underdrainage would be expected to decrease as the tailings become locally more consolidated above the underdrainage***, and higher pressures (> 1 MPa) on the pipes could potentially crush them.
  - Combined average flow of 4.46 ML/day.
  - Average incident rainfall of 0.46 ML/day.
  - Average evaporation of 0.11 ML/day.

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[2] McLemore, V.T., Fakhimi, A., Van Zyl, D., Ayakwah, G.F., Anim, K.B.K., Ennim, F., Felli, P., Fredlund, D., Gutierrez, L.A.F., Nunoo, S., Tachie-Menson, S. and Viterbo, V.C. (2009). *Questa Rock Pile Weathering Stability Project : Literature review of other rock piles: characterization, weathering, and stability*. New Mexico Bureau of Geology and Mineral Resources.

- The installation of piezometers and settlement plates, as recommended by PSM to monitor the performance of TSF upstream Stages 8 and 9 against design assumptions, ***is endorsed.***
- PSM assessed the risk of overtopping of TSF due to storm events in the final stages of filling with tailings as LOW.
- PSM considered the likelihood of the following additional potential contributors to overtopping of TSF upstream Stages 8 and 9:
    - Geotechnical stability leading to overtopping – Assessed by PSM as LOW.
    - Piping or internal erosion leading to overtopping – Assessed by PSM as RARE.
    - Erosion of the outer face leading to overtopping – Assessed by PSM as RARE.
    - Elevated pore water pressures due to loss of efficiency of the underdrainage – Assessed by PSM as UNLIKELY for Stage 8 and MODERATELY LIKELY for Stage 9 and, importantly, PSM recommended that outflows from the underdrainage continue to be monitored.

2.3 Store and Release Cover Over IWL

2.3.1 IWL Cover Design

Hillgrove Resources summarised the IWL and Cover Design in a Report for the SA DEM, dated 15 February 2019. A plan of the IWL and associated waste storages is reproduced as Figure 1. Underlying the IWL is a 5 m thick base layer of NAF waste rock, shown schematically as reproduced in Figure 2***, which will serve to pass any uncontaminated surface flows beneath the IWL***. To limit oxygen ingress into the PAF waste rock, a thick encapsulation of PAF waste rock was dozed and compacted against the sides of the IWL (see Figure 2). NAF waste rock was dozed over the sides of the IWL to form a 2 m thick store and release layer, with a nominal slope of 20^{o} over the upper half of the slope, and 14^{o} over the lower half of the slope (see Figure 2). 100 mm thickness of topsoil was added and ripped, prior to revegetation. The final top of the IWL will be relatively flat, on which a 1 m thickness of loose NAF waste rock will be placed, and 100 mm of topsoil will be added and ripped, prior to revegetation.

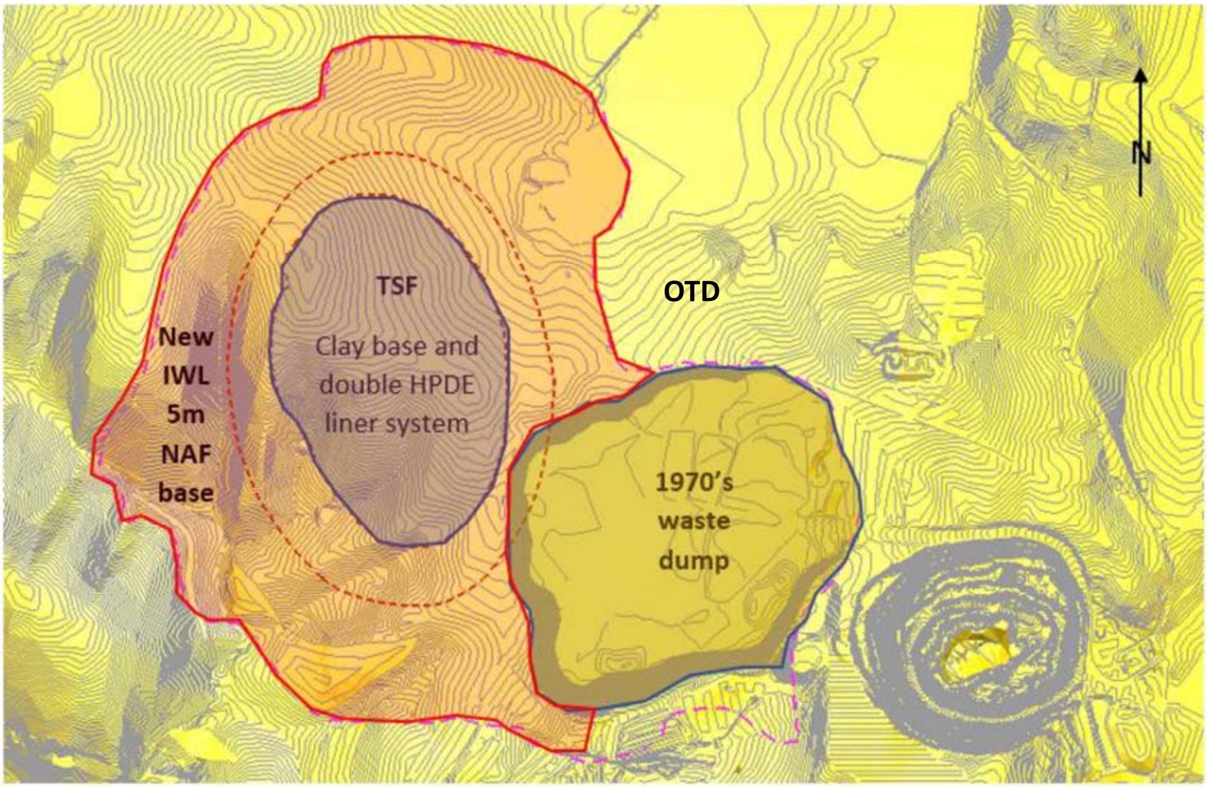

Figure 1 Plan of IWL and older waste storages (source: Figure 9 of Hillgrove Resources Report)

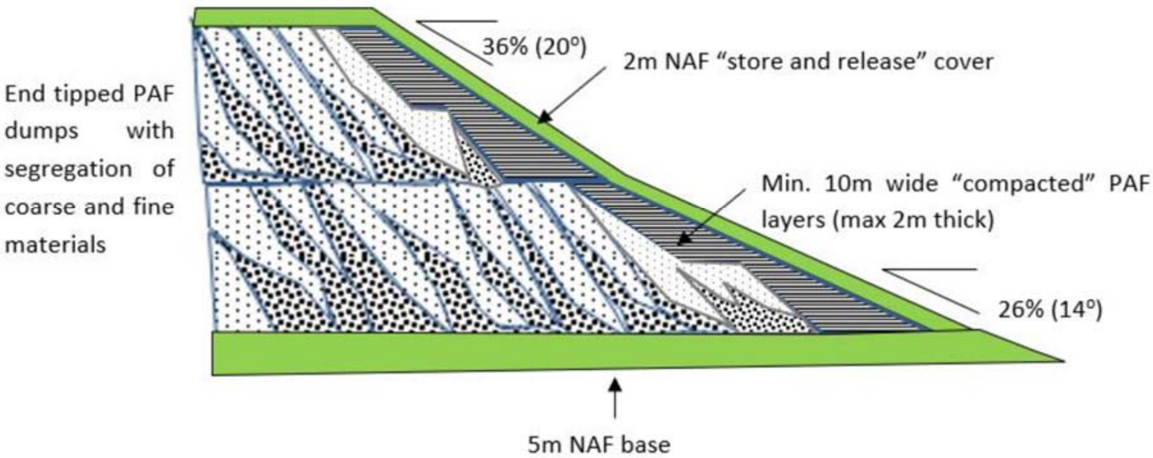

Figure 2 Schematic of PAF encapsulation cover design for IWL (source: Figure 11 of Hillgrove Resources Report)

The choice of a store and release cover for the IWL was based on recommendations in the GARD Guide (2009)[3], which relates annual rainfall to the potential evapotranspiration to rainfall ratio, as shown in Figure 3. The store and release cover comprises a 1 to 2 m thick NAF store and release layer overlain by a 100 mm thick growth medium, with the surface ripped to bring some rock to the surface to provide erosion resistance, prior to revegetation, and in addition to that provided by subsequent revegetation. A plan of the IWL store and release cover system is shown in Figure 4.

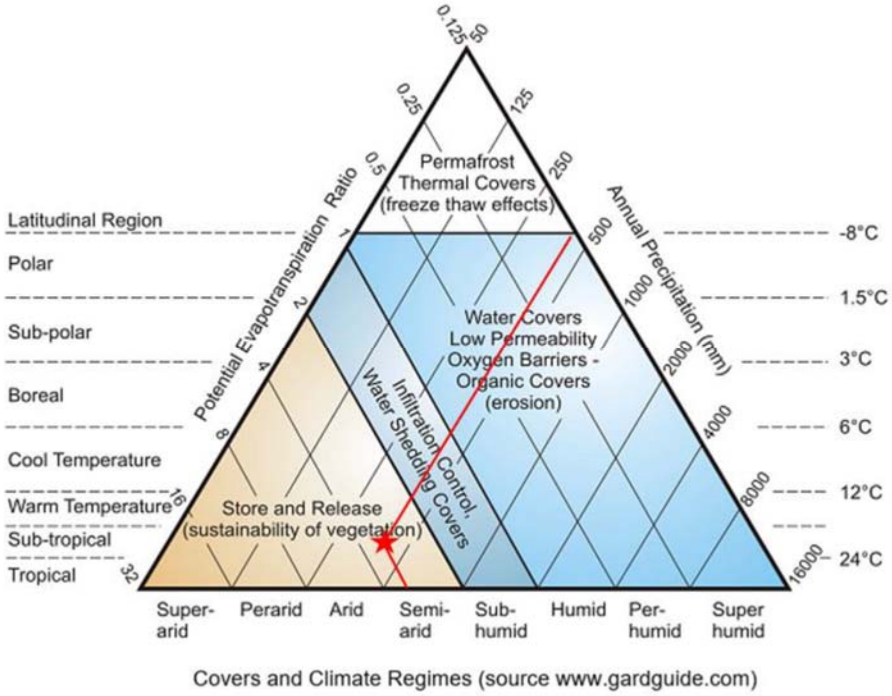

Figure 3 Selection of store and release cover for IWL (source: GARD Guide, 2009)

Preliminary numerical modelling using SoilCover indicated net percolation through the store and release cover from negligible for an average rainfall year, high runoff and poor revegetation to 150 mm for a high rainfall year, low runoff and no revegetation. Low net percolation results from rainfall infiltration being limited to about 0.5 m depth, from which it is removed by evapotranspiration.

Erosion studies conducted by Landloch assessed that the IWL would be stable without revegetation for 300 years, and that there was adequate cover depth to maintain effective encapsulation of the underlying PAF waste rock. Revegetation of the cover will improve its erosion resistance and increase the removal of rainfall infiltration via evapotranspiration.

Seeding and revegetation trials of the completed store and release cover commenced in April 2016, both directly on placed NAF waste rock and on topsoiled NAF waste rock. The topsoiled revegetation trials were successful in establishing a revegetation cover, while revegetation was not successful directly on NAF waste rock.

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[3] GARD. (2009). *Global Acid Rock Drainage Guide*. International Network for Acid Prevention. http://www.gardguide.com/index.php?title=Main_Page

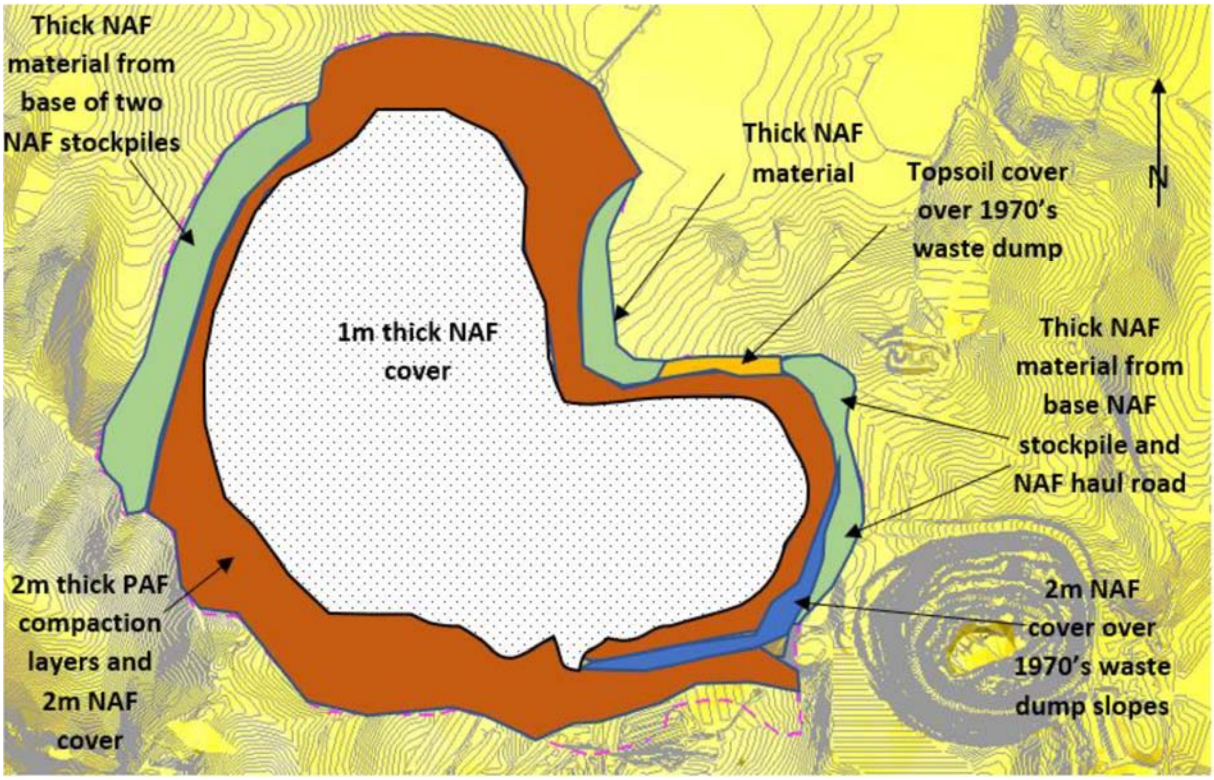


Figure 4 Plan of IWL store and release cover system (source: Figure 13 of Hillgrove Resources Report)

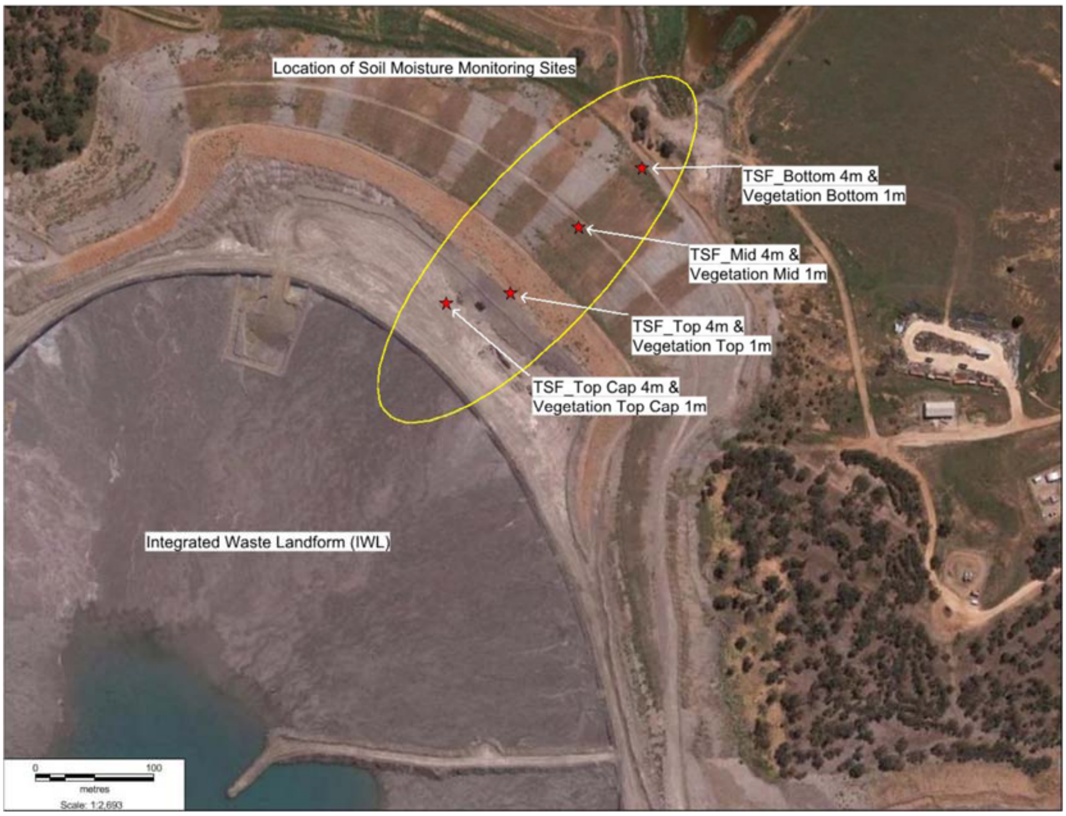
During 2017, the cover materials were sampled for testing to support numerical modelling of cover performance, and the cover was instrumented to assess moisture flows. These data were to be used subsequently to validate and calibrate the numerical simulation of cover performance over time.

2.3.2 Geochemical Assessment of Surface Waters

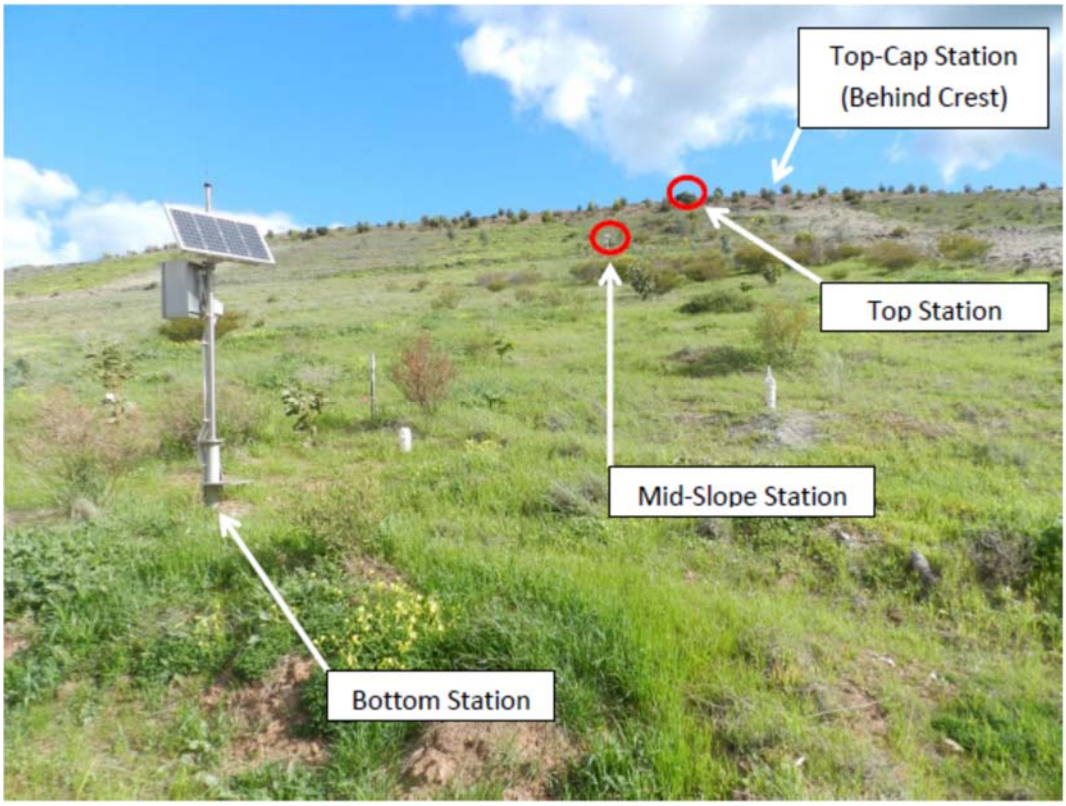
JBS&G reported on 4 December 2018 a geochemical assessment of the surface waters at the Kanmantoo Copper Mine site. The chemical signature of the surface expression of groundwater at the north-eastern toe of the IWL and that of an old OTD seepage sample were similar (that is, low pH and similar metal, sulphate and ammonia concentrations), indicating that the current expression is most likely due to groundwater mounding beneath the IWL coming into contact with the OTD entrained water. There is no evidence that the current TSF is the source of the expression, nor that the liner beneath the TSF has ruptured.

2.3.3 Soil Moisture Monitoring

Hillgrove Resources reported on soil moisture, oxygen, climate and water quality monitoring to 10 September 2019, obtained from the four monitoring stations located as reproduced in Figure 5. Revegetation had established to decreasing degrees from the Bottom monitoring station up the slope. The monitoring has covered two winters and one summer, during which time the Top-Slope, Mid-Slope and Bottom monitoring stations show the majority of the moisture variation within the upper 0.5 m of the 2 m thick store and release cover, as expected from the preliminary SoilCover modelling, indicating the effective removal of rainfall infiltration via evapotranspiration. The Top-Cap monitoring station showed preferred pathway flow due to a sinkhole through the topsoil, which has since been filled.



(a)



(b)

Figure 5 Location of moisture sensors in store and release slope cover (source: Figure 2 of Hillgrove Resources Report)

The cover monitoring site locations are considered to provide a more than adequate analogue for the rehabilitated IWL and the sensor arrays are sufficient to monitor cover performance, including the number of monitoring sites and the number and types of instruments. The monitoring data collected over 18 months are considered sufficient to demonstrate the successful performance of the IWL cover system.

The number of monitoring sites are representative of the IWL in that they are located to represent the different aspects of the landform; i.e., the toe (bottom slope), mid-slope, upper slope (being steeper than the lower slope area) and the top cap (i.e., top surface) area. The data from these monitoring locations are robust and representative to date. This monitoring then provides a relevant analogue for the material types and cover system placed across the entirety of the IWL. These monitoring locations are placed on the portion of the IWL that was covered first, hence providing the longest possible dataset for cover monitoring. As such, these four sites are sufficient for verification of the IWL cover efficiency.

Five years of cover monitoring data from the placement of the final top IWL cover is considered adequate given that by this time the monitoring locations would have collected an additional 2 to 4 years of data before final top cover placement. The monitoring period covers the establishment and drainage of the landform as it moves towards achieving steady state.

The current monitoring system, as installed and operated, adequately monitors wetting and drying front depths into the cover. This is the critical performance monitoring requirement for a store and release cover and validates its operating efficiency.

2.3.4 IWL SoilCover Modelling

Unsaturated Soil Engineering Ltd. (USEL) reported on the results of laboratory testing of cover materials conducted by The University of Queensland (independent of Professor Williams), and on numerical simulations of the performance of the store and release cover using SoilCover, with the laboratory data providing input parameters.

The eight cover material samples tested gave similar particle size distributions, with 20 to 40% of particles finer than 0.075 mm and being well-graded to coarse-grained gravel size. Hence, the material is ideal for a store and release cover, with the fines offering excellent moisture retention capacity, while being sufficiently well-graded and coarse to provide erosion resistance. Samples at the upper and lower bound of the particle size distributions were selected for Soil Water Characteristic Curve (SWCC) testing, placed loose and lightly-compacted under an applied stress of 40 kPa, representing approximately 2 m depth of cover. The saturated hydraulic conductivity of the loose, coarse-grained sample was 1.0 x 10^{-6} m/s, while that of the lightly-compacted, fine-grained sample was 7.8 x 10^{-7} m/s. The SWCCs varied, and the loosest (worst case) curve was used in numerical simulations of the worst case 1 m thick NAF waste rock cover overlain by 100 mm of topsoil. Saturated hydraulic conductivities of 1.0 x 10^{-4} m/s, 1.0 x 10^{-4} m/s and 1.0 x 10^{-4} m/s, were assumed for the topsoil, the underlying PAF waste rock and the underlying tailings, respectively.

The results of the SoilCover simulations show extremely low downward moisture fluxes of < 25 mm/year, for average annual rainfall of 437 m/year, potential evaporation of 1,437 mm/year, and no revegetation. No moisture reaches the base of a 1 m thickness of NAF waste rock. Poor revegetation reverses this flux to net evapotranspirative at < 5 mm/year.

Applying the high rainfall (580 mm) and low evaporation (1,187 mm) experienced during 2016, the maximum calculated moisture flux was 87 mm/year for no revegetation. This is equivalent to a compacted clay liner under a unit hydraulic gradient having a saturated hydraulic conductivity of 3×10^{-9} m/sec. In summary, the SoilCover model results show extremely low to negative net percolation rates at the base of a 1 m thickness of NAF waste rock.

The SoilCover modelling is appropriate and adequate to demonstrate the acceptable performance of the store and release cover. The detailed results are consistent with the results of the preliminary SoilCover modelling results, which were undertaken before the cover had been constructed and monitoring commenced.

2.4 IWL Cover Erosion Modelling

2.4.1 Interim Landform Evolution Modelling

In their interim Report dated 7 December 2017, Landloch carried out a site investigation, and described WEPP erosion modelling and SIBERIA landform evolution modelling. The site investigation indicated that the topsoil appears to be erodible, but capable of supporting revegetation. The NAF waste rock is generally blocky and erosion resistant at its angle of repose***, with the likelihood that any fines will have washed in or off the slope***. It has no to some capacity to support grass. The NAF/PAF waste rock in place for over 20 years at its angle of repose indicates that its rocky nature generally provides armouring and will assist in stabilising slopes at closure.

WEPP erosion modelling will be used to generate time series data of runoff and erosion for the slopes and materials at the Kanmantoo site. The WEPP output will be analysed to derive parameters for SIBERIA modelling, which will be run for the final three-dimensional slopes of the IWL.

2.4.2 Landform Evolution Modelling

In their Report dated February 2019, Landloch defined "acceptable" erosion on the basis that a predicted average annual erosion rate of < 5 t/ha/year (***< about 0.25 mm/year for a unit weight of 2 t/m³***) exhibits a low tendency to rill. ***This rate of erosion would result in < 75 mm loss of cover thickness over 300 years.*** Hence, a 1 m cover thickness of the flat top of the IWL and 2 m on the side slopes should be more than sufficient if the average annual erosion rate is < 5 t/ha/year.

The results of SIBERA landform evolution modelling showed that:

- NAF waste rock appears to be an effective surface armour, provided that it constitutes > 30% of the surface***, although dozing the NAF waste rock would reduce its particle size to finer than that seen on angle of repose slopes, by about an order of magnitude***.
- Topsoil, ripped to bring some NAF waste rock to the surface, can be used on the IWL.

- It will be critical to retain runoff on the top of the rehabilitated IWL, since the discharge of concentrated flows from the top of waste landforms onto the outer batter slopes is a very common cause of gullying and landform failure. This can be controlled by crest bunding.
- Rip lines on the side slopes of the IWL should be no deeper than 300 mm from peak to trough to avoid excessive water ponding and overtopping, resulting in concentrated flow and rilling.
- Gypsum could be added to the topsoil to reduce clay dispersion potential.
- The WEPP and SIBERIA modelling accounted for both no revegetation and a very poor revegetation cover, both of which are conservative assumptions. The establishment of an effective revegetation cover (e.g., > 30% surface contact cover) will further reduce the rates of erosion and gully initiation across the landform.
- It is predicted that bare (un-vegetated) NAF waste rock on the IWL will remain erosionally stable, with erosion rates of < 1 t/ha/year on average after 300 years of simulation.
- Gully development to a maximum depth of 0.5 m after 300 years was predicted after 300 years of simulation, implying that a 1 to 2 m cover would remain effective after 300 years.
- Slope angles of up to 20° comprise approximately 82% of the IWL surface, and are predicted to erode minimally in the long-term. A cover thickness of 2 m is recommended for slopes > 20°.
- The RWD has sufficient capacity to act as a silt trap to store eroded sediment. It is predicted that after 300 years, only 20% of the RWD will be filled with eroded sediment, based on a highly conservative scenario with an average rate of erosion of 5 t/ha/year. In reality, erosion rates are likely to be lower over some sections of the landform which, combined with revegetation, will reduce the volume of sediment transported into the RWD.

2.4.3 Erodibility Testing and Modelling

On review of the February 2019 Landloch Report, DEM requested that the erosion modelling be updated to account for the topsoil that would be utilised in creating the revegetation cover. With the potential to continue underground mining and/or move tailings from the OTD into the TSF, additional staged lifts were designed and these were accounted for in the revised modelling.

Two types of surface soil covers were considered:

- A mixture of topsoil and NAF waste rock with 1 part topsoil to 5-parts rock ripped to a depth of 0.5 m. This will be applied to the majority of the IWL surface, where slope gradients are < 20° (approximately 82% of the landform surface).
- A thin layer of topsoil (0.1 m) spread over the NAF waste rock. This will be applied where slope gradients are > 20° (approximately 18% of the landform surface).

Laboratory-based studies of runoff and erosion were carried out on the 1:5 topsoil:NAF waste rock mixture and on topsoil alone. The results of the laboratory studies were used to derive parameters required for the WEPP erosion model and the SIBEIRA landform evolution model. A conservative 30% revegetation cover was assumed in the erosion simulations. Simulations of runoff and erosion for the shallower slopes (< 20°) and the steeper slopes (> 20°) were carried out using WEPP, both without and with revegetation. SIBERIA was run with 30% revegetation cover to consider the likelihood of rill and gully development in the shallower and deeper covers, on the shallower and steeper slopes.

The results of the WEPP modelling indicated that the erosion of the topsoil:NAF mixture will be within acceptable thresholds without revegetation, with erosion rates reduced even further with 30% revegetation cover. A 0.1 m topsoil cover with 30% revegetation placed on 33° slopes was predicted to generally erode above acceptable thresholds.

SIBERIA simulations of the two cover scenarios on the IWL, with 30% revegetation cover on the topsoil:NAF mixture, indicated that erosion will not exceed 0.5 m deep at any point on the IWL after 300 years. Hence, the proposed depths of NAF waste rock over PAF waste rock are considered suitable. Erosion of a 0.1 m topsoil cover would initially be high and decrease as the underlying NAF waste rock is increasingly exposed. By year 192 of the simulation, the 0.1 m topsoil cover is predicted to be completely eroded, with the underlying NAF waste rock eroding at very low rates. No gully erosion is predicted to occur on any point of the IWL.

There are three sediment containment structures proposed to be in place at closure: the RWS dam, the Northern sediment pond and the North-eastern sediment pond (proposed, but not yet constructed). The RWS dam is predicted to reach approximately 30% capacity after 300 years, and the Northern sediment pond is predicted to reach approximately 7% capacity after 300 years. Both are considered to have sufficient capacity to store sediment from contributing catchments in the long-term. The Northeast pond is predicted to have 5,555 m^3 of sediment deposited, and should be built to capture approximately 17,000 m^3 of sediment, reaching 33% capacity after 300 years.

3 SITE VISIT

The site visit on 23-24 July 2019 provided an opportunity to overview the key features of the Kanmantoo Mine site, which include:

- TSF, which is the current tailings storage facility constructed initially using the downstream method, with the final Stages 8 and 9 constructed using the upstream method on an HDPE liner and underdrainage, with a central decant.
- Store and release cover over the IWL, incorporating the waste rock dump, TSF, and RWD.

3.1 TSF

The key features of the TSF are captured in the photographs in Figures 6 to 9.

Figure 6 TSF from central decant pond

(a)

(b)

Figure 7 TSF, showing: (a) access to central decant, and (b) central decant

(a)

(b)

Figure 8 TSF, showing: (a) central decant return water pipe, and (b) central decant from access

(a) **(b)**

Figure 9 TSF, showing: (a) distant central decant, and (b) desiccated sandy tailings beach midway along access to central decant

3.2 Store and Release Cover Over IWL

The key features of store and release cover over the IWL are captured in the photographs in Figures 10 to 16. Figure 10 to 14 show various stages of reshaping IWL slopes, covering with NAF waste rock, topsoiling and revegetating to form a store and release cover. Figure 15 shows the instrumentation of the store and release cover, designed to monitor moisture flows, and Figure 16 shows the surface expression of groundwater emanating from the toe of the IWL, across the surface of the OTD tailings beach, which is being intercepted and drained.

(a) **(b)**

Figure 10 Reshaping and covering, showing: (a) unreshaped upper lift of TSF, and (b) reshaped IWL slope covered with NAF waste rock

Figure 11 Reshaped IWL, with revegetated store and release cover comprising NAF waste rock and topsoil

(a)

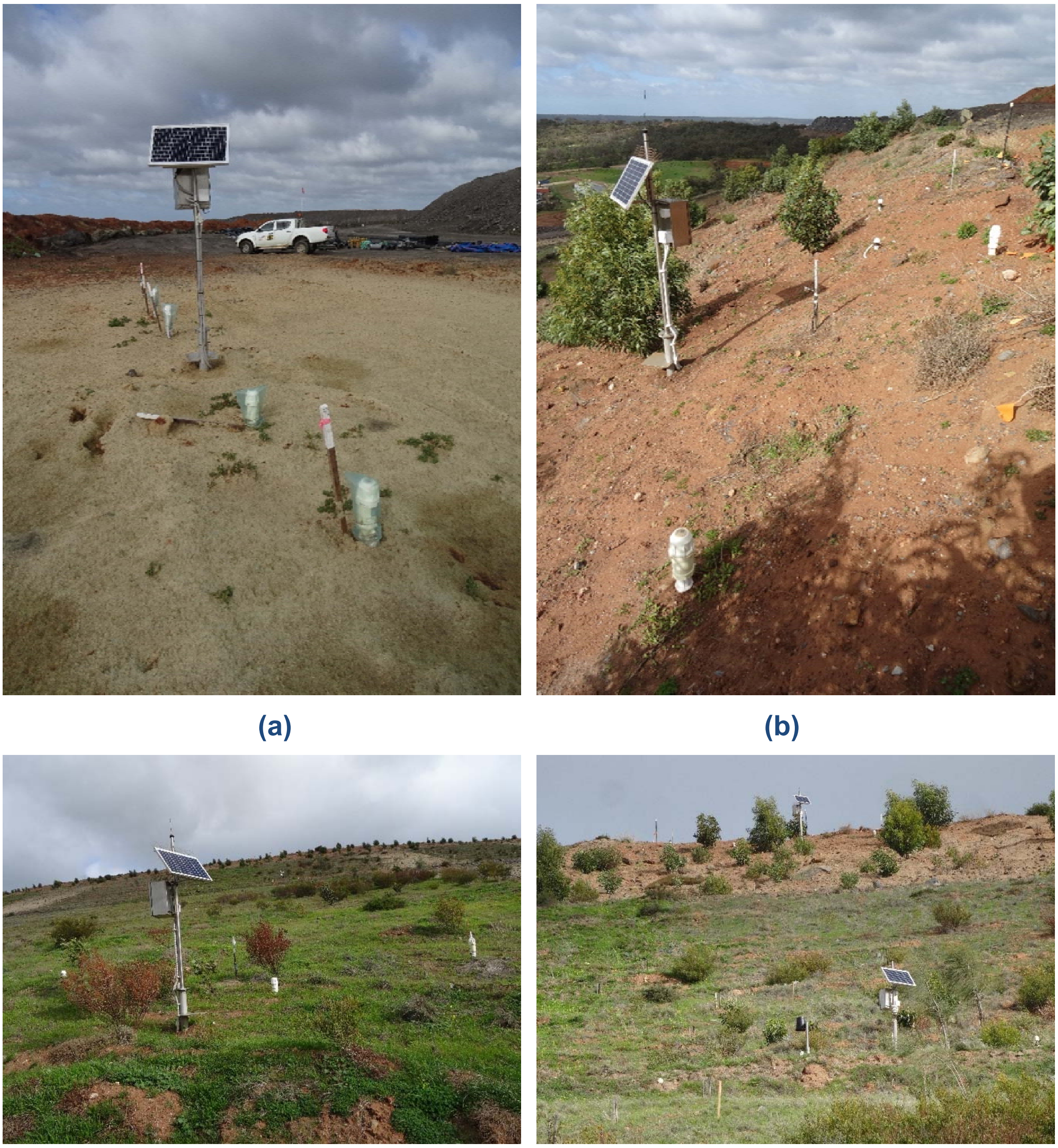
(b)

Figure 12 Store and release cover on side slopes of IWL, showing: (a) revegetating slope and natural remnant bush below, and (b) reshaped and covered lower slope, and un-reshaped upper slope

(a) (b)

Figure 13 Store and release cover on reshaped side slopes of IWL, showing: (a) reshaping, and (b) erosion of excess thickness of topsoil

Figure 14 Variably textured and revegetated store and release cover on steep IWL slope below TSF and above RWD



(a) (b) (c) (d)

Figure 15 Instrumentation of store and release cover, showing: (a) crest array, (b) crest-edge array, (c) mid-height array, and toe array

Figure 16 Surface expression of Groundwater at toe of IWL across surface of OTD tailings beach, which is being intercepted and drained

4 INDEPENDENT REVIEW COMMENTS AND CONCLUSIONS

The design, construction and operation of the TSF upstream Stages 8 and 9 are considered to be suitable and more than adequate for the site conditions. The design, construction, modelling and monitoring of the store and release cover on the IWL are also considered to be suitable and more than adequate for the site conditions. The performance of the store and release cover has been demonstrated through modelling and monitoring to be more than adequate for the site conditions.

Detailed comments and conclusions arising from the Independent Review are summarised in point form under the headings TSF upstream Stages 8 and 9, store and release cover over IWL, and IWL cover erosion modelling, in the following sections.

4.1 Comments Arising from Independent Review

4.1.1 TSF Upstream Stages 8 and 9

PSM, in their report on CPTu testing of the tailings dated 10 October 2018:

- Did not offer interpretation of the CPTu data such as Soil Behaviour Type, estimated friction angle, estimated stiffness, or liquefaction susceptibility. The fact that the tailings are well-drained towards the underdrainage would mitigate their liquefaction potential.
- Selected a friction angle for the tailings of 32^o is conservative compared to a measured value of 34^o from direct shear strength testing, a friction angle for the PAF waste rock of 38^o that is considered very conservative and would likely be about 43^o, and presumed a friction angle for the liner of 20^o that is reasonable.
- Presumed for the foundation a cohesion of 5 kPa and a friction angle of 35^o, which are considered reasonable.

PSM, in their initial geotechnical stability analysis and water balance assessment dated 23 November 2018:

- Calculated some marginal FoS values for surficial slip. In reality, there will be some suction-induced apparent cohesion towards the surface, which would reduce the potential for surficial slip.

PSM, in their revised design of TSF upstream Stages 8 and 9 dated 3 September 2019:

- Gave interpreted CPTu data that showed some of the tailings to be liquefiable. However, under operating conditions, the tailings underlying the upstream raises are well-drained, and the PGA is below the typical threshold for liquefaction of about 0.13g (see Section 3.2); hence liquefaction would not be expected. Post-closure the tailings are expected to drain down and hence would not be expected to liquefy under the MCE.
- Estimated the maximum earthquake-induced settlement to be about 180 mm or a minor 0.2% of the maximum embankment height of 91 m for no liquefaction of the tailings and 700 mm, or 0.8%, assuming liquefaction of the upper 30 m depth of tailings, which is considered unlikely. In neither case is there a potential for loss of tailings.

- Calculated FoS values for the upstream slopes generally marginally higher than unity, apart from those for surficial slip. This is expected since they are at the angle of repose of the waste rock at approximately 37°. However, the selected friction angle of the waste rock of 38° is considered very conservative. A more reasonable value would be 6° higher than the angle of repose, or 43°, which would increase the FoS by about 20% for the portion of the slip surface passing through the PAF waste rock. Further, geotechnical stability will improve markedly as tailings are deposited against the upstream slopes, raising the FoS to well above the minimum values suggested ANCOLD (2012).
- Stated that the effectiveness of the underdrainage would be expected to decrease as the tailings become locally more consolidated above the underdrainage, and higher pressures (> 1 MPa) on the pipes in Stage 9 could potentially crush them, requiring careful monitoring.
- Recommended the installation of piezometers and settlement plates to monitor the performance of TSF upstream Stages 8 and 9 against design assumptions, which is endorsed.

4.1.2 Store and Release Cover Over IWL

The selection of a store and release cover over the IWL is well-founded, and its design and construction are sound, as supported by the positive monitoring results and SoilCover numerical simulations, which indicate moisture cycling mostly within the upper 0.5 m of the cover.

The cover monitoring site locations are considered to provide a more than adequate analogue for the rehabilitated IWL and the sensor arrays are sufficient to monitor cover performance, including the number of monitoring sites and the number and types of instruments. The monitoring data collected over 18 months are considered sufficient to demonstrate the successful performance of the IWL cover system.

The number of monitoring sites are representative of the IWL in that they are located to represent the different aspects of the landform; i.e., the toe (bottom slope), mid-slope, upper slope (being steeper than the lower slope area) and the top cap (i.e., top surface) area. The data from these monitoring locations are robust and representative to date. This monitoring then provides a relevant analogue for the material types and cover system placed across the entirety of the IWL. These monitoring locations are placed on the portion of the IWL that was covered first, hence providing the longest possible dataset for cover monitoring. As such, these four sites are sufficient for verification of the IWL cover efficiency.

Five years of cover monitoring data from the placement of the final top IWL cover is considered adequate given that by this time the monitoring locations would have collected an additional 2 to 4 years of data before final top cover placement. The monitoring period covers the establishment and drainage of the landform as it moves towards achieving steady state.

The current monitoring system, as installed and operated, adequately monitors wetting and drying front depths into the cover. This is the critical performance monitoring requirement for a store and release cover and validates its operating efficiency.

The SoilCover modelling is appropriate and adequate to demonstrate the acceptable performance of the store and release cover. The detailed results are consistent with the results of the preliminary SoilCover modelling results, which were undertaken before the cover had been constructed and monitoring commenced.

4.1.3 IWL Cover Erosion Modelling

Landloch, in their interim Report dated 7 December 2017:

- Observed the NAF waste rock to be generally blocky and erosion resistant at its angle of repose. However, any fines will have washed in or off the slope.

Landloch, in their Report dated February 2019:

- Defined "acceptable" erosion on the basis that a predicted average annual erosion rate of < 5 t/ha/year (< about 0.25 mm/year for a unit weight of 2 t/m^3) exhibits a low tendency to rill. This rate of erosion would result in < 75 mm loss of cover thickness over 300 years. Hence, a 1 m cover thickness of the flat top of the IWL and 2 m on the side slopes should be more than sufficient if the average annual erosion rate is < 5 t/ha/year.
- Stated that NAF waste rock appears to be an effective surface armour, provided that it constitutes > 30% of the surface, although dozing the NAF waste rock would reduce its particle size to finer than that seen on angle of repose slopes, by about an order of magnitude.

Landloch in their Report dated August 2019:

- Predicted from WEPP modelling, informed by laboratory runoff and erosion testing, that the erosion of the topsoil:NAF mixture without revegetation will be within acceptable thresholds, with erosion rates reduced even further with 30% revegetation cover. A 0.1 m topsoil cover with 30% revegetation placed on 33° slopes was predicted to generally erode above acceptable thresholds.
- Predicted from SIBERIA simulations, informed by laboratory runoff and erosion testing, of the two cover scenarios on the IWL with 30% revegetation cover on the topsoil:NAF mixture that erosion will not exceed 0.5 m deep at any point on the IWL after 300 years. Hence, the proposed depths of NAF waste rock over PAF waste rock are considered suitable. Erosion of a 0.1 m topsoil cover would initially be high and decrease as the underlying NAF waste rock is increasingly exposed. By year 192 of the simulation, the 0.1 m topsoil cover is predicted to be completely eroded, with the underlying NAF waste rock eroding at very low rates. No gully erosion is predicted to occur on any point of the IWL.
- The three sediment containment structures proposed to be in place at closure: the RWS dam, the Northern sediment pond and the North-eastern sediment pond (proposed, but not yet constructed), are considered to provide ample storage capacity for the expected sediment off the IWL over 300 years.

4.2 Conclusions Arising from Independent Review

4.2.1 TSF Upstream Stages 8 and 9

Overall, the downstream slopes of TSF upstream Stages 8 and 9 are considered to have adequate geotechnical stability, as supported by:

- The FoS values calculated by PSM for the downstream slopes were generally in accordance with the minimum values suggested by ANCOLD (2012) of > 1.5 for static loading and > 1.0 for earthquake loading, apart from those for surficial slip.
- Conservative friction angles were selected by PSM for the tailings of 32° (compared to a measured value of 34° from direct shear strength testing), and for the PAF waste rock of 38° (which would likely be about 43°, and would increase the FoS by up to 20% for the portion of the slip surface passing through the PAF waste rock).
- There will be some suction-induced apparent cohesion towards the surface of the downstream slope, which would reduce the potential for surficial slip.

Overall, the upstream slopes of TSF upstream Stages 8 and 9 are considered to have adequate geotechnical stability, as supported by:

- The initially low geotechnical stability of the upstream slopes is of little consequence, since any slips would be surficial and limited to the PAF waste rock.
- A very conservative friction angle of 38° was selected by PSM for the PAF waste rock. A more likely value would be about 43°, which would increase the FoS by up to 20% for the portion of the slip surface passing through the PAF waste rock.
- The geotechnical stability of the upstream slopes would improve markedly as tailings are deposited against them, raising the FoS values to well above the minimum values suggested by ANCOLD (2012).

The tailings are not expected to be susceptible to earthquake-induced or static liquefaction, as supported by:

- PSM assessed the risk of liquefaction of the tailings as LOW.
- Under operating conditions, the tailings underlying the upstream raises are well-drained, and the PGA is below the typical threshold for liquefaction of about 0.13g; hence earthquake-induced liquefaction would not be expected.
- Static liquefaction is also unlikely, since the upper 10 m depth of the tailings underlying the upstream Stages 8 and 9 are unsaturated.
- The maximum earthquake-induced settlement estimated by PSM of about 180 mm or a minor 0.2% of the maximum embankment height of 91 m for no liquefaction of the tailings, and 700 mm, or 0.8%, assuming liquefaction of the upper 30 m depth of tailings, which is considered unlikely. In neither case is there a potential for loss of tailings.
- Post-closure, the tailings are expected to drain down further and hence would not be expected to liquefy under the MCE.

4.2.2 Store and Release Cover Over IWL

A store and release cover for the IWL is appropriate for the climatic setting of Kanmantoo, and the design implemented has been demonstrated to limit the net percolation of rainfall into the underlying PAF waste rock, as supported by:

- The choice of a store and release cover for the IWL was based on recommendations in the GARD Guide (2009), which relates annual rainfall to the potential evapotranspiration to rainfall ratio.
- Underlying the IWL is a 5 m thick base layer of NAF waste rock, which will serve to pass any uncontaminated surface flows beneath the IWL.
- To limit oxygen ingress into the PAF waste rock, a thick encapsulation of PAF waste rock was dozed and compacted against the sides of the IWL.
- NAF waste rock was dozed over the sides of the IWL to form a 2 m thick store and release layer, with a nominal slope of 20° over the upper half of the slope, and 14° over the lower half of the slope, with a 100 mm thickness of topsoil added and ripped, prior to revegetation.
- The final top of the IWL will be relatively flat, on which a 1 m thickness of loose NAF waste rock will be placed, and 100 mm of topsoil will be added and ripped, prior to revegetation.
- Hillgrove Resources reported on soil moisture, climate and water quality monitoring, obtained from the four monitoring stations located up a sloping section of the IWL. Revegetation had established to decreasing degrees from the Bottom monitoring station up the slope. The monitoring has covered two winters and one summer, during which time the Top-Slope, Mid-Slope and Bottom monitoring stations show the majority of the moisture variation within the upper 0.5 m of the 2 m deep store and release cover, as expected from the preliminary SoilCover modelling, indicating the effective removal of rainfall infiltration via evapotranspiration. The Top-Cap monitoring station showed preferred pathway flow due to a sinkhole through the topsoil, which has since been filled.
- USEL reported the results of SoilCover simulations of the performance of the store and release cover, which showed extremely low (unvegetated) to negative (vegetated) infiltrated moisture at a depth of 1 m within a store and release NAF waste rock layer, due to cycling of moisture mainly within the upper 0.5 m depth.

4.1.3 IWL Cover Erosion Modelling

Site observations, and WEPP and SIBERIA modelling, demonstrated that the store and release cover will be stable against erosion for over 300 years, as supported by:

- Landloch described the NAF waste rock exposed on angle of repose slopes as generally blocky and erosion resistant, with the likelihood that any fines will have washed in or off the slope. It has no to some capacity to support grass.
- Topsoil, ripped to bring some NAF waste rock to the surface, can be used on the IWL, possibly amended with gypsum to reduce potential clay dispersion.

- It will be critical to retain runoff on the top of the rehabilitated IWL, since the discharge of concentrated flows from the top of waste landforms onto the outer batter slopes is a very common cause of gullying and landform failure. This can be controlled by crest bunding.
- Rip lines on the side slopes of the IWL should be no deeper than 300 mm from peak to trough to concentrated flow and rilling.
- Predictions from WEPP modelling with no or 30% revegetation on the topsoil:NAF mixture, both of which are conservative assumptions, that the IWL will remain erosionally stable, with erosion rates of < 1 t/ha/year on average after 300 years of simulation.
- Predictions from SIBERIA modelling of the two cover scenarios on the IWL with 30% revegetation cover on the topsoil:NAF mixture that erosion will not exceed 0.5 m deep at any point on the IWL after 300 years, well within the cover thicknesses of 1 m on shallower slopes (< 20^{o}, comprising approximately 82% of the IWL surface), and 2 m on steeper slopes (> 20^{o}, comprising approximately 18% of the IWL surface).
- No gully erosion is predicted to occur on any point of the IWL.
- The three sediment containment structures proposed to be in place at closure: the RWS dam, the Northern sediment pond and the North-eastern sediment pond (proposed, but not yet constructed), are considered to provide ample storage capacity for the expected sediment off the IWL over 300 years.

APPENDIX A – Curriculum Vitae

Professor David J Williams

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Professor David Williams is a Chartered and Registered Professional Engineer with over 40 years of experience. His discipline area is Geotechnical Engineering, and he is internationally recognised for his expertise and experience in mine waste management and mine closure. He is particularly recognised for his expertise in tailings dams, and the closure and rehabilitation of tailings dams and waste rock dumps, including the design of covers. He carries out high-level reviews of and provides expert advice and opinion on tailings dam designs, tailings and waste rock facility closure, and the closure and rehabilitation of open pits.

He authored in 2016 the Tailings Management Handbook, as part of the Commonwealth Leading practice sustainable development program for the mining industry. He is on the Working Party for the Australian National Committee for Large Dams Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure published in 2012 and commissioned to write updates.

QUALIFICATIONS

1979	PhD, Soil Mechanics	University of Cambridge, England
1975	BE (Hons I), Civil Engineering	Monash University, Australia

AWARDS/DISTINCTIONS/FELLOWSHIPS

1996	Japan Society for the Promotion of Science Fellow
1995	The University of Queensland Collaborative Research Travel Grant
1995	Australian Minerals and Energy Environment Foundation (AMEEF) Travelling Scholarship
1993	Australian Research Fellow (Industry)
1992	AMEEF Environmental Excellence Award (Individual)
1990	Masuda Fellow for Collaborative Research in Japan, Jan-Feb
1989	The University of Queensland Collaborative Research Travel Grant

MEMBERSHIPS

From 2015	Member, Australasian Institute of Mining and Metallurgy
From 2015	Registered Professional Engineer of Queensland (RPEQ)
1986-1987	Member, National Committee, Australian Geomechanics Society
2007-2008	
From 1984	Member, Queensland Committee, Australian Geomechanics Society, Chair in 1986
From 1980	Member, Australian Geomechanics Society
From 1980	Member then Fellow, Institution of Engineers, Australia

EMPLOYMENT HISTORY

2007 – Present	Professor of Geotechnical Engineering Founder and Director of Geotechnical Engineering Centre Manager of the Large Open Pit Project School of Civil Engineering The University of Queensland
1994 – 2007	Associate Professor of Geomechanics Department of Civil Engineering The University of Queensland
1990 – 1994	Senior Lecturer in Geomechanics Department of Civil Engineering The University of Queensland
1983 – 1989	Lecturer in Geomechanics Department of Civil Engineering The University of Queensland
1980 – 1983	Geotechnical Engineer Melbourne and Brisbane Golder Associates Pty Ltd
1979 – 1980	Engineer Country Roads Board (CRB) of Victoria
1976 – 1979	Research Student University of Cambridge, England
1972 – 1976	Engineer, Cadet Engineer, CRB, Victoria

SUMMARY OF CONSULTING COMMISSIONS

Board and Expert Panel Memberships

- Member of Independent Technical Review Board for Minera Escondida-BHP, Chile form 2019.
- Member of Expert Panel commissioned to investigate the technical causes of the failure of Tailings Dam I at the Córrego de Feijão Mine in the State of Minas Gerais, Brazil on 25 January 2019
- Member of Independent Technical Review Board for Rio Tinto Alcan Yarwun Residue Management Area Embankment Raise Designs from 2016
- Member of Independent Technical Review Panel of Life-of-Mine Tailings Storage Facility at Glencore's McArthur River Mine, Northern Territory, Australia from 2015
- Member of Northern Territory EPA Board, from 2012 to 2014

Peer Reviews of Major Projects

- Sole Independent Expert Geotechnical Reviewer for Unity Mining Limited from 2016
- Sole Independent Expert Geotechnical Reviewer for Bluestone Mines Tasmania JV Pty Ltd from 2015
- Sole Reviewer of Proposed Integrated Waste Landform Design for Central Eyre Iron Project in 2015
- Sole Independent Expert Geotechnical Reviewer for Rio Tinto Alcan Gove Residue Disposal Area from 2015
- Sole Independent Expert Geotechnical Reviewer and Annual Dam Inspections for QAL Residue Disposal Area and Ash Dams from 2013
- Sole Independent Expert Geotechnical Reviewer for Rio Tinto Alcan Yarwun Residue Management Area from 2013
- Led International Peer Review for the South Deposit TSF at Savage River Mine in Tasmania in 2012/13
- Sole Independent Expert Geotechnical Reviewer for Rio Tinto Alcan Weipa Tailings Storage Facilities in 2012 and 2014
- Peer Review of Harvey Creek Non-Erodable Waste Rock Dump Design for Ok Tedi Mining Limited in 2010/11
- Member of Expert Peer Review Team for Rio Tinto Alcan Weipa Tailings Storage Facilities from 2009
- Member of the International Technical Advisory Group reporting to the South Australian Government on Rehabilitation of Brukunga Pyrite Mine from 2007
- Led International Peer Reviews for the Savage River Rehabilitation Project in Tasmania in 2002, 2005, 2009 and 2013

- Led International Peer Review on handling acid generating waste rock dumping and dump closure strategies at Cadia Hill Gold Mine in New South Wales in 2002/3
- Member of the Peer Review Team for Stage 2 of the Stuart Oil Shale Project at Gladstone in Queensland in 2004
- Peer Reviewer of the rehabilitation of the San Manuel Copper Mine tailings facility in Arizona, USA in 2004
- Member of the 2005 Peer Review Team that reviewed future red mud disposal, containment and rehabilitation at QAL at Gladstone in Queensland in 2005
- Geotechnical Reviewer of the breach of the co-disposal dam at Burton Coal in Queensland in 2005
- Peer Reviewer of the conceptual closure plan for Worsley Alumina red mud storage in Western Australia in 2005
- Peer Reviewer for waste rock dump covers for Century Mine in North Queensland from 2007
- During 2006, David was an Expert Advisor to the EIS team for the Olympic Dam Expansion Project in South Australia, providing expert input on disposal, hydrology and closure issues for both waste rock and tailings

Expert Witness

- Expert witness through Corrs Chambers Westgarth Lawyers, in relation to coal washery rejects used as filling for residential sub-division purposes
- Expert witness through McCullough Robertson Lawyers, in relation to the failure of a concrete arch reclaim tunnel beneath a coal stockpile
- Expert witness in relation to professional misconduct cases brought by the Queensland Professional Engineers Registration Board
- Numerous expert witness commissions related to residential and commercial building footing failures and slope instability

Consultancies

Professor David John Williams is widely sought for his expert input, in particular to mine waste disposal and mine site rehabilitation and remediation at operating mines throughout Australia and overseas. In Australia, he has consulted on numerous coal mines throughout Queensland and New South Wales; on Red Dome Gold Mine closure, Kidston closure, Osborne waste disposal, Ivanhoe Cloncurry mine closure, Phosphate Hill gypsum disposal, QERL processed waste storage facility closure, and Century Zinc Mine waste rock dumping in Queensland; Cadia Hill Gold Mine waste rock dumping and dump closure in New South Wales; Mt Morgans Gold Mine co-disposal, WMC Resources' nickel operations tailings closure and Minara heap leaching in Western Australia; waste disposal issues at the Ballarat East and Heathcote gold mines in Victoria; and a review of ARD treatments at Savage River Mine in Tasmania. Overseas he has consulted on tailings depositional design and water balance for the Kori Kollo Mine in Bolivia, a review of co-disposal of tailings and waste rock at Porgera Gold Mine and the closure of Misima Gold Mine in PNG, waste disposal design for the Goro Nickel project in New Caledonia, and advice on co-disposal for the Martabe Project in Indonesia.

David has been involved in material characterisation testing and the design of numerous mine waste covers throughout Australia, and the design, installation and monitoring of lysimeters and mine waste covers at Kidston Gold Mines, WMC Resources' Mt Keith Nickel Operations, QERL's Stuart Oil Shale Project, a large-scale trial waste rock dump at Cadia Hill Gold Mine, and a large-scale trial tailings cell at Jubilee Nickel Mine.

David has been invited to visit numerous mining regions and individual mines throughout Australia, and in Canada, the USA, Brazil, South Africa, UK, China, Chile, PNG, New Caledonia, Spain and Mozambique.

MAJOR RESEARCH ACHIEVEMENTS

From 1989, Professor Williams carried out research under NERDDC and ACARP Projects on the characterisation of the deposit formed on the pumped co-disposal of combined washery wastes, which has since been adopted at numerous coal mines in Australia and Indonesia.

From 1996, David developed the store/release cover system suited to seasonally dry climates, for application to covering acid generating rock dumps at Kidston Gold Mine in north Queensland, and has had a long-term involvement in researching and monitoring this cover system, as evidenced by his numerous papers on his research on this topic. The store/release cover system on the tops of the Kidston rock dumps has been shown to limit percolation to less than 1% of rainfall, and to support a sustainable vegetation cover comparable to that occurring along water courses in the area. He was also involved in the development of a rehabilitation strategy for the side slopes of the rock dumps at Kidston designed to maximise geotechnical and erosional stability while promoting vegetation, and analysed the wetting up by rainfall infiltration and subsequent drain-down of and seepage from the rock dumps. Store/release covers have now been adopted at numerous mine sites in dry climates worldwide.

From 1999 to 2001, David led ACARP Project C8039 to develop a risk assessment and cost-effectiveness analysis for the rehabilitation of Bowen Basin coal mine spoil. The results of the project were reported in a Literature Review and Commentary and Project Final Report, plus a spreadsheet-based risk assessment and cost-effectiveness analysis, available at: www.uq.edu.au/civil/. In 2006, David undertook a closure study for Xstrata's new Rolleston Coal Project in the Bowen Basin Coalfields.

David has since 2000 been involved in the closure design for the waste rock dump at Cadia Hill Gold Mine in New South Wales, including studies on the use of mixtures of benign trafficked rock and tailings as an alternative cover material, to overcome the shortage of suitable natural materials. In 2002/3, he led an international peer review of the rock dumping operation and closure plan. In 2004, David was successful in an ARC Linkage grant application with Cadia totalling over $ 700,000 over 3 years, which has led to the construction of a 15 m high, world-class, demonstration, instrumented rock dump covering 7,000 m^2. The instrumentation includes a full weather station, 24 lysimeters at the base of the dump to monitor seepage, lysimeters on the top surface to monitor rainfall infiltration and three store/release trial covers constructed using natural and mine waste materials. To date it has shown that about 70% of the rainfall incident on the traffic-compacted top of the dump infiltrates, with the majority going into storage within the dump during the first year, and only small amounts percolating to the base of the dump. The behaviour of the cover trials has to date been dominated by the moisture state at which they were constructed. Monitoring of the instrumented rock dump is expected to continue for at least 10 years.

From 2000 to 2003, David was a principal researcher into the physical and geochemical nature of acid generating waste rock dumps in Southern Carolina, USA (Rio Tinto's Ridgeway Mine) and Sudbury, Canada (Inco's Whistle Dump), sampled as they were being excavated and moved to a pit.

From 2001 to 2005, David led an ARC Spirt research project with industry partner WMC Resources focussed on an assessment of the long-term seepage and runoff from mine tailings storage facilities, to facilitate lease surrender. This included the monitoring of trial covers on tailings over the duration of the project and large-scale laboratory column testing and numerical analyses. Natural salt pan and rocky slope analogues under the same climatic and similar geochemical conditions were also studied to point to sustainable approaches for rehabilitating the tailings storage facilities.

From 2010, David has led three ACARP Projects, C19022, C20047 and C25040, investigating the settlement and stability of high coal mine spoil, the behaviour of problematic clay-rich coal mine tailings, and the behaviour of "mud" derived from spoil on wetting-up.

David has been sponsored by mining companies and consultants to visit numerous mining regions and mine sites worldwide, both to impart and extend his knowledge. Since 2000, he has developed a relationship with the International Network for Acid Prevention (INAP), and has contributed to INAP-sponsored research and development projects and workshops involving mine sites in the USA, Canada, Australia and PNG.

Research funding has totalled over $10 million, including funding from ARC, ARC-SPIRT, ARC Linkage, NERDDC, ACARP-AMIRA, ACARP, MIM CRA-ATD, Kidston Gold Mines, BHP Coal and WMC Resources, Cadia Holdings, Jubilee Mines NL.

PUBLICATIONS

Professor Williams has over 300 refereed publications, including five book chapters, over 100 refereed journal articles and over 200 refereed conference publications, plus numerous research and consulting reports. About two-thirds of these publications are in the mine waste field.

Appendix E - Kanmantoo Pumped Hydro Energy Storage, Underground Development and Groundwater Recovery Groundwater Impact Assessment Modelling Summary Report for Hillgrove Resources (Mining One 2019a)

KANMANTOO PUMPED HYDRO ENERGY STORAGE, UNDERGROUND DEVELOPMENT AND GROUNDWATER RECOVERY

GROUNDWATER IMPACT ASSESSMENT MODELLING SUMMARY REPORT

For

HILLGROVE RESOURCES

Job No.	2676_G
Doc No.	6015v2
Date:	November 2019
Prepared by:	Alexis Valenza

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Certified System Quality ISO 9001 SAI GLOBAL

FINAL REPORT

TABLE OF CONTENTS

TABLE INDEX

FIGURE INDEX

APPENDIX

ABBREVIATIONS

ADE	Advection Dispersion Equation
AHD	Australian Height Datum
AS	Australian Standard
BGCS	Biotite Garnet Chlorite Schist
BRCA	Bremer River Catchment Area
BSch	Biotite Schist
CGM	Conceptual Groundwater Model
COPC	Contaminants of Potential Concern
CPU	Central Processing Unit
DEM	Digital Elevation Model
DSA	Detailed Study Area
GABS	Garnet Andalusite Biotite Schist
GDM	Geotechnical Domain Model
GL	Gigalitres
GMMP	Groundwater Monitoring and Management Plan
GMO	Groundwater Management Objective
GSI	Geological Strength Index
ha	Hectare
IES	Iterative Ensemble Smoother
m	Metres
mg/L	Milligrams per Litre
mV	Millivolts
NRMS	Normalised Root Mean Squared
OTD	Old Tailings Dam
PHES	Pumped Hydro Energy Storage
RL	Relative Level (mAHD +1000)
RSA	Regional Study Area
RWS	Return Water Storage Dam
SGS	Sequential Gaussian Simulation
SSE	Sum of Squared Errors
TSF	Tailings Storage Facility

1 INTRODUCTION

1.1 Background

The Kanmantoo Copper Mine (the site) is located 50 km southeast of Adelaide. The mine was operational from 1970 to 1976 and an open pit was excavated to a depth of 120 m. The mine exploits ore hosted within a biotite garnet chlorite schist (BCGS), which is located within a body of garnet and andalusite biotite schist (GABS) which is the predominant rock type exposed in the Giant Pit. Biotite schist (BSch), which regionally hosts the other rock types, is exposed in the upper eastern and western walls of the Giant Pit. In 2011, Hillgrove Resources (HGO) redeveloped the historical mine and over seven years, expanded the original pit and developed several pits including the Kavanagh Pit, and ultimately expanded and deepened Kavanagh to form the Giant Pit which was extended to 360 m depth at end of open pit mining in May 2019 (Ref 15). It has been proposed that the pit be used as the lower pond of a pumped hydro energy storage scheme (PHES).

HGO further propose to develop an underground mine (Kavanagh) below the Giant Pit whilst the PHES is being developed (two years). A lift of the Tailings Storage Facility (TSF) will be required as part of the operation. Hillgrove Resources is assessing whether the development of the UG and TSF may have a detrimental impact on groundwaters and whether the general findings of the groundwater modelling completed in 2018 are still applicable.

Mining One was commissioned by HGO to amend the existing model and integrate the underground development below Giant Pit, the placement into the pit of waste material, groundwater volumes generated by the underground and raising the TSF to account for the placement of the mine tailings.

This report provides the results and documentation of simulations of any underground mining impacts on groundwater both with and without the PHES.

1.2 Scheme Layout

The main feature of the site is Giant Pit, which reached a final depth of 360 m in May 2019. Mill tailings are stored in a double lined drained pond TSF of approximately 40 ha (Ref. 14).

Mining during an earlier era has left an old tailings dam (OTD), of approximately 30 ha that lies immediately to the north of the Giant Pit. It was probably poorly constructed by today’s standards and has legacy acid leachate issues (Ref. 14). The proposed pumped hydro energy storage scheme (PHES) concept would consist of an upper pond located on undisturbed ground to the northwest of the OTD, and using Giant Pit as the lower pond. The scheme is based on 250 MW of capacity operating for 7.5 hours at a gross head of 215 m to 278 m and would have the following characteristics (extracted from Ref. 14):

- *2x125MW generator units, driven by reversible pump turbines with rated head of 242m*
- *7.5 hours of storage available on a daily basis*
- *Upper Pond varying from RL1215 to RL1223 for volume of 3.4GL; concrete faced rock fill dam with crest at RL1225 and volume of approximately 0.63 million cubic metres (Mcm); potential to draw the pond down lower for increased storage*

- *Waterway consisting of a 1,450m long, 5m diameter steel pipeline and tunnel to an underground surge tank, vertical shaft and high-pressure tunnel bifurcating to two turbines, with 2x150mx3.75m tailrace tunnels into the Lower Pond*
- *Lower Pond in the Giant Pit varying from RL945 to RL1000, with potential to fill to higher level for increased storage*
- *A 6m horseshoe access tunnel from the Giant Pit ramp to the underground powerhouse cavern, with separate transformer cavern*
- *Underground step-up transformers to 275kV, with cables to the surface, and overhead lines to a new Kanmantoo 275/132kV substation on the 275 kV Main Grid supplying Adelaide.*

1.3 Scope of Work

1.3.1 Stage 1

Stage 1 included the following key phases:

- A review of background information including:
  - Climate
  - Hydrology
  - Previous reports, both provided by Hillgrove and in the public domain geological and hydrogeological reports
  - Public domain groundwater data
  - Local groundwater data
  - Mine development stages between 2011 and planned end of mine date

  The review was conducted to develop a conceptual model of the groundwater flow system, select appropriate model domains and boundary conditions, and develop a model calibration dataset.
- A numerical model of groundwater flow was constructed to represent a conceptual model. It is noted that at the time the model was constructed, the pit was assumed to be going to approximately 400m in depth, so this was modelled.
- A model calibration and uncertainty analysis were conducted and considered the conceptual model, available data and necessary predictions while focusing on quantifying and reducing predictive uncertainty. This process produced 150 alternative model parameter realisations that match observation data.
- Initial predictive simulations were conducted to provide estimates of groundwater changes due to PHES operation and likely long-term contaminant transport directions.
- The kinetic geochemistry simulations were completed to assess water quality changes with several sources of water being mixed together. In addition, the alkali dosing remediation of acidic Return Water Storage Dam (RWS) water was explored. Mining One was assisted by EHS Support (specialist geochemist consultants) in conducting the geochemistry simulation.
- This report is a summary version of Mining One’s report (Ref. 23) that was produced to document the model development, analysis and initial predictive runs to serve as a reference for further work and inform the PHES project.

1.3.2 Stage 2

Stage 2 included the following key phases:

- Integration of the underground workings (five orebodies and associated stopes) and of the proposed TSF lift into the existing groundwater model, discretisation and associated mesh refinement.
- Assignment of boundary conditions and discrete features to represent drainage into the underground mine; Assignment of boundary conditions to represent the placement of fill material into the pit and to represent the TSF level increase to 1266 mRL.
- A predictive simulation that includes a 2-year period of progressive underground mining and TSF filling.
- Predictive simulations of the likely long-term transport directions.
- Model long-term recovery period to 2272, 250 years after the end of the underground mine development

1.3.3 Response to comments

A series of comments were raised by EPA and DEM following the review of the Stage 1 reports (Ref 23 and Ref 24) and the preliminary Stage 2 report (Ref 25) focusing on the modeling findings of the underground development.

Response to these comments is provided in Appendix E of this report.

1.4 Modelling Objectives

The numerical groundwater flow model described in this report was developed to support a groundwater impact assessment of the PHES operation by providing quantitative estimates of groundwater levels around the Giant Pit, both pre-and post-operation, and predictions of pore pressure and infiltration rate variations due to rapid drawdowns associated with the PHES. Additionally, particle tracking and transport modelling were required to determine whether the rapid drawdowns and changes in local flow systems could mobilise contaminants associated with legacy mining at the OTD.

The numerical groundwater model was then modified to assess any groundwater impact of an underground operation and associated TSF lift, including recovery of groundwater, both with and without PHES. It was compared to the calibration and predictions obtained in 2018 (Ref. 23) by providing quantitative estimates of groundwater levels around the Giant Pit, both pre- and post-operation. Additionally, particle tracking was required to determine whether the lift in TSF could alter flow patterns (and potentially mobilise contaminants associated with the TSF).

The Kanmantoo modelling project was conducted and documented in accordance with the Australian Groundwater Modelling Guidelines (Ref. 2). However, the guiding principle of the project was based on more recent documents detailing best practice for groundwater modelling within a risk-based framework (Ref. 21).

This approach focuses on the prediction of inherent uncertainty, and the application of the modelling process as a method of using observation data and a conceptual model to reduce this.

The level of uncertainty of a large and complex groundwater system can be relatively high if a single set of predictions is being used, irrespective of the level of conceptualisation undertaken and the range of data within a set. There is a very large number of potential combinations of parameters for a calibrated model. The uncertainty analysis explores these combinations and provides a “range” of predictions.

2 CONCEPTUAL MODEL

The conceptual groundwater model (CGM) was developed based upon a review of previous hydrogeological investigations, groundwater data provided by Hillgrove, and an analysis of publicly available datasets for the regional topography, climate, and groundwater levels. It is acknowledged that this CGM was created based upon current site knowledge, and the conceptual model can be refined as more data is collected in the future.

2.1 Lower Pond Geological Setting

The geological, hydrogeological and geotechnical settings for the model were derived from Hillgrove's Geotechnical Domain Model in their Principal Mining Hazard Management Plan (Ref. 17) and associated numerical files (Ref. 18).

The Geological Survey of South Australia's 1:250,000 Barker Sheet indicates that the mine is located within Brukunga Formation rocks of the Cambrian Kanmantoo Group, comprising metamorphosed inter-bedded phyllites and greywackes, with lenticular pyritic and calc-silicate lenses.

In the area of the mine, the meta-sediments have been metamorphosed to schists with a generally north-south striking foliation, dipping moderately to very steeply toward the east, and with remnant bedding which dips and strikes in a similar direction. Figure 2-1 shows an east-west cross-section of the geology, looking toward the north. The main rock types, and their abbreviations used throughout this report, are:

- Biotite Schist (BSch), the host rock that bounds the other rock units on the eastern and western margins. It is light grey, fine grained, matt textured and highly foliated, and is a softer, more ductile and more readily weathered upon exposure than those listed below;
- Garnet Andalusite Biotite Schist (GABS) is grey-green and foliated. It consists of large (5 to 10 mm) porphyroblastic andalusite crystals making up an average 8% of the rock, set in a coarse-grained schistose matrix of biotite (52), quartz (27%), almandine garnet (16%) and chlorite (5%); and
- Biotite Garnet Chlorite Schist (BCGS) is poorly foliated and fine grained. It is gradational with the GABS and is thought to be a metamorphic chloritisation and alteration of the latter rock type due to mineral replacements. The lenticular orebodies are contained within the BCGS.

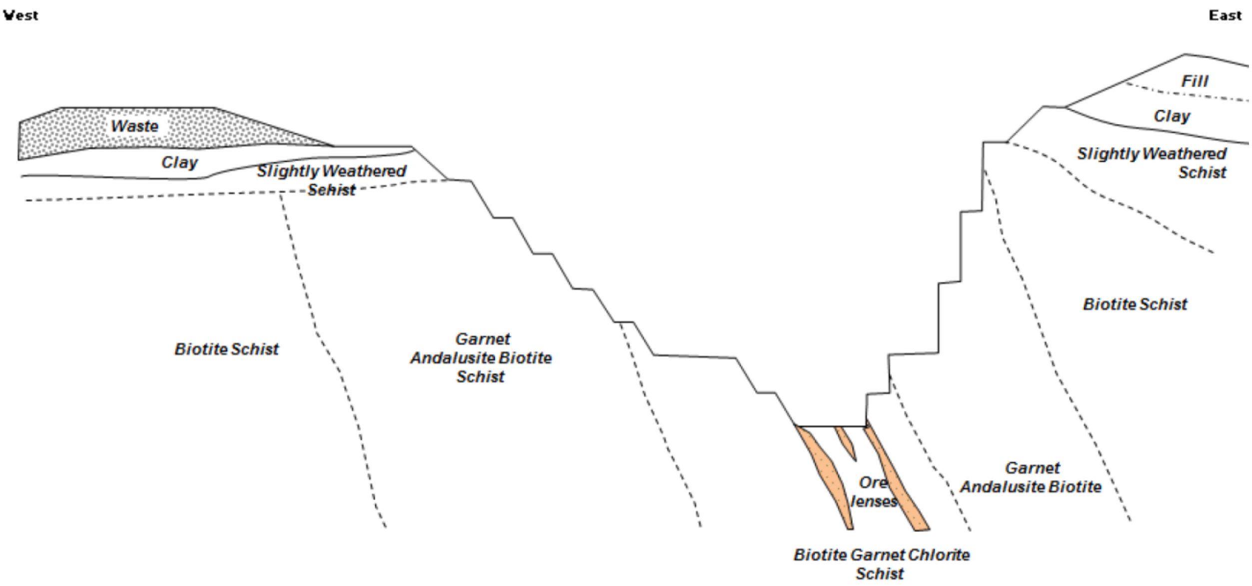

Figure 2-1: Kavanagh Pit Generalised Geological Cross Section (Hillgrove 2015[17])

2.2 Upper Pond Geological Setting

Geophysical, geotechnical and hydrogeological investigations of the proposed PHES concept scheme were carried out in September and October 2018 by GHD (Refs. 15 and 16), from which the following summary is sourced:

- *The investigations at the upstream site found reasonably consistent conditions with shallow soils overlying extremely weathered schist bedrock becoming less weathered at depth. Slightly weathered rock is typically found at 3-4 m depth in the abutments, deepening to 8 m in the centre of the valley, associated with deeper weathering and disturbance because of an inferred fault zone.*
- *Permeability measured in borehole packer tests was low on the south abutment (BH01 and BH02) but higher in the north abutment at BH03, with Lugeon values of 17 and 18 recorded. The rock was observed to be more brecciated in this area, possibly associated with shear displacement. This higher permeability suggests that a thorough drilling and foundation grouting program would be required to control seepage.*
- *At the alternative OTD site, the clay cap layer varied in thickness across the infiltration testing locations, ranging from 0 – 200 mm. Under the clay cap, unconsolidated Sandy SILT/Silty SAND was noted. Minor variations in tailings material were noted across site, with the sand content of the material increasing in the eastern section of the tailings dam. The infiltration rate test results are generally consistent and fall within the same order of magnitude of 10^{-4} m/s, which is consistent with the expected k values of unconsolidated silt and sand materials.*

2.3 Site Hydro-Stratigraphy

The predominant aquifer system is comprised of fractured metasediments (andalusite - quartzbiotite - garnet ± staurolite schists) of the Cambrian aged Kanmantoo Group (SKM 2011 (Ref. 32), REM 2007 (Ref. 30)). Fresh bedrock is overlain by highly weathered bedrock and groundwater mainly occurs in discrete fracture zones within the fresh bedrock that are likely to be confined, or compartmentalised aquifers with high heterogeneity (SKM 2011). The weathered bedrock tends to form confining layers and Quaternary sediments are too thin to form useable aquifers (GHD 2018b (Ref. 15), REM 2007 (Ref. 30)). Values of hydraulic conductivity at water supply wells KBM005b and KBM008b were obtained from 24 hour aquifer tests conducted in 2010 (Ref. 31). Values of transmissivity and storativity were estimated at 0.5 - 1.5 m^2/day and 0.003 - 0.02 m^2/day respectively.

In the development of a predictive numerical model, the following key aspects of the hydro-stratigraphic conceptual model were considered:

- Groundwater flow will be controlled by discrete fracture zones within highly heterogeneous compartmentalised aquifers composed of relatively low permeability geological units.
- Weathered rock at shallow depths may have reduced permeability due to weathering products infilling fractures, or greater permeability due to lower overburden loading and consequent larger fracture apertures.
- Fracture apertures and the resulting elevated hydraulic conductivity is likely to be inversely proportional to depth. Rocks at greater depth are subjected to higher lithostatic stresses which can compress fractures.

A review of the regional structural geology indicated that local scale fractures and associated compartmentalised aquifers that are the dominant groundwater bearing units, may have an approximately north-south orientation.

2.3.1 Site Observations

Ongoing groundwater monitoring has been conducted by Hillgrove since 2011. Data obtained prior to 2011 have been integrated by REM (Ref. 30) into the general groundwater database.

A series of baseline groundwater monitoring investigations were commissioned by Hillgrove between 2006 and 2011 (Ref. 20). The baseline information was also used to develop a Groundwater Monitoring and Management Plan (GMMP) specific to the site. The current version of the GMMP was finalised in late 2017 by JBS&G. Compliance monitoring has been conducted by JBS&G (Ref. 20) since 2011 according to the GMMP.

The regional groundwater is interpreted to flow in a general south-easterly direction beneath the northern portion of the Site, and south to south-easterly direction in the southern portion of the site and beneath the TSF, consistent with the undulating topography (Ref. 20).

Consistent with historical data, Giant Pit continues to act as a groundwater sink with groundwater flow in the vicinity of the pit occurring in a radially inward direction. Based on surrounding piezometer records, the water table in the near vicinity of Giant Pit slopes is interpreted to be extremely steep.

According to Hillgrove (Ref. 17), "*seepage is seen along occasional discontinuities on the pit walls but ground-water flow into the pit is very low, estimated to be less than 5 L/s"*.

Based on Hillgrove's observations, dewatering has historically only occurred during the wetter months of the year. Groundwater is generally encountered in the collars of the blast holes when drilling the first shot of each bench. Once the first shot is fired, groundwater quickly drains into the shot rock blast-fractured zone and the problems become reduced for the following shots.

2.4 Conceptual Flow Boundaries

The site is located within the Bremer River Catchment Area (BRCA). The centre of the BRCA is approximately 45 km southeast of Adelaide and 35 km north of the Bremer River mouth at Lake Alexandrina. The aerial extent of the BRCA watershed bounded by hydrological divides is 30 km from north to south and 20 km from east to west (light pink zone in Figure 2-2). The hydrological divides form natural no-flow boundaries in the groundwater system and recharge occurs at the surface. Seepage faces occur in creeks and the Giant Pit. Rainfall is the predominant source of recharge and has been regionally estimated at 30 mm/yr. Localised recharge may occur along ephemeral watercourses during high rainfall-runoff conditions. Discharge from the site occurs via downgradient groundwater flow across the south and east boundaries and through evapotranspiration from the open pits (Ref. 30).

Mining activities from 2011 to 2018, did not require substantial water extraction to manage flow into the Giant Pit and large drawdowns of groundwater head have not been observed. Therefore, it was assumed that groundwater drawdown would not propagate large distances during the operational time-frame. Previous analytical modelling predicted, as a worst-case scenario, that drawdowns of 1.0 m would extend to a maximum of approximately 1,300 m from the southern and eastern boundaries of the site, and a lesser distance from the west and north boundaries (Ref. 30). Consequently, an approximate 12 km by 12 km subset of the overall watershed area was selected as the model domain to represent a detailed study area (DSA) within the wider regional study area (RSA). The model domain was large enough to ensure no impact of boundary conditions upon the model results and captured the key stresses on the groundwater system (both current and future).

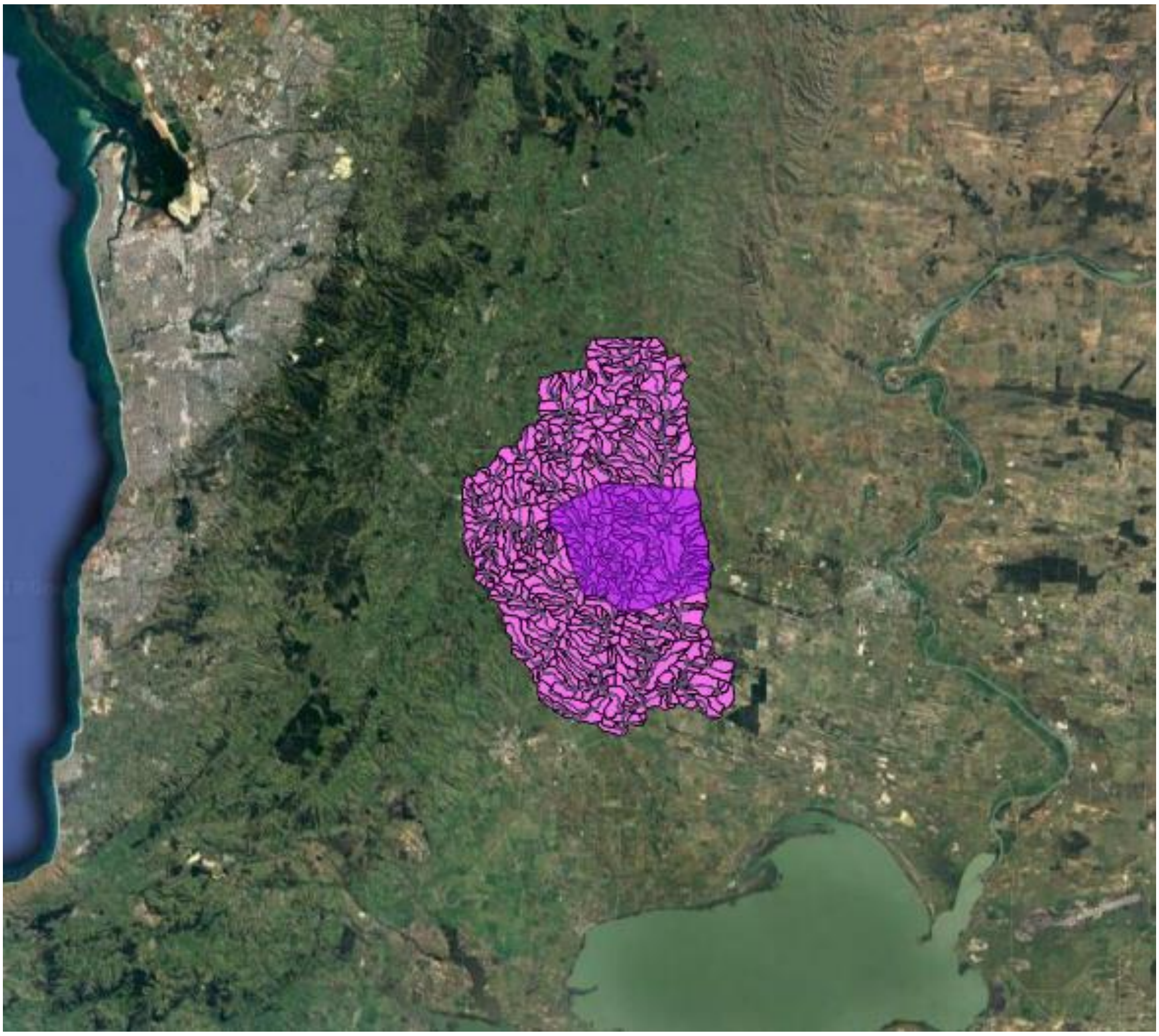

Figure 2-2: Bremer River Catchment Area, Southeast of Adelaide, South Australia

2.5 Groundwater Flow and Quality

2.5.1 Regional Groundwater Flow

Groundwater levels and well location data from the Australian Groundwater Explorer database were obtained for the lower Murray Basin, and refined to retain only data in the Upper Bremer River Watershed (Ref. 4). Groundwater levels were contoured and regional flow was interpreted to be in a south-south-easterly direction.

2.5.2 Local Groundwater Flow

Prior to mining, groundwater likely flowed towards the Bremer River valley in the southeast and the Nairne/Dawseley creek in the south (Ref. 30). Since mining, the direction of groundwater flow in the northern section of the site is south-easterly (Figure 2-3). Groundwater flow in the southern section of the site is dominated by flow towards the open pits but, is generally in a south south-easterly direction (Ref. 20). Due to the fractured nature of the bedrock, hydraulic conductivity is highly variable across the site and groundwater flow is likely to be extremely heterogeneous, compartmentalised and predominantly fracture-driven.

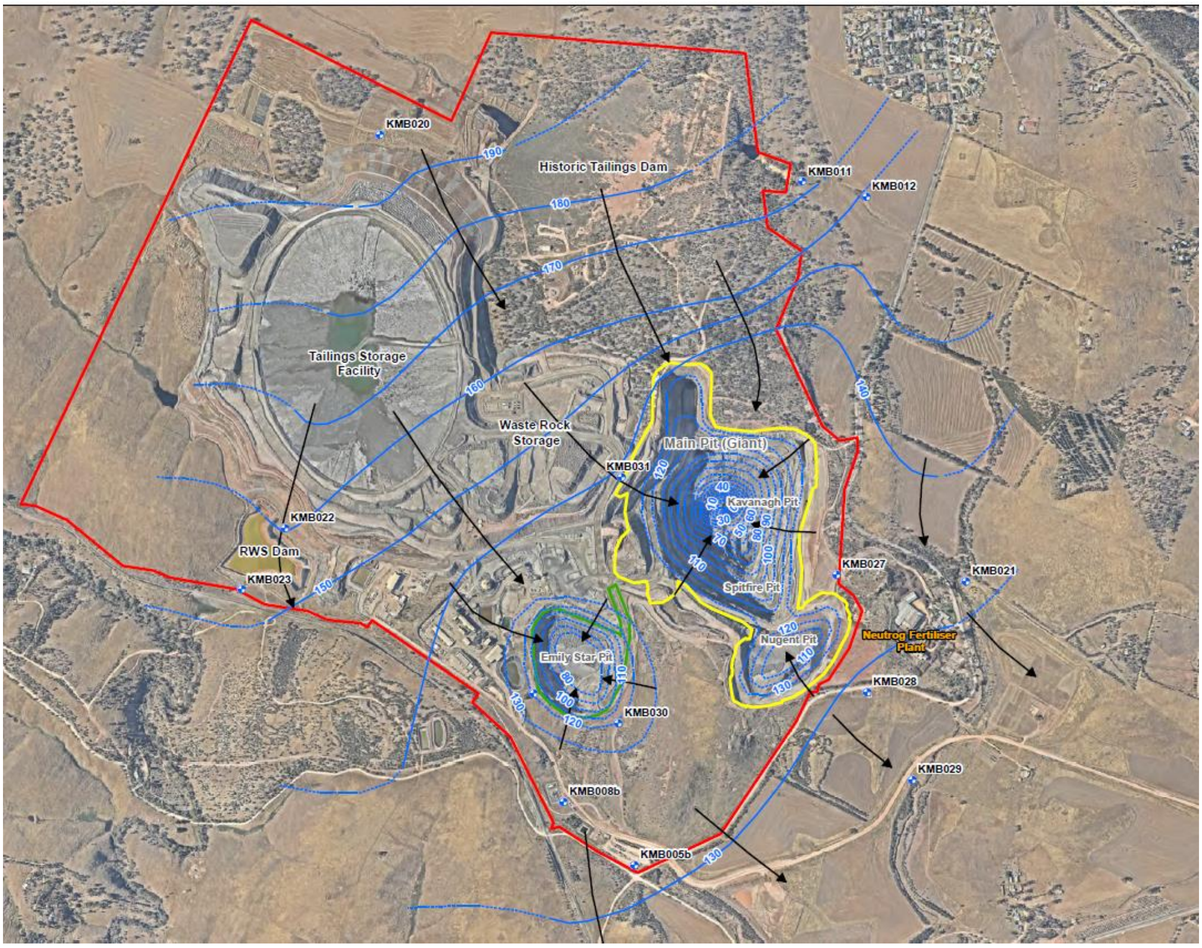

Figure 2-3: Groundwater Flow at the Kanmantoo Mine Site (Ref. 20)

A conceptual hydrogeological cross section of the site was developed by Resource and Environmental Management Pty Ltd (Ref. 30) and is shown in Figure 2-4.

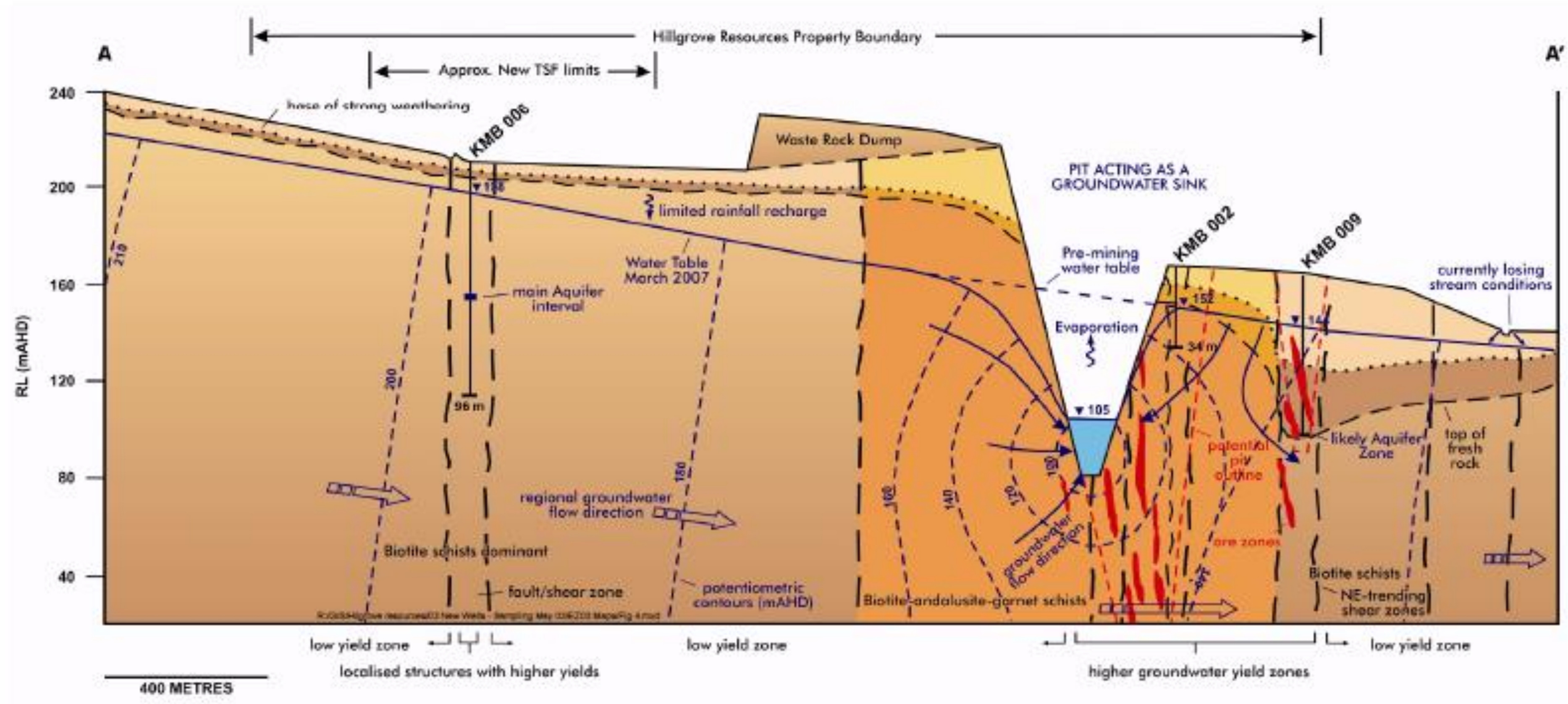

Figure 2-4: Conceptual Geology of Kanmantoo Mine (Ref. 30)

2.5.3 Groundwater Quality

Historical mining resulted in groundwater quality impacts at the site. Elevated levels of heavy metals including cadmium, cobalt, copper, zinc, lead, nickel and manganese have been detected in wells near the Giant Pit, the OTD and the waste rock dump (Ref. 30). The OTD is believed to be the primary source of elevated concentrations of contaminants of potential concern (COPC). Baseline groundwater quality sampling was conducted at the site from 2006 to 2011 and used to develop a site-specific GMMP (Ref. 20). In accordance with the requirements of the GMMP and relevant mine lease conditions, concentrations of COPC (i.e. heavy metals and nutrients) have been regularly monitored since mining recommenced in 2011.

Particle tracking and mass transport modelling focused on identifying flow patterns, potential migration pathways, and delineating the extent of impacted groundwater due to historical mining.

3 MODEL DESIGN CALIBRATION

3.1 PHES Model Design

The model was constructed using FEFLOW Version 7.1 (Ref. 7), a three-dimensional (3D) finite element groundwater modelling software. FEFLOW allows simulation of both saturated and unsaturated flow in addition to contaminant transport, which are all required to successfully model the complex flow regime at the site.

A detailed description of the model design and construction is provided in Mining One Report Ref. 23. This section summarises the information contained in that report.

3.1.1 Spatial Discretisation

For the model construction and mesh generation process, a DSA was defined within the model domain to include the Giant Pit, OTD, TSF, and the proposed Upper Pond for the PHES (Figure 3-1).

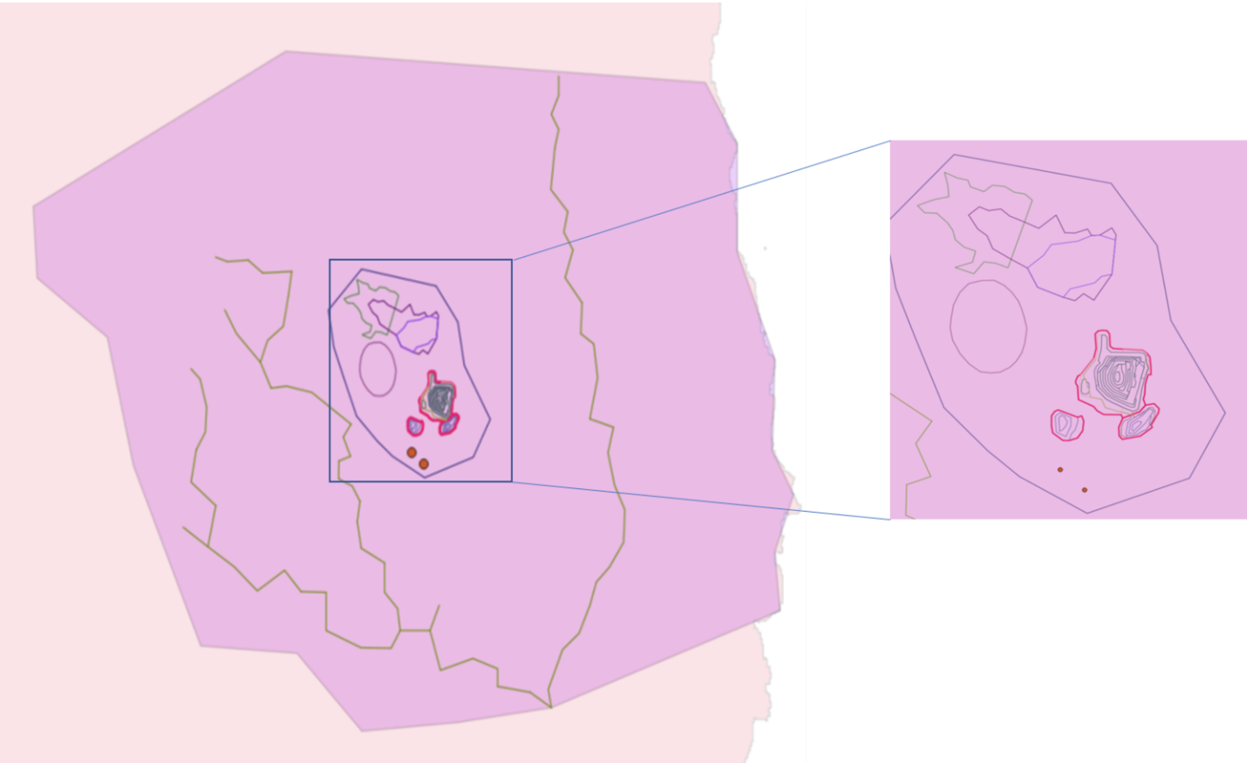

Figure 3-1: Maps Included in the Super-Mesh of the DSA

Project specific features included in the 2D mesh included outlines of the:

- OTD
- TSF
- Outlines of the two options for the PHES Upper Pond
- Contours of mine development including:

  - Simplified 30 m contours of the final (2019) Giant Pit from 150 m to -140 m elevation, relative to the Australian Height Datum (AHD)
  - Simplified 30 m contours of the mined and backfilled Emily and Nugent pits in October 2015
  - Simplified 10 and 30 m contours of the final (2019) Giant Pit and October 2015 Emily and Nugent pits for the upper-most three model layers
- Points representing the locations of the KBM005b and KBM008b water supply wells

Based on the 2D mesh described above, two 3D models were developed with the addition of hydrogeologic layers to the mesh. Two different layering conceptualisations were used to develop both a simple calibration model and a more complex predictive model. It is standard practice to generate a simpler model during the calibration process that is specific to the calibration period to maximise computational efficiency. The following models were constructed:

- **Calibration Model**: A 13-layer model was developed to represent the changing depths of the Giant, Emily and Nugent pits from 2011 to March 2018 (the calibration period).
- **Predictive Model**: A 15-layer model was developed to represent the changing depths of the Giant, Emily and Nugent pits from 2011 to mining completion in about April 2019 (the predictive period). Two additional layers were included in the predictive model to represent the final pit depth of –140 m AHD, estimated to be reached in 2019.

Vertical layer elevations and model thicknesses are shown in Figure 3-2.

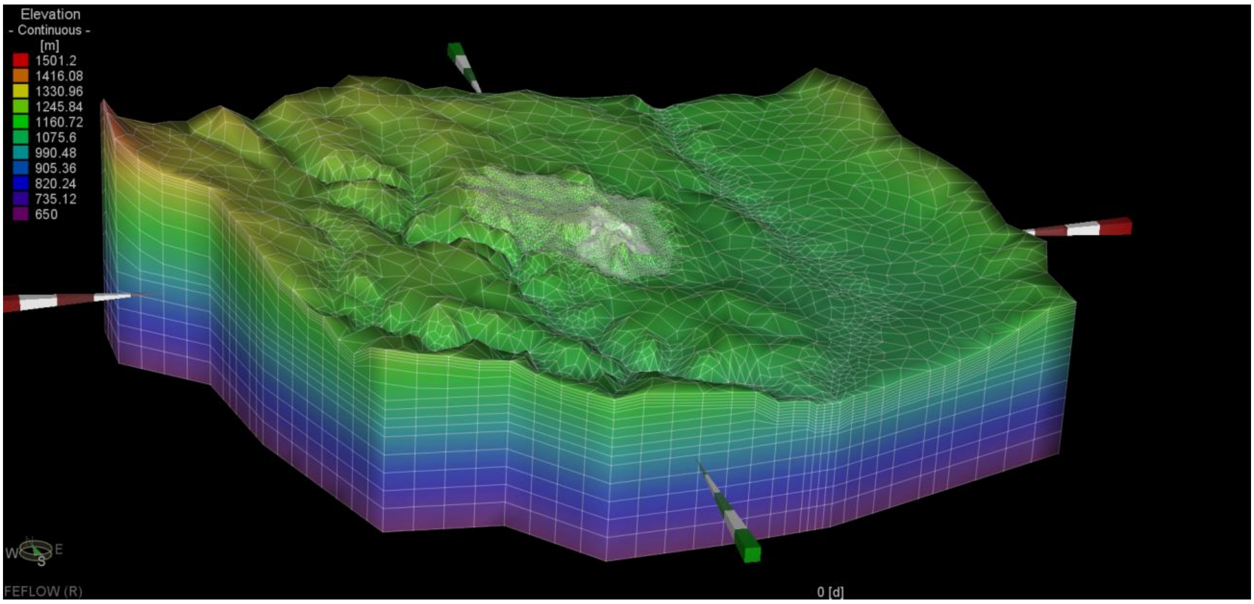

Figure 3-2: FEFLOW Finite Element Predictive Model of RSA

3.1.2 Boundary and Initial Conditions

Boundary conditions applied to the model edges include natural no-flow conditions at hydrological divides significant enough to be considered likely groundwater flow divides, and Cauchy (head dependent flux) boundary conditions elsewhere to capture the inflow/outflow from the greater region. The model base consisted of a no-flow boundary to replicate impermeable bedrock. Recharge was applied at the model surface, and discharge into creeks and the pit lake was represented by seepage face boundary conditions. Seepage face boundary conditions are fixed head conditions placed at the constrained surface elevation to only allow flow out of the model domain.

For the numerical model, groundwater was conceptualised to discharge into creeks, rivers and the Giant Pit, and follow the regional groundwater flow system out the Cauchy boundary on the south side of the model domain. Daily rainfall and evapotranspiration data at the Adelaide Airport weather station was obtained from the Bureau of Meteorology Database (Ref. 5).

3.1.3 Steady State Model

A steady state model simulates the long-term equilibrium that a groundwater system will approach if stresses on the system do not change with time. A steady state model was used in the calibration procedure described in Section 3.3 to learn about parameter combinations that were consistent with pre-2011 mine development observations.

3.1.4 Temporal Discretisation

A transient groundwater flow simulation was used to model progression of mining from 2011 to 2018 for calibration purposes. Instead of calibrating to two separate models for steady state and transient simulations, a single transient model with an extended (100-year) simulation period prior to 2011 was used so that the model could reach a steady state.

3.2 Underground Model Design

The sequential excavation and dewatering of five identified ore bodies extending from the final Giant Pit was simulated between final pit development in 2020 and final underground development in 2022, followed by 250 years of recovery. The simulation results including the underground mining were compared to a baseline simulation including only open pit development to assess the additional groundwater impacts of the planned underground mining operation.

3.2.1 Meshing

The geometry of the proposed underground mine was provided by HGO and included five discrete main orebodies: OB2, OB3U, OB3L, OB9, and OB10.

3.2.1.1 Two-Dimensional Model Mesh

The 2D plan view of the mesh was refined in the area of the underground mine development to have a node spacing of approximately 5 m. This refinement resulted in a total of 12,562 nodes per slice relative to 11,044 in the original model. Other than the local refinement in the area of underground mining, the 2D mesh retained the same geometry and features as the original model (Figure 3-3).

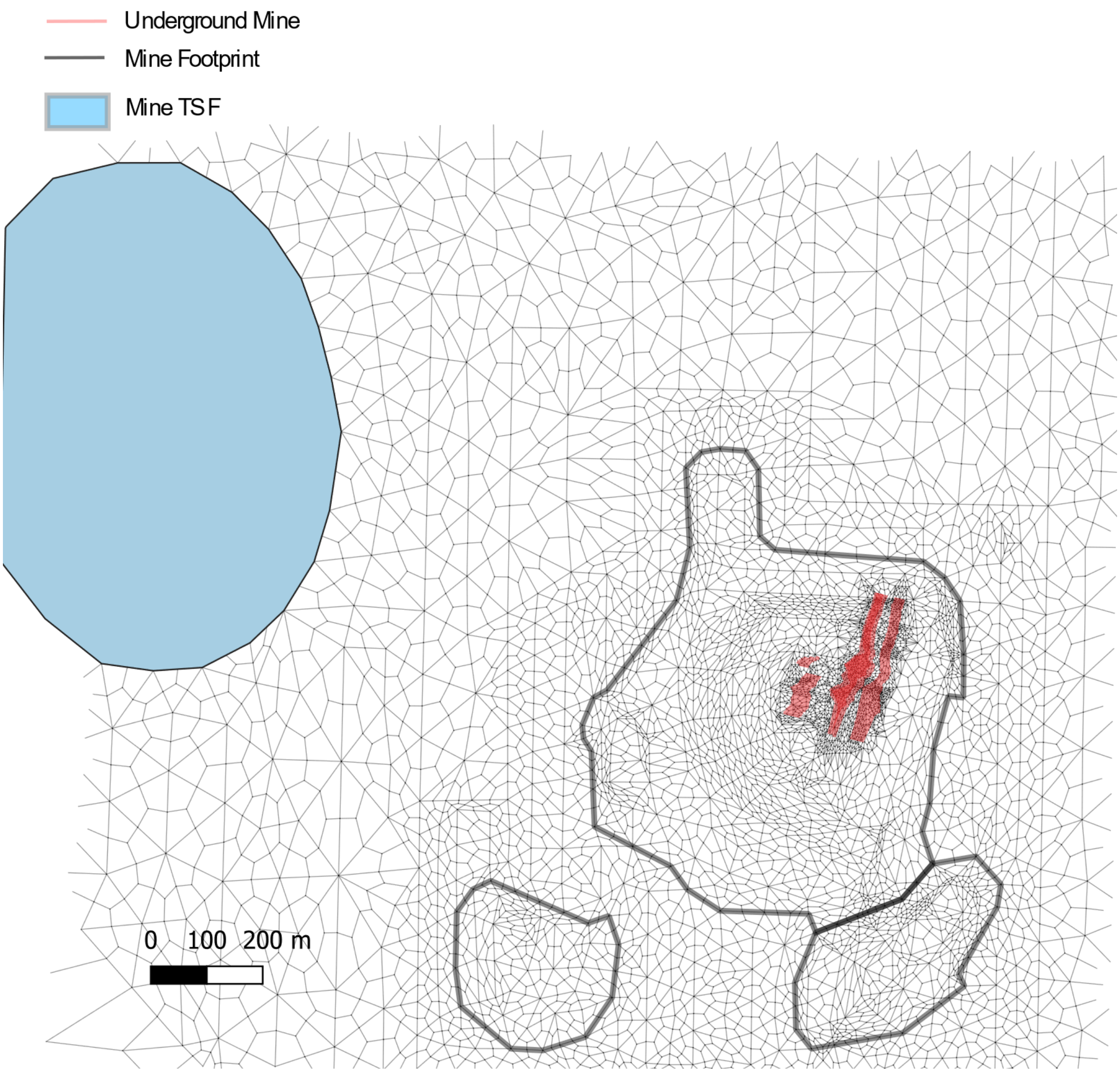

Figure 3-3: Refined Mesh with Location of Underground Mine Extensions (from Left to Right OB2, OB3U, OB3L, OB9 & OB10), Open Pit Mine Footprint and TSF

3.2.1.2 Three-Dimensional Model Mesh (Hydrogeological Layers)

The vertical discretization of the original model was refined from 15 to 29 layers, to achieve a layer thickness of approximately 15m over the elevation range of 730m to 910m RL where the underground excavation is planned. With the exception of the layer refinement, the vertical discretization and geometry of the 3D model was the same as the original model used for predictions of open pit mining. The elevations of the refined layering are listed in Table 3-1.

Table 3-1: Model Layering

Slice	Layer	Hydrogeologic Unit	Elevation* (m)	Layer Thickness (m)
1		Surface	Ground surface	
2	1	Kanmantoo Group (Weathered)	Ground surface – 10	10
3	2	Kanmantoo Group (Weathered)	Ground surface – 20	10
4	3	Kanmantoo Group (Weathered)	Ground surface – 30	10
5	4	Kanmantoo Group	Lesser of ground surface - 40 or 1150	10 to 30
6	5	Kanmantoo Group	Lesser of ground surface - 50 or 1120	10 to 30
7	6	Kanmantoo Group	Lesser of ground surface - 60 or 1090	10 to 30
8	7	Kanmantoo Group	Lesser of ground surface - 70 or 1060	10 to 30
9	8	Kanmantoo Group	Lesser of ground surface - 80 or 1030	10 to 30
10	9	Kanmantoo Group	Lesser of ground surface - 85 or 1015	5 to 15
11	10	Kanmantoo Group	Lesser of ground surface - 90 or 1000	5 to 15
12	11	Kanmantoo Group	Lesser of ground surface - 95 or 985	5 to 15
13	12	Kanmantoo Group	Lesser of ground surface - 100 or 970	5 to 15
14	13	Kanmantoo Group	Lesser of ground surface - 105 or 940	5 to 15
15	14	Kanmantoo Group	Lesser of ground surface - 110 or 910	5 to 15
16	15	Kanmantoo Group	Lesser of ground surface - 115 or 895	5 to 15
17	16	Kanmantoo Group	Lesser of ground surface - 120 or 880	5 to 15
18	17	Kanmantoo Group	Lesser of ground surface - 125 or 865	5 to 15
19	18	Kanmantoo Group	Lesser of ground surface - 130 or 850	5 to 15
20	19	Kanmantoo Group	Lesser of ground surface - 135 or 835	5 to 15
21	20	Kanmantoo Group	Lesser of ground surface - 140 or 820	5 to 15
22	21	Kanmantoo Group	Lesser of ground surface - 145 or 805	5 to 15
23	22	Kanmantoo Group	790	15
24	23	Kanmantoo Group	775	15
25	24	Kanmantoo Group	760	15
26	25	Kanmantoo Group	745	15
27	26	Kanmantoo Group	730	15
28	27	Kanmantoo Group	710	20
29	28	Kanmantoo Group	680	30
30	29	Kanmantoo Group	650	30

3.2.2 Sequencing

Simulation of open pit mining was represented with the updated mesh and layering. However, the methods of representing the open pit remained unchanged from the previous model (Ref.23). The simulation of underground post 2019 mining is shown in Table 3-2.

Table 3-2: Underground Mine Phase Details

Underground Mine Phase	Top Elevation (mRL)	Bottom Elevation (mRL)	Start Time	End Time
OB2	970	790	1/11/2019	1/05/2020
OB3U	880	835	1/05/2020	1/11/2020
OB3L	820	760	1/11/2020	1/05/2021
OB9	820	760	1/05/2021	1/11/2021
OB10	835	760	1/11/2021	1/05/2022

Previous modelling assessed flow patterns in the vicinity of the OTD and considered the TSF as being completely drained within a few years of the PHES starting.

A specific stability and water balance study was completed by PSM in 2018 (Ref.29). The phasing of the decommissioning confirms that the current TSF will stop operating and will be fully drained within 4 to 5 years.

3.2.3 Geometry

Similar to how open pit mine development was represented, the underground mine dewatering was simulated using time varying specified head boundary conditions that decreased from the node head levels at the end of open pit mining to the elevation of the base of the orebody. The boundaries were constrained to only take water out of the model. In the open pit mine simulation, the hydraulic conductivity of the orebody increased, and specific storage decreased over the time of simulated development to represent the material excavation. The porosity of the elements representing the ore bodies changed to 1.0 at the end of each mining period.

With the underground mining simulation, the porosity in the main pit was changed to 0.3 rather than 1.0 so that the deposition into the pit of the waste rock from underground mining operations could be simulated.

3.2.4 Boundary Conditions

Boundary conditions applied to the model edges are unchanged from the original model. Also, recharge and the representation of open pit mine development remain unchanged.

3.2.4.1 Underground Mine Representation

Excavation and dewatering of the underground mine development were represented with time varying material properties and specified head boundary conditions similar to the representation of open pit mining. Five unique underground mining phases were included in the simulation which are shown in plan view on Figure 3-3 and details are provided in Table 3-2

At the start of each phase, nodes along the base were activated and assigned with conditions that linearly changed from the elevation of the base of open pit to the elevation of the base of current phase over the elapsed time-span. Boundary conditions were constrained to only release water from the system and inflows were precluded to simulate only dewatering rather than any addition of water to the groundwater system.

To simulate excavation of rock from the model domain as underground mining progresses, material property values of the excavated sediment were changed from background to values of high hydraulic conductivity, and low specific storage to represent open hole conditions. The open hole property values used were:

- Hydraulic Conductivity = 100 m/d
- Specific Storage = 1.0 e-10 d-1

3.2.4.2 Tailings Storage Facility

The TSF was represented as a Cauchy boundary condition at the surface of the model with a reference head elevation that simulated the water level in the TSF. The boundary condition changed over time to account for the increasing TSF elevation as mine development continues. The TSF boundary condition appears in May 2013, with a reference head elevation of 1,215 m and linearly increases to 1,248 m at March 2018 and 1,258 m at April 2019. To simulate the additional material from underground works at the TSF, the boundary condition was further increased to both 1,266 m by January 2022, and 1,274 m by November 2023. Drainage of the TSF is then simulated by a linear decrease in reference head elevation to 1,215 m in November 2028. After 2028 the boundary condition is removed to simulate a fully drained pond.

It is noted that the TSF water is contained in a closed system where both the TSF and the returned water storage dam are lined. The Cauchy condition was used to simulate the water mounding recorded at the surrounding piezometers (KMB020 and KMB022), and associated with the dam effect of the TSF and the reduction in evaporation within the TSF footprint.

3.2.4.3 Evaporation from Pit

Evaporation from the mine pit following active dewatering was represented in the same two ways as it was in the original long-term predictive scenarios in (Ref 23). From the end of open pit mine development and dewatering in 2019 until 2024, evaporation from the pit was represented as a specified flux boundary condition applied to all nodes along the base of the pit with full saturation at a rate of 4 mm/day. This representation captures the evaporation from a relatively empty pit well. However, as the pit fills, the surface area of the pit base grows larger than the surface area of the pit lake and the resulting total evaporation becomes too high. To account for this, from 2024 onwards the simulated pit water level is used to calculate a pit lake surface area based on the pit geometry. A total evaporation rate from the pit is then calculated by multiplying the pit lake surface area by 4 mm/day evaporation. This total evaporation rate is then applied as extraction well boundary conditions at the base of the pit.

3.2.5 Temporal Discretisation

A transient, groundwater flow simulation was used to model the progression of open pit mining from 2011 to 2019, underground mining from 2019 to 2022 and a 250-year recovery period from 2022 to 2272. As with the original modelling work, a single transient model with an extended (100 year) simulation period prior to 2011 was used so that the model could reach a steady state prior to the commencement of mining activity.

The base calibrated parameters were used to run a steady state equilibrium model. Results of the steady state simulations were used as initial conditions for the transient model to provide starting points near expected values.

For the initial 100-year, quasi-steady state, portion of the simulation, adaptive time stepping was used with unrestricted timestep growth. Adaptive time-stepping and the quasi-steady state approach was considered preferable to a coupled steady state and transient simulation because it was considerably computationally faster. After the initial 100-year quasi-steady state portion of the simulation, additional fixed timesteps were inserted to ensure adaptive timesteps were less than 30 days and included the start and end dates of the open pit and underground mining phases. During the 2250-yearrecovery phase, additional timesteps were enforced to provide outputs at 10, 20, 50, 100, 150, 200, and 250 years post mining.

3.3 Model Calibration

Calibration involves an iterative process to estimate the hydrogeological parameters so that the simulated output matches the historical observations within acceptable error ranges. It is conducted to improve confidence in the predictions generated by the model. Both steady state and transient calibrations were conducted.

Representative calibration targets were determined based upon data from both Hillgrove and the Groundwater Explorer database.

3.3.1 Calibration Targets

Pre-2011 data was recorded to form steady state, hydraulic head, calibration targets. The pre-2011 data was assessed for quality and average values were calculated at each location.

Predictions for this study are dependent on the equilibrium groundwater flow system and alterations due to changing stresses. Post-2011 transient observations were processed to yield information about the way the system responds to stress.

3.3.2 Calibration Methodology

As discussed in Section 2 and in this Section, the conceptual hydro-stratigraphic model is based upon highly heterogeneous, compartmentalised aquifers composed of fractured rock that are likely to be altered near the surface by weathering, and at depth, by loading and fracture compression. To respect the conceptual model, an equivalent porous medium approach was adopted. Adjustable model parameters included horizontal and vertical hydraulic conductivity, specific storage, unsaturated flow porosity, recharge and flow rates at the four Cauchy type boundaries applied at the model edges and area of the new TSF.

Calibration was attempted using PEST parameter optimisation software (Ref. 33) and a simple zone-based parameterisation. Ultimately, an iterative ensemble smoother (IES) method with up to 500 geostatistical parameter realisations was used to successfully calibrate the model.

3.3.3 Model to Measurement Misfit

The normalised root mean squared (NRMS) error between simulated and observed results for each of the eight observation groups is shown in Table 3-3.

Table 3-3: Root Mean Squared (NRMS) Error between Observed and Simulated Results

Observation Group	NRMS (%)
Drawdown	14.03
First Hydraulic Heads	27.34
Differential Head Changes	8.38
Hillgrove Steady State Hydraulic Heads	6.63
Hillgrove Steady State Hydraulic Head Gradients	4.87
Groundwater Explorer Depths to Water	30.54
Groundwater Explorer Hydraulic Head Gradients	4.12
Groundwater Explorer Hydraulic Heads	5.79

Table 3-3 shows that the calibrated model replicates the observation data sufficiently well and does not indicate any substantial issues. The NRMS error between simulated and observed steady state, hydraulic heads and gradients at a local and regional scale are approximately 6 and 4 %, respectively. The model reproduces the regional and local patterns of observed hydraulic head to an acceptable level.

3.3.4 Sensitivity and Verification

Model parameter sensitivity analysis was addressed through a review of the multiple parameter realisations from the IES calibration process. Recharge was found to be sensitive and was decreased from the initial value so a reasonable match to observed water levels and gradients could be obtained. The horizontal hydraulic conductivity field of the base parameter set assumed heterogeneity that was consistent with a conceptual model of fractured rock with compartmentalised aquifers. This indicated horizontal hydraulic conductivity is sensitive to the observation dataset. Inflow transfer rate of the Cauchy boundary condition that represented either a groundwater source (due to dam effect and mounding) or potential source from the TSF, decreased from initial values showing a sensitivity to observation data.

Many other parameters had mean values and ranges that were relatively unchanged from initial estimates, such as specific storage far from the Giant Pit, suggesting that they are relatively insensitive to the observation data. Of the 150 alternative model parameter sets produced during the IES calibration, 50 parameter sets were used for forward predictions.

4 GEOCHEMICAL MODELLING METHODOLOGY

Mining One engaged the services of EHS Support (EHS) to provide geochemical expertise in the assessment of water quality changes during the PHES.

Further support was provided to assess water quality changes when one or more sources of water contribute to the recovery of water within the Giant Pit after underground mining.

The following section describing the scenarios analysed, the model input, the modelling methodology and the findings of the geochemical assessment have been extracted from EHS Support report which are presented in Appendix D.

4.1 Modelling Objectives

The objective of modelling was to use volumes of the identified water sources to explore the changes in water quality as differing ratios of water sources are mixed. A geochemical modelling program, PHREEQC, has been used to calculate the effects of mixing waters of varying compositions and volumes.

The following geochemical interactions were simulated within the mixed waters using PHREEQC:

1. Speciation of source waters;
2. Mixing of specified ratios of source waters; and
3. Addition of alkali to change pH and metal solubility.

4.2 GMO

RWS water, has elevated metals (aluminium, cobalt, copper, iron, manganese and nickel) and low pH, with respect to the Groundwater Management Objective (GMO) values provided by Hillgrove.

It is noted that the GMO was established as a reference for comparison with regional groundwater values. Groundwater modelling shows that the pit is acting as a sink with an inward groundwater flow. Considering that the upper pond will be lined, it is understood that the local system will be functioning as a closed loop and is not expected to interact with the surrounding environment for the foreseeable future.

Potentially corrosive parameters (pH, chloride and sulphate) were compared to the guideline criteria sourced from Australian Standard (AS) 2159 (2009) (Ref. 1).

4.3 PHES Simulation Scenarios

Mining One and EHS developed a range of scenarios that could occur during the filling of Giant Pit to 1,000 m RL but prior to the commencement of PHES activities. The sequence of events proposed for the scheme are provided in Table 4-1.

Table 4-1: Sequence of Events for the Development of PHES

Sequence	Description
1	The pit is mined until mid-2019 - 836 m RL
2	Pit level naturally recovers until mid-2021 - groundwater source mainly (assume 100% no rainfall or evaporation impact) - 866 m RL
3	Mid 2021 to end of 2021 - pit topped up to 1000 m RL using RWS
4	Daily PHES from 940 m RL to 1000 m RL. Water is pumped to the upper pond at night and is allowed to flow down during the day
5	The lifespan of PHES is 50 years

A combination of scenarios was developed to simulate the sequence of events as groundwater recovers within Giant Pit. Supplemental sources of water from Mount Barker, the RWS and the River Murray are used to increase the volume to 5.2 GL by the end of 2021. The scenarios focus on the timeframes 2019 to mid-2021 (Scenario 0) and mid-2021 to the end of 2021 (Scenario 1 to 3).

The modelled scenarios are presented in Table 4-2. The water volumes considered in the simulation were obtained from the groundwater modeling findings.

Table 4-2: Scenarios of Source Water Mixing

Scenario	Source Water	Description
0	Groundwater recovery	Average and worst-case groundwater quality
1 & 1a	Base case top-up 1: lower pond, average quality 1a: lower pond, worst-case quality	Groundwater volume 1 + River Murray 50% & Mt Barker 50% volume 2 to attain 5.1 gigalitres (GL)
2	Raw RWS top-up 2: average quality for RWS 2a: worst-case quality for RWS	Groundwater volume 1 + RWS untreated 4 GL + River Murray 50% & Mt Barker 50% to attain 5.2 GL
3	Treated RWS contribution 3: average quality for RWS 3a: worst-case quality for RWS	Groundwater volume 1 + RWS treated 4 GL + River Murray 50% & Mt Barker 50% to attain 5.2 GL

The water mixing scenarios only cover Sequences 1 to 3, i.e. the mixing of water sources to attain 1000 m RL in Giant Pit prior to the commencement of the PHES.

4.3.1 PHES Model Inputs

The sequence of events proposed for the scheme are provided in Section 5.2 of the Mining One's detailed modelling report (Ref. 23) and in Appendix D and are summarised below.

4.3.1.1 Source Volumes

The source input waters for the filling of Giant Pit to about 5.2 GL or to 1,000 m RL, are groundwater, Mount Barker, River Murray and RWS water (Table 4-3).

Table 4-3: Summary of Scenarios (Volumes in m^3)

Scenario	Description	Total Volume	GW Volume	Murray Volume	Mt Barker Volume	RWS Volume
0	Average and worst-case groundwater quality	164,400	-	-	-	-
1	Groundwater volume + River Murray 50% & Mt Barker 50% to achieve 5.09 GL	5,089,000	164,400	2,462,300	2,462,300	-
2	Groundwater volume + RWS untreated 4GL + River Murray 50% & Mt Barker 50% to achieve 5.2GL	5,253,400	164,400	544,500	544,500	4,000,000
3	Groundwater volume + RWS treated 4GL + River Murray 50% & Mt Barker 50% to achieve 5.2GL	5,253,400	164,400	544,500	544,500	4,000,000

Exceedances of GMO values for each source water are provided in Section 5.2 of Mining One's modelling report (Ref. 23 and Appendix D). Most sources report exceedances prior to the mixing, which include aluminium, cobalt, copper, iron, manganese and nickel. Only Mount Barker water does not exceed any of the GMO values.

4.3.1.2 Scenario 0

Scenario 0 uses the average and maximum concentrations of the dataset collected from 15 groundwater monitoring well locations within the capture zone of Giant Pit (Ref. 20). The groundwater compositions derived from these two datasets are representative of anticipated average and worst-case groundwater quality at mid-2021. The total volume in Giant Pit at this time is estimated as 164,400 m^3. The minimum pH value (pH 5.05) was selected as it is below the GMO.

4.3.1.3 Scenario 1

Scenario 1 is representative of the anticipated volume of groundwater in Giant Pit in mid-2021 with additional water from the River Murray and Mount Barker to make up a Giant Pit volume of about 5.1 GL.

4.3.1.4 Scenario 2

Scenario 2 uses an additional source of water from the RWS. The volumes of water sourced from Mount Barker and the River Murray are reduced and 4 GL of RWS water is used (with groundwater) to make up a Giant Pit volume of 5.2 GL.

4.3.1.5 Scenario 3

Scenario 3 uses the same volumes of water as Scenario 2. However, the RWS source is treated with calcium hydroxide.

It is noted that calcium hydroxide lowers the acidity, increases the pH and decreases the solubility of metal species by decreasing the solubility of metals, mineral phases form and precipitate which reduces the concentration of dissolved metals which may exceed the GMO

4.4 Underground Mining Simulation Scenarios

Mining One provided EHS Support with a further two scenarios that could occur during the natural recovery of the Giant Pit over a 250- year period. The sequence of events proposed for the scheme are provided in Table 4-4 and the Scenarios are presented in Table 4-5.

Table 4-4: Sequence of Events for the Natural Recovery of the MP

Sequence	Description
1	The pit was mined until mid-2019, to a final level of RL 836 m
2	Scenario 1 - Pit naturally recovers to a depth of 59.6 m (895.6 RL) by 2272
3	Scenario 2 – Mid-2022 to mid-2027 – 4 GL of RWS water added and pit naturally recovers to a depth of 91.4 m (927.4 RL) by 2272

Table 4-5: Scenarios of Source Water Recovery and Mixing

Scenario	Source Water	Description
1	GW	Average groundwater quality
1a	GW	Worst case groundwater quality – lowest pH and highest concentrations
2	GW and RWS	Average groundwater quality + 4 GL RWS water between years 1 to 5
2a	GW and RWS	Worst case groundwater quality – lowest pH and highest concentrations

4.4.1 Underground Mine Model Inputs

Groundwater quality data from the Kanmantoo Copper Mine (April 2007 to September 2018) was used to develop an average and worst-case water quality. RWS water quality (March 2012 to September 2018) was used to develop the mean RWS water quality.

Evaporation deficits and groundwater recharge volumes were provided by Mining One. An injection volume of 4 GL RWS water is simulated in the hydrogeological modelling, however, a proportion of this volume is lost as seepage into the surrounding unsaturated media. The remaining calculated volume is used in the geochemical modelling as the added RWS water.

The model input files were developed in a sequential layout. Each time-step defined in the geochemical model aligns with a time period from the hydrogeological modelling. This has been summarised in Table 4-6 below.

Table 4-6: Model Time-Steps and Processes

Hydrogeological Model Period (Years)	Geochemical Model Time-Step	Geochemical Model Process
0	1	Speciation of Groundwater In-flow Evaporation
0-10	2	Speciation of Groundwater In-flow Mix with existing pit water from previous time-step Evaporation
10-20	3	Speciation of Groundwater In-flow Mix with existing pit water from previous time-step Evaporation
20-50	4	Speciation of Groundwater In-flow Mix with existing pit water from previous time-step Evaporation
50-100	5	Speciation of Groundwater In-flow Mix with existing pit water from previous time-step Evaporation
100-150	6	Speciation of Groundwater In-flow Mix with existing pit water from previous time-step Evaporation
150-200	7	Speciation of Groundwater In-flow Mix with existing pit water from previous time-step Evaporation
200-250	8	Speciation of Groundwater In-flow Mix with existing pit water from previous time-step Evaporation

Table 4-7 provides the volumes (m3) of water discharged into the pit and lost by evaporation for each time-step between 2022 and 2272.

Table 4-7: Summary of Scenarios (Volumes m^3)

Period (Years)	Time-Step	Scenario						
		1 & 1a			2 & 2a			
		Groundwater Inflow[1]	Evaporation	Total volume	Groundwater Inflow[2]	RWS	Evaporation	Total volume
0	1	50	-36	14	39	-	-39	14
10	2	522	-56	466	51,180	1,339,928	-51,180	1,339,928
20	3	111,820	-13,799	98,020	51,180	-	-51,180	1,339,935
50	4	669,894	-30,778	639,116	50,825	-	-50,825	1,328,406
100	5	684,295	-31,154	653,141	50,779	-	-50,779	1,326,904
150	6	684,513	-31,160	653,353	50,157	-	-50,157	1,306,710
200	7	684,839	-31,168	653,670	50,153	-	-50,153	1,306,565
250	8	685,344	-31,182	654,163	50,150	-	-50,150	1,306,468

[1] Includes pit volume from previous time-step

[2] Includes pit volume from previous time-step

4.4.1.1 Scenario 1 & 1a

Scenario 1 and 1a use the average and highest concentrations of water quality respectively from the fifteen groundwater monitoring well locations within the capture zone of the Giant Pit (JBS&G, 2017). The minimum pH value (pH 5.05) was used for the maximum groundwater quality as it is below the GMO.

4.4.1.2 Scenario 2 & 2a

Scenario 2 and 2a use the average and highest groundwater concentrations respectively, and an additional source of water from the RWS. A volume of 4 GL of RWS water is injected between Year 0 and 5 in addition to the groundwater recharge contribution

4.5 Assumptions and Limitations

The assumptions related to the modelling methodology aforementioned include the following elements:

- Groundwater intersected by the monitoring well screens is assumed to be from the same groundwater body and is within the same catchment zone that discharges to Giant Pit (except KMB021, KMB024, KMB025 and KMB029 which are assumed to be outside the catchment zone and separated from the remaining wells by a groundwater divide).
- The mixing of two or more water chemistries results in kinetically determined reactions. It is not intended that the geochemical simulations have the site derived (or measured) kinetic rates to undertake a kinetic assessment. The geochemical simulations have been conducted assuming geochemical equilibrium is achieved instantaneously between the waters that will be mixed together.
- The geochemical modelling has used average source water qualities and simulated steady-state equilibrium conditions after mixing or alkaline amendment.
- It is assumed that there is no interaction between the waters and the walls of Giant Pit which could modify the resident water chemistry.
- It is assumed for geochemical modelling purposes that no evaporation of Giant Pit water will occur which could result in an increase in electrical conductivity and total dissolved solids (salinity) due to evapo-concentration.
- When amendment of the RWS water is conducted, it is assumed that the mineral phases precipitated during the geochemical simulation are flocculated and removed from the water. This is to ensure no dissolution of mineral phases occurs if physico-chemical conditions change (mainly pH and redox potential).
- Acidity characteristics of RWS water have been based on the pH and the potential for acidity generation as metal oxyhydroxides deprotonate as pH is increased by alkali amendment. Total acidity has not been reported so acidity is assumed based on these assumptions.
- Oxidation of groundwater and subsequent deprotonation of hydrolysed metal species, has not been modelled.
- The analytical suite for groundwater is not as extensive in groundwater as it is for other water sources (Mount Barker, River Murray and RWS waters).
- Sorption and co-precipitation which results in the removal of cobalt, copper, nickel and zinc have not been modelled, as input parameters to control these reactions have not been

measured. However, the sorption and co-precipitation (onto aluminium, iron and manganese oxyhydroxides) potential of these metals is high, as demonstrated by the physical studies discussed in Earth Systems' report (Ref. 10).

5 RESULTS

5.1 PHES Results

5.1.1 Groundwater Flow and Transport Model Predictions

The predictive model was used to evaluate the following predictive simulations:

1. Mining activities, final Giant Pit design, and pit lake recovery (2011 – 2021)
2. Giant Pit filling with water and detailed daily rapid drawdown due to PHES operation (2021-2022).
3. Long term 50-year PHES operation and 200-year recovery (2021-2271)
4. Particle tracking and contaminant transport (2021-2271)

5.1.1.1 Predictive Simulation 1: Mining Activities, Final Giant Pit Design and Pit Lake Recovery (2011 – 2021)

Fifty model parameter sets were used to simulate mining from beginning to end, and the natural recovery of the water level in the Giant Pit for the following three years (until 2021). The predictive period was 2011 to 2021. To simulate pit water level recovery after the completion of mining in about mid-2019, all the fixed head boundary conditions used to simulate pit dewatering were terminated, which allowed hydraulic head levels in the pit to rise.

Evaporation from the surface of the Giant Pit lake was simulated using a specified flux boundary condition set at 4 mm/day. The evaporation value was estimated by evaluating long-term, average rainfall and potential evaporation differences. Giant Pit recovery levels in 2021 were calculated for each of the fifty parameter sets and are shown in Figure 5-1.

A pit lake level of 866m RL corresponding to the maximum simulation iterations was considered for the pit volume calculations for the geochemical analysis.

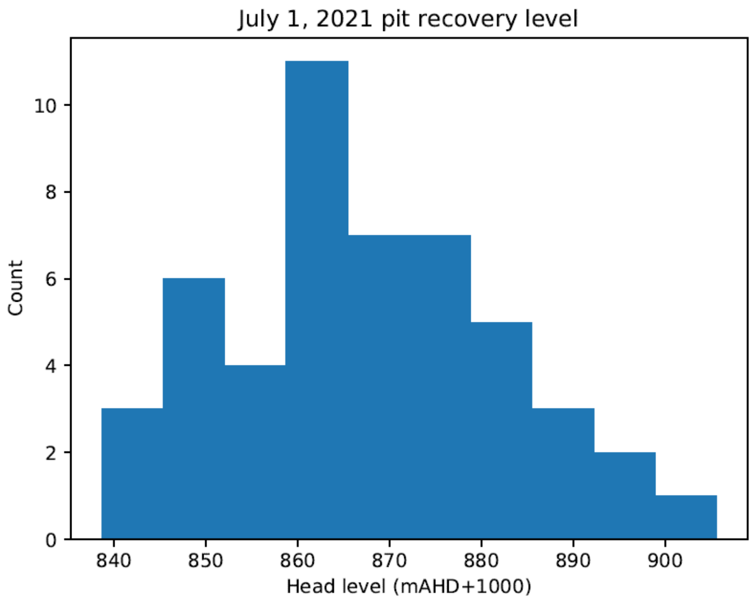

Figure 5-1: 2021 Giant Pit Recovery Levels for Fifty Parameter Sets

The range of recovery is presented in Figure 5-2. This chart plots the results of recovery post mining (May 2019) considering three of the 50 parameters sets (calibrated set, fast response parameters set and slow response parameters set). The pit level recovery at the end of 2021 is estimated to range between 852 m RL (slow parameter set) and 892 m RL (fast parameter set).

It is most likely that the recovery would be around 866 m RL but the above range could apply. It is noted that in the case of higher rainfall over the 2019 – 2021 period, recovery of the pit could exceed these values.

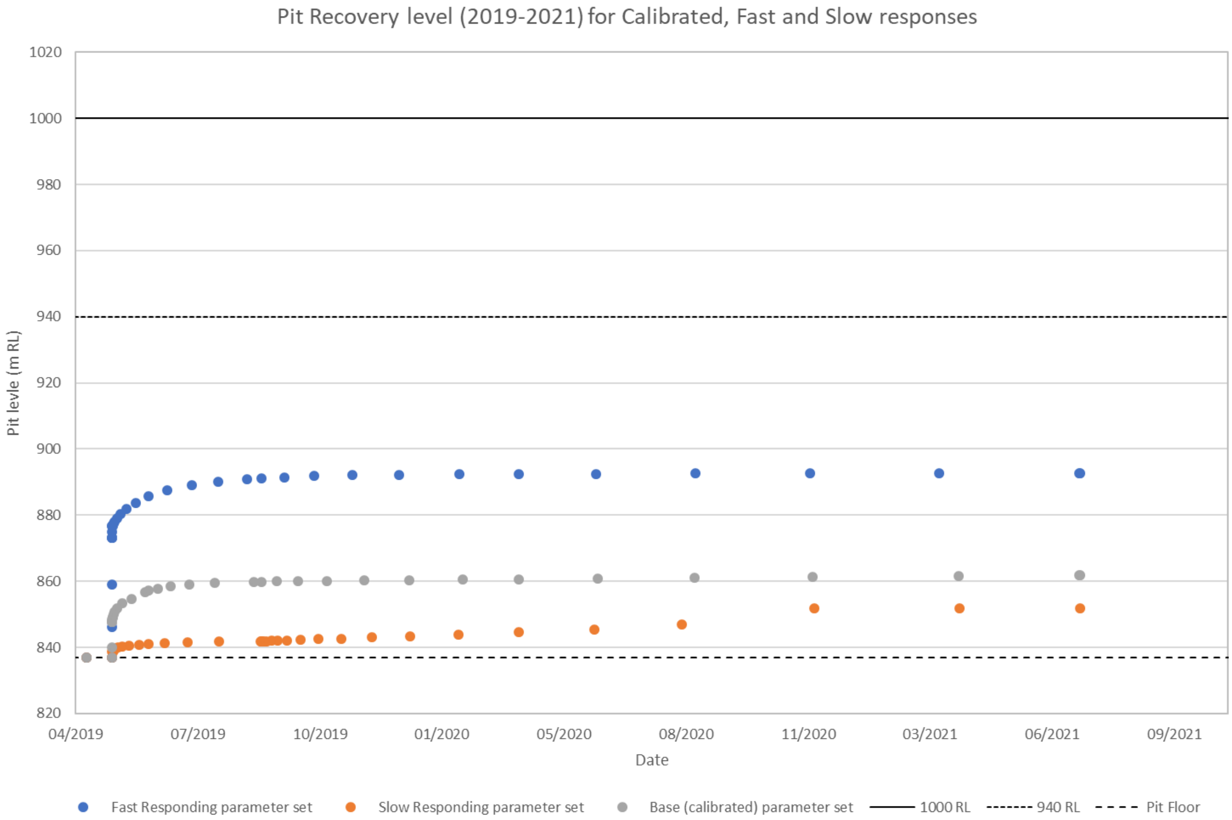

Figure 5-2: 2019-2021 Giant Pit Recovery Levels Chart for Calibrated, Fast and Slow Parameter Set

5.1.1.2 Predictive Simulation 2: PHES Daily Rapid Drawdown analysis and Extraction or Pore Water Pressure Grid

In the second predictive scenario, the proposed daily operation of the PHES scheme was simulated from 2021 onwards to simulate pore water pressure changes behind the slopes during a rapid drawdown scenario. The simulation is based on the scenario that:

➢ In 2021, water will be pumped into the Giant Pit until head levels reach a reduced level (RL) of 1,000 m (which is equivalent to 0 m AHD). At night, water will be pumped from the pit to the upper pond until levels drop to 940 m. During the day, pit levels will increase back to 1,000 m due to filling from PHES power generation.

The parameter sets producing the highest and lowest 2021 pit lake recovery levels were selected as two alternative scenarios. Hydraulic head levels around the Giant Pit at the full (1,000 m RL) stage and the empty (940 m RL) stage after one year of simulation have been exported for both parameter sets.

Daily operations have been simulated and only minor pore water pressure changes are predicted for the rapid drawdown scenario. These have been incorporated into a 3D stress analysis by Mining One (Ref. 26), which has been completed concurrently with this report.

5.1.1.3 Predictive Simulation 3: Long Term 50-year PHES Operation and 200-year Recovery (2021-2271)

The third predictive scenario simulated 50 years of PHES operation from 2021 to 2071, followed by a 200-year recovery period.

The head was fixed and held constant for 50 years at 1,000 and 940 m RL for the constantly full and empty pit scenarios respectively. At the end of the 50-year PHES operational period, fixed head boundary conditions holding the pit level constant were removed.

Evaporation was accounted for by determining the lake surface area at any given level from the known relationship between level and lake surface area, and multiplying it by an estimated average evaporation rate of 4 mm/d to give the total evaporative flux at a given water level.

The impact to groundwater was simulated for the following options for Upper Pond:

1. No additional construction required for Upper Pond. This scenario represents the option of using the current TSF as the Upper Pond for the PHES operation.
2. Construction of a pond overlying the OTD that is lined with a fully impermeable liner. This option was simulated by setting recharge to zero in the pond area at the start of the simulation.
3. Construction of a fully lined pond upstream of the OTD. This scenario was simulated by setting recharge to zero in the area of the pond at the start of the simulation.
4. Construction of an unlined pond upstream of the OTD. This scenario was simulated by fixing the head at the surface nodes in the pond area to the head of the pond surface for the duration of the PHES operation. The fixed heads were removed after 50 years so that drainage of the upper pond could be represented at the end of PHES operation.

The first three options were simulated using both the constantly full and constantly empty pit level scenarios. Construction of an unlined pond was only simulated under the constantly empty pit scenario to provide a conservative estimate of the impact on groundwater from pond leakage. Seven predictive scenarios were produced. The scenarios and the 50-year pit level predictions and are listed in Table 5-1 and show a minimal difference in final pit head levels between the Upper Pond options.

Table 5-1: Long Term PHES Operation and Recovery Simulations

Run	Constant Pit Level during PHES	Upper Pond Option	Final Pit Head (m RL)
1	1000	No additional construction (TSF used)	963.0
2	940	No additional construction (TSF used)	925.2
3	1000	Fully lined upper pond over the OTD	967.1
4	940	Fully lined upper pond over the OTD	924.6
5	1000	Fully lined upper pond upstream of the OTD	966.0
6	940	Fully lined upper pond upstream of the OTD	924.8
7	940	Unlined upper pond upstream of the OTD	925.1

The fixed head level used for the 50-year PHES operation simulation has a larger effect on the final pit head level than the Upper Pond option. The two main reasons for this difference are:

- The low hydraulic conductivity values in the rock surrounding the pit result in low flows into the pit and a long response time to stresses; and
- The constantly full pit scenario results in more fully saturated elements near the pit, which increases relative hydraulic conductivity of the pit walls and pit inflows. The relatively course vertical discretisation of 30 m may lead to single layer, saturation changes disproportionately impacting small scale simulation results.

An analysis of the rate of loss out of the unlined upper pond has been completed for the 50 years of simulated PHES operation using a Zone Budget limited to the pond footprint. The total budget for the constant head nodes representing the unlined pond had a volume of 3.8E6 m^3, corresponding to about 76,000 m^3/year (or 76 ML/year).

5.1.1.4 Predictive Simulation 4: Particle Tracking and Contaminant Transport (2021-2271)

5.1.1.5 Particle Tracking

A particle tracking and contaminant mass transport simulation was conducted due to concerns about the potential migration of COPC from the OTD toward offsite receptors. To simulate long term potential impacts, particle tracking analysis was based upon the results of predictive Simulation 3. Particle tracking analysis produces lines that follow the direction of groundwater flow from a starting point to a future location, and can be useful for identifying potential contaminant transport pathways. Particle path lines over a 250-year simulation were generated for each of the 7 long term PHES scenarios shown in Table 5-1.

Path lines were found to be similar for all seven scenarios, with flow trending southward and converging in a zone of high hydraulic conductivity at the base of the OTD (Figure 5-3). The high hydraulic conductivity zone controlling local flow patterns, trends in a north-south direction west of the Giant Pit and, extends from the OTD to the southern edge of the DSA. The furthest distance any particle travelled from the edge of the OTD was a lateral distance of 300 m. Vertically, the particles generally shifted downwards as they travelled south, following the trend of the water table.

5.1.1.6 Random Walk Particle Tracking and Contaminant Transport Simulations

Particle tracking is used to identify dominant flow directions described by the process of advection. However, particle tracking does not include the random diffusion and dispersion effects that are fundamental components of numerical simulations of contaminant mass transport. Diffusion describes the process of mass transport resulting from random mixing of solutes in fluid, while dispersion describes solute spreading due to small scale heterogeneity and preferential pathways.

In heterogeneous, fractured rock aquifers, the dispersive effect of small-scale heterogeneity is expected to be very large. The random component is calculated based on the same diffusion and dispersion parameters that control the solution of mass transport simulations. As particle numbers become very high, the random walk particle density approaches the solution of the advection dispersion equation (ADE). At lower numbers of particles, the random walk approach can provide the same insights to mass transport pathways as numerical transport simulations at considerably lower computational cost. A random walk simulation was run with the same seed locations as the particle tracking analysis, but with 24 particles per location and a molecular diffusion value of $1E^{-9} m^2/s$, longitudinal dispersity of 5 m, lateral dispersity of 0.5 m and a porosity of 0.3.

The results are presented in Figure 5-4 and show the likely flow paths of COPCs are from the OTD into the north-south, high hydraulic conductivity feature, and then east towards the Giant Pit. The high hydraulic conductivity feature contains a large density of particles that have not entered the pit after 250 years. It is uncertain whether a change in groundwater condition post the 250 years modelled would impact these particles and whether a proportion of particles would continue traveling south along the high hydraulic conductivity zone under different stress conditions after 250 years (Figure 5-4).

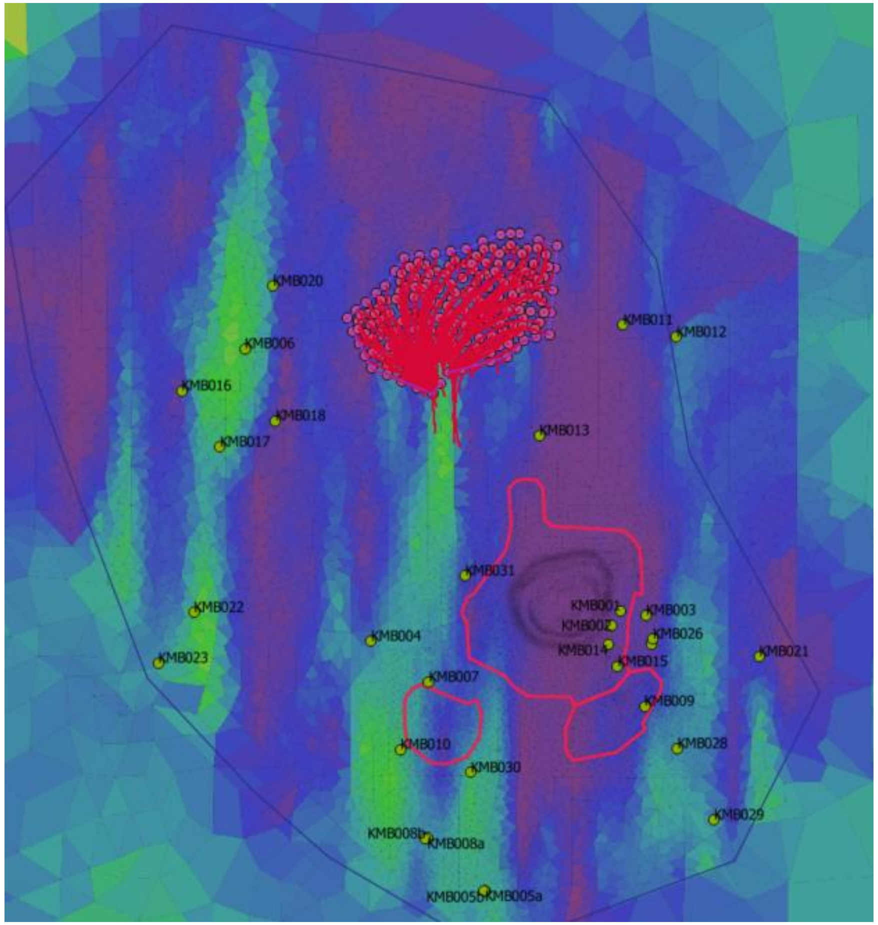

Figure 5-3: Particle Tracking Path Lines over 250 Years for Seven PHES Scenarios

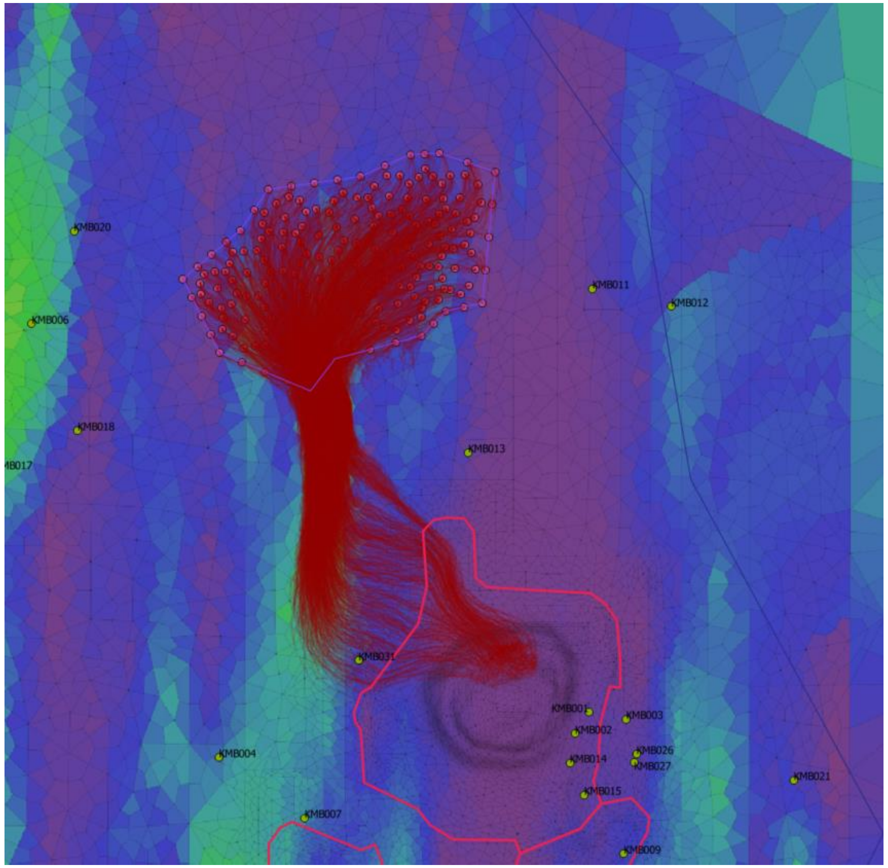

Figure 5-4: Random Walk Particle Tracking Path Lines over 250 Years for Seven PHES Scenarios

5.1.1.7 Numerical Simulation of Mass Transport

As part of the scope of work, a mass transport simulation was run for 250 years by adding a mass transport component to the scenarios of predictive Simulation 3 listed in Table 5-1. The initial concentration of a typical COPC was defined as 500 mg/L at nodes inside the OTD and 50 mg/L elsewhere. Nodes along the base of the OTD that were used as release locations for the particle tracking, were defined as constant concentration boundary conditions of 500 mg/L. Parameters for diffusion, dispersion and porosity remained unchanged from the random walk simulation. The coupled, transient flow, and transport simulation had the same spatial and temporal discretisation and stresses as the previously run flow Simulation 3.

The contour lines of simulated COPC concentration at the end of the 250-year simulation are shown on Figure 5-5. The contour intervals were selected to omit the confusing effects of numerical errors near the edges of the OTD and are superimposed on the random walk particle tracking solution. The contours of the mass transport simulation support the same conclusions as the random walk simulation. A plot of the plume migration after 10 years and 100 years is presented in Appendix C on Figures 11 and 12 respectively.

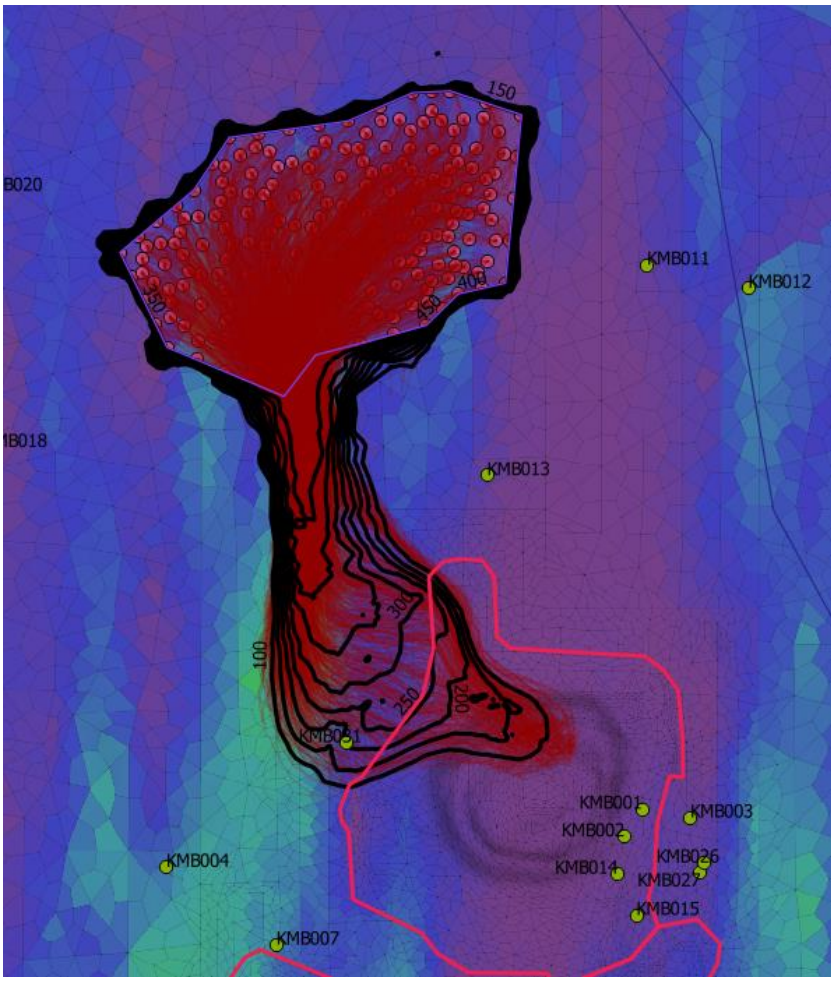

Figure 5-5: Coupled, Transient Flow, and Transport Simulation for 7 PHES Scenarios

Groundwater flowpaths within the mine lease are captured by Giant Pit's inward hydraulic gradient for the duration of the simulation. However, it is noted that localised spikes recorded at KMB011 and KMB012 are not reflected in the model. It is understood that the COPC concentrations recorded at these wells are a result of migration from the leachate pond located at the toe of the OTD, rather than originating from vertical migration from the base of the OTD.

In case of stormwater events, it is expected that the leachate pond may overflow, and that leachate may migrate downstream, before percolating into the ground and reaching perched lenses (as recorded at KMB011 and KMB012 bores).

5.1.2 Results of the Geochemical Simulation

The mixing of various source waters has been qualitatively simulated to produce a uniform water body in the Kanmantoo Giant Pit (lower pond). The source waters include groundwater, surface water and treated and untreated RWS water.

Average and worst-case values (Scenarios 1, 1a, 2, 2a and 3, 3a) for the input parameters are presented in Tables 4.1 to Table 4.6 of EHS geochemistry simulations presented Appendix D.

For the initial Scenarios 1 and 1a, groundwater and River Murray water contribute to the exceedances of GMO values. In Scenarios 2 and 2a, RWS water becomes the dominant component and is responsible for the exceedances of GMO values. Treatment of RWS water for Scenarios 3 and 3a does increase pH and lower concentrations of manganese and iron to below the GMO values. However, the contribution of aluminium from groundwater and River Murray water means that these scenarios still exceed the GMO value (Table 5-2).

Results for the modelled scenarios (summarised below) are presented in Table 5-2, for:

- **Scenario 1 (lower pond average quality) & 1a (lower pond worst-case quality)** – groundwater, River Murray 50% and Mount Barker water 50%;
- **Scenario 2 (average quality for RWS) & 2a (worst-case quality for RWS)** - groundwater, untreated RWS 4GL, River Murray 50% and Mount Barker water 50%; and
- **Scenario 3 & 3a (similar to 2 & 2a with treated RWS)** - groundwater, treated RWS 4GL, River Murray 50% and Mount Barker water 50%.

Table 5-2: Summary of Scenarios and Water Quality [1]

Scenario	Source Water	% of total volume	Analytes Exceeding GMO [2]	GMO Values
1	Groundwater mean quality River Murray mean quality Mt Barker mean quality	4 48 48	Aluminium (0.75 mg/L)	0.13 mg/L
1a	Groundwater maximum quality River Murray mean quality Mt Barker mean quality	4 48 48	Aluminium (0.90 mg/L) Cobalt (0.80 mg/L) Copper (0.30 mg/L) Iron (30 mg/L) Manganese (5.3 mg/L) Nickel (0.18 mg/L)	0.13 mg/L 0.14 mg/L 0.031 mg/L 11 mg/L 3.7 mg/L 0.1 mg/L

Scenario	Source Water	% of total volume	Analytes Exceeding GMO [2]	GMO Values
2	Groundwater mean quality River Murray mean quality Mt Barker mean quality RWS untreated	4 10 10 76	Aluminium (1.26 mg/L) Cobalt (0.60 mg/L) Copper (4.84 mg/L) Iron (22 mg/L) Manganese (4.4 mg/L) Nickel (0.39 mg/L) pH (5.5)	0.13 mg/L 0.14 mg/L 0.031 mg/L 11 mg/L 3.7 mg/L 0.1 mg/L 6.0-8.5
2a	Groundwater maximum quality River Murray mean quality Mt Barker mean quality RWS untreated	4 10 10 76	Aluminium (1.41 mg/L) Cobalt (1.30 mg/L) Copper (5.11 mg/L) Iron (48 mg/L) Manganese (9.3 mg/L) Nickel (0.55 mg/L) pH (5.47)	0.13 mg/L 0.14 mg/L 0.031 mg/L 11 mg/L 3.7 mg/L 0.1 mg/L 6.0-8.5
3	Groundwater mean quality River Murray mean quality Mt Barker mean quality RWS treated	4 10 10 76	Aluminium (0.16 mg/L) Cobalt (0.60 mg/L) Copper (4.84 mg/L) Nickel (0.39 mg/L)	0.13 mg/L 0.14 mg/L 0.031 mg/L 0.1 mg/L
3a	Groundwater maximum quality River Murray mean quality Mt Barker mean quality RWS treated	4 10 10 76	Aluminium (0.31 mg/L) Cobalt (1.30 mg/L) Copper (5.11 mg/L) Iron (29 mg/L) Manganese (5.3 mg/L) Nickel (0.55 mg/L)	0.13 mg/L 0.14 mg/L 0.031 mg/L 11 mg/L 3.7 mg/L 0.1 mg/L

Notes:

1 Detailed simulations results are presented in Appendix D.

2 It is noted that exceedance against the GMO are expressed as reference only as the modelling results indicate that pit acts as a sink over the entire modelling period and therefore does not affect the regional aquifers.

In order to protect the concrete infrastructure of the PHES, it is recommended in AS2159 (2009[1]) that chloride and sulphate should be less than 6,000 mg/L and 1,000 mg/L respectively and pH greater than 5.5.

Table 5-3 summarises the values of pH, chloride and sulphate from the scenarios with a comparison against the AS2159 guideline values. This comparison demonstrates a low risk of concrete degradation associated with contact to the project waters. However, the pH values from Scenarios 2 and 2a do potentially present a corrosive source. This is related to the use of untreated acidic RWS (pH 4.05) water in these two scenarios.

Table 5-3: Potentially Corrosive Analytes

Parameters	Buildings and Structures AS2159 (2009) concentrations	Scenario					
		1	1a	2	2a	3	3a
pH	>5.5	6.49	6.45	**5.50**	**5.47**	6.28	6.13
Chloride mg/L	<6,000	197	441	456	700	456	700
Sulphate mg/L	<1,000	48	127	595	674	595	674

The source waters for the filling of Giant Pit (lower pond), to 5.2 GL or to 1,000 m RL, and their anticipated volume estimates are presented in Table 5-4.

Table 5-4: Summary of Volume Estimates (m^3) for Scenarios 1, 2 and 3

Scenario	Description	Total Volume	GW Volume	Murray Volume	Mt Barker Volume	RWS Volume
1	Groundwater volume 0 + River Murray 50% & Mt Barker 50% to achieve 5.09 GL	5,089,000	164,400	2,462,300	2,462,300	-
2	Groundwater volume 0 + RWS untreated 4GL + River Murray 50% & Mt Barker 50% to achieve 5.2GL	5,253,400	164,400	544,500	544,500	4,000,000
3	Groundwater volume 0 + RWS treated 4GL + River Murray 50% & Mt Barker 50% to achieve 5.2GL	5,253,400	164,400	544,500	544,500	4,000,000

5.2 Underground Mining Results

5.2.1 Groundwater Flow Predictions

The model was used to evaluate the following predictive simulations:

1. Baseline simulation covering the open pit activities until mid-2019, followed by recovery until late 2023.
2. Impact of underground and TSF at 1,266mRL
3. Particle tracking (2019-2021)

4. Mining activities, including underground development, followed by 250 years of natural recovery with no additional water added to the mine pit.
5. Mining activities, including underground development, followed by 250 years of natural recovery, with 4 GL of water added to the main pit between 2022 and 2024

5.2.1.1 Predictive Simulation 1 & 2: Baseline Simulation Covering The Open Pit Activities Until Mid-2019, Followed By Recovery Until Late 2023 & Impact Of Underground and TSF at 1,266mRL

Figure 5-6 shows the difference in water table elevation at 1/10/2023 between the simulation including underground mining and the simulation not including underground mining. As expected, there are substantial (> 200 m) decreases in the water table with the additional groundwater stress of underground mining.

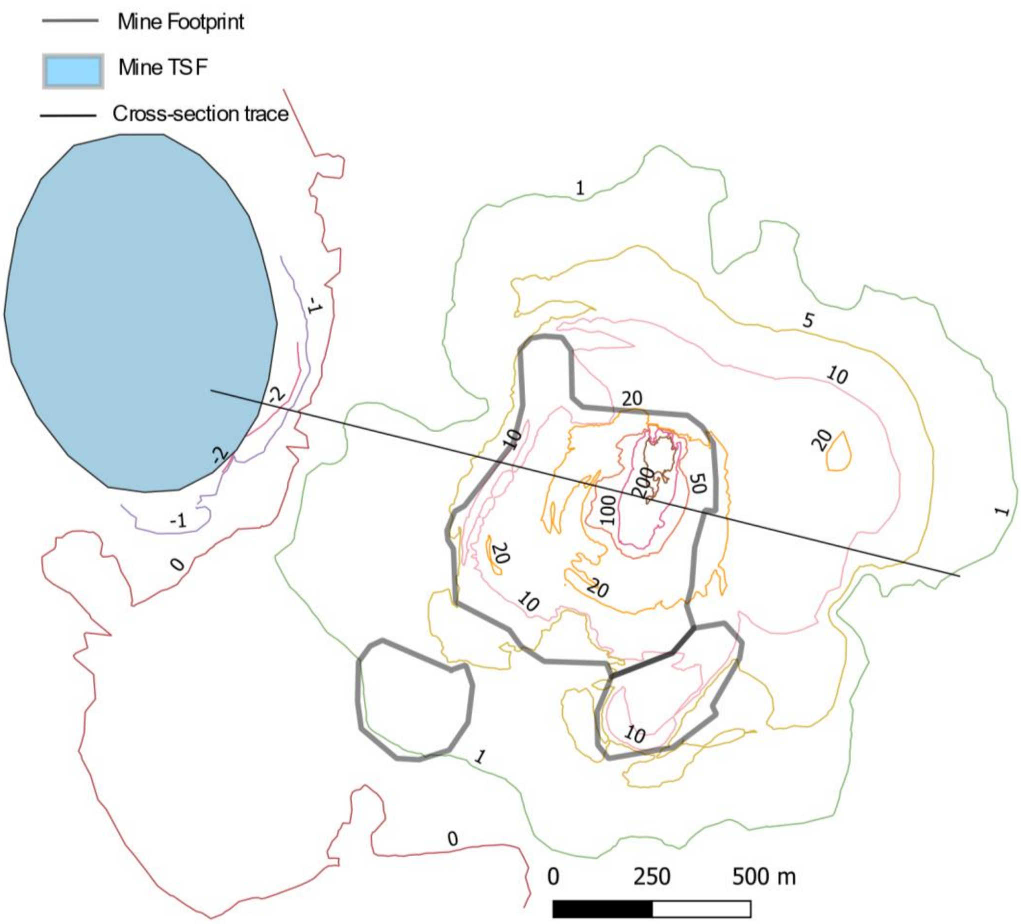

Figure 5-6: Difference in 2023 Water Table Elevation Between Simulations that Do and Do Not Include Underground Mining Groundwater Impacts

The groundwater head between the Simulations 1 & 2 (No UG, UG+TSF at 1,266mRL) are presented in Appendix C. The difference in groundwater head between Simulation 1 and 2 is presented in Figure 5-6 (above) and in Appendix C.

However, the large magnitude changes are predominantly laterally contained in the footprint of the open pit mine, so are likely to have no effect after the mine is filled prior to PHES operation. Outside the footprint of the open pit mine, the changes in water table elevation greater than 5m are largely to the east of the mine pit within 600 m of the edge of the pit wall and have a maximum magnitude of less than 25 m. The location of the change in water table elevation to the east of the pit coincides with a higher hydraulic conductivity zone east of the main pit shown in Figure 4-3 from the previous modelling report (Ref. 23).

A cross section of the 2023 water table from the simulation including underground mining and a 1,266m TSF is presented in Figure 5-7.

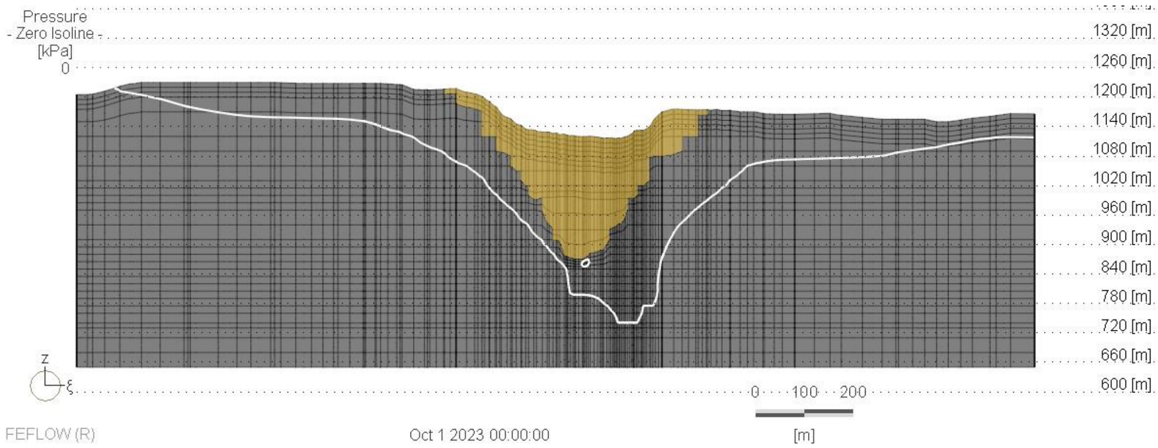

Figure 5-7: Cross-Section Through Mine Showing October 2023 Water Table (Zero Pressure Line), After Underground Mining and Two Years Of Recovery. The Model Surface is the 2011 Land Surface, and the Yellow Zone the Final 2019 Pit Development

The inward gradient and “sink” type behaviour identified in the previous model remains valid with the underground scenarios modelled.

The effect of increasing the TSF elevation from the baseline 1,258m to 1,266m to account for additional material from underground mining causes up to a 2m increase in water table level outside the TSF perimeter on the south east side of the TSF. The increase on the eastern side of the TSF is due to the damming effect and is presented in Figure 73, Appendix C.

These scenarios demonstrate that over time, water table around the TSF can locally reach ground surface on the eastern edge of the TSF embankment. The drainage of the TSF and the removal of the liner is understood to reduce the damming effect modelled in this scenario.

5.2.1.2 Predictive Simulation 3: Particle Tracking (2019 – 2021)

Particle tracking was conducted due to concerns about the potential migration of COPC from the TSF toward offsite receptors if the liner were to breach. To simulate long term potential impacts, particle tracking analysis was based upon the results of Simulation 3. Particle tracking analysis produces lines that follow the direction of groundwater flow from a starting point underneath the liner to a future location and can be useful for identifying potential contaminant transport pathways should the liner fail. Particle path lines were simulated, starting in 2013 and traveling to the end of the simulation, using an effective porosity of one to two orders of magnitude higher than that obtained during the calibration of the previous model to speed up the advection velocity.

Without artificially accelerating the process, the distance traveled by the particles between 2019 and 2023 would be too small to be visible on the model output. Under this scenario, some particles are heading towards the creek, some heading towards the pit and some really not moving (Figure 74, Appendix C). For the particles that are not ending in a boundary condition (i.e. most of them), the flow rate is almost nil at those locations and the particles stop in unsaturated elements with no real flow and connectivity to groundwater.

It is important to note that the particle tracking scenario was run to assess the impact of potential migration of COPC on the surrounding groundwater and receptors, would the TSF liner fail and remain undrained for an extensive period (well beyond the proposed closure timeframe developed by HGO and PSM).

In the event of a failure of the liner, there would be the potential for the driving head in the TSF tailings to begin the long-term process of transporting COPC into the groundwater system. Although it is unlikely that the liner will fail, the draining of the tailings upon closure of the TSF will greatly reduce the head pressures and the risk of transporting contaminants into the regional groundwater regime. As noted above most of these particles would stop or be directed towards the pit sink.

5.2.1.3 Predictive Simulation 4 & 5: Mining Activities, Including Underground Development, Followed by 250 Years of Natural Recovery With No Additional Water Added to the Mine Pit. Mining Activities, Including Underground Development, Followed by 250 Years of Natural Recovery, with 4 GL of Water Added to the Main Pit Between 2022 and 2024

The simulated groundwater level changes due to mine development and the 250 year recovery period are presented at 10, 20, 50, 100, 150, 200, and 250 years post mining as:

- Maps of drawdown from the initial pre-2011 steady state simulation
- Cross section views of the simulated water table elevation
- Tables of drawdown values at point locations

Figure 5-8 shows drawdown contours from the 250-year post mining (2272) end of simulation along with the locations of the cross-section and point observations.

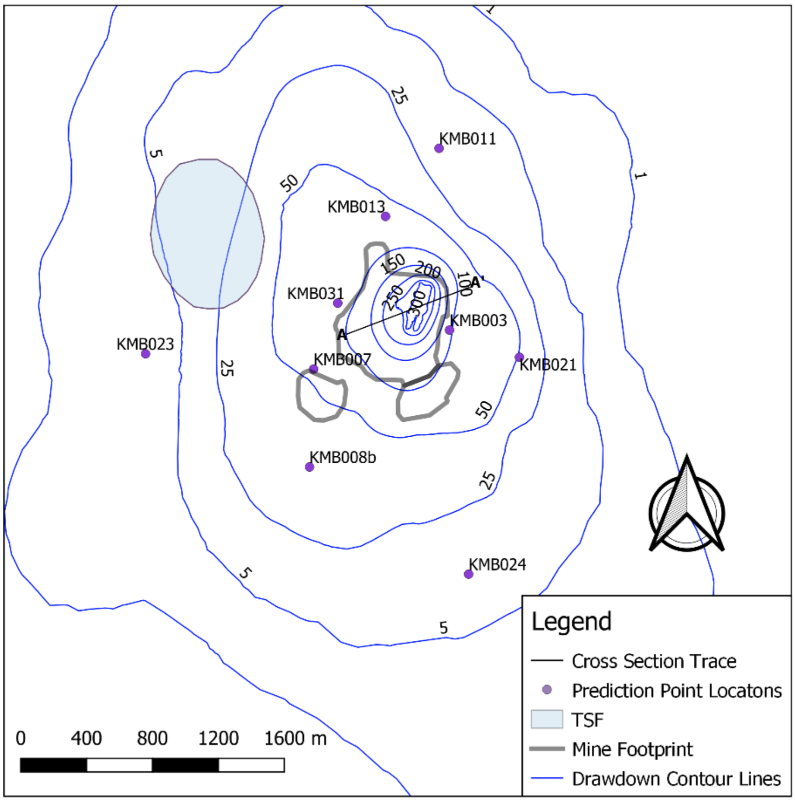

Figure 5-8: Simulation 4: 250 year Drawdown contours, Cross Section and Point Observation Locations

The zero-pressure surface (water table) is highly complex through most of the simulation due to the underground mine development. So spatial contour maps of drawdown from 2011 steady state conditions are based on hydraulic head values from a model slice (19) located at an elevation just below the base of open pit mining. Figure 5-9, Figure 5-10 and Appendix C show the drawdown contours for simulation 4 and 5 at 10, 20, 50, 100, 150, 200, and 250 years post mining, Appendix C also shows the water table elevation along the cross-section.

The contour plots (Figure 5-9 and Figure 5-10) show that the 1 m drawdown impact from the mine dewatering remain within approximately 4 km radius of the mine pit. The 5 m drawdown impact remains within 2 km of the pit. The drawdown contours and cross-section images show that the recovery from mine dewatering is predicted to be very slow with substantial desaturation due to underground mine development persisting after 250 years of recovery. The calibrated hydraulic conductivity values in the area of underground mining are all very low (~10^{-9}-10^{-10}m/s). Low hydraulic conductivities result in predictions of low rates of groundwater inflow during mine development and very slow groundwater recovery.

To quantitatively assess the uncertainty in the drawdown predictions shown in the contour plots, Simulation 5 was run with six alternative parameter sets from the calibration-constrained parameter uncertainty analysis described in (Ref 23) The predictive simulations required more than 24 hours to run and due to the large output file size application of cloud computing was difficult.

Six alternative parameter sets were feasible to run on local computers and were selected based on the results of the original simulations of open pit mine development and recovery. The simulation of open pit development and recovery described in Mining One's report (Ref. 23) was conducted with 50 alternative parameter sets. The three parameter sets leading to both the highest and lowest predicted pit recovery were selected for use in these long running simulations of underground mine development and recovery. Simulated drawdown at locations shown on Figure 5-8 for both simulation 4 and 5 are listed in Table 5-5. To assess the uncertainty in the drawdown predictions, the maximum and minimum drawdowns obtained from the five alternative parameter simulation 5 are also listed in Table 5-5.

The uncertainty in drawdown predictions can be assessed by looking at the difference in maximum and minimum predicted drawdown values at point locations with the 6 alternative parameter scenarios listed in Table 5-5. Larger drawdown predictions tend to have larger ranges of uncertainty, while lower drawdown predictions have lower ranges of uncertainty. For groundwater impact predictions, this uncertainty analysis indicates that the simulated, large magnitude, dynamic changes in water level near the mine pit are considerably uncertain. However, the lower magnitude predictions of the extent of groundwater impact (1m and 5m contours of predicted groundwater drawdown) are better constrained by observation data and useful for decision making. Drawdown impacts to any receptors more than 4 km from the pit are likely to be less than 1 m.

It is important to note that the excess drawdown associated with the underground would not occur if the underground was flooded by the PHES or by possibly placing the RWS waters into the pit once mining and tailings production ceases (if the PHES did not proceed).

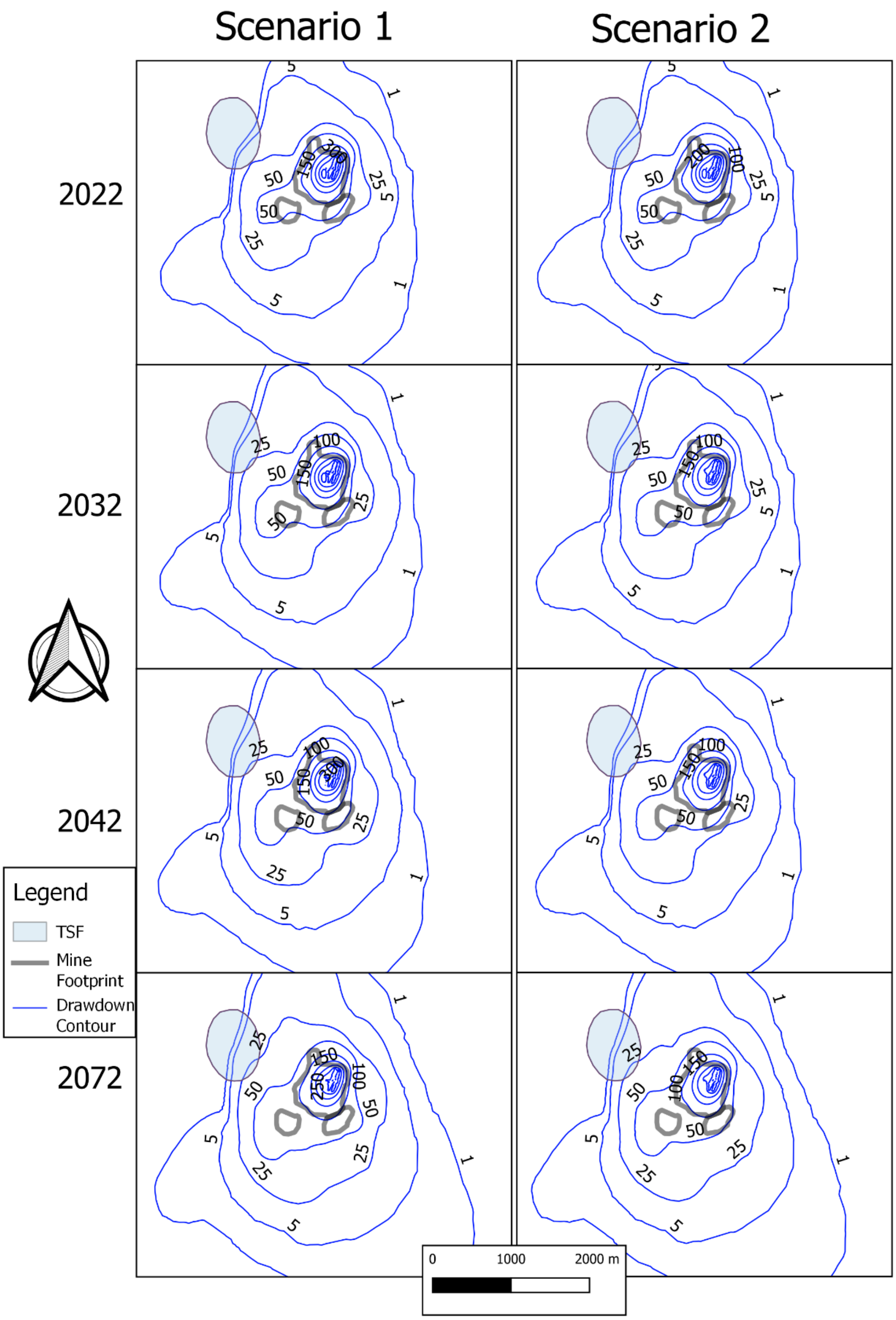

Figure 5-9: Drawdown in the First 50 Years Post Mining

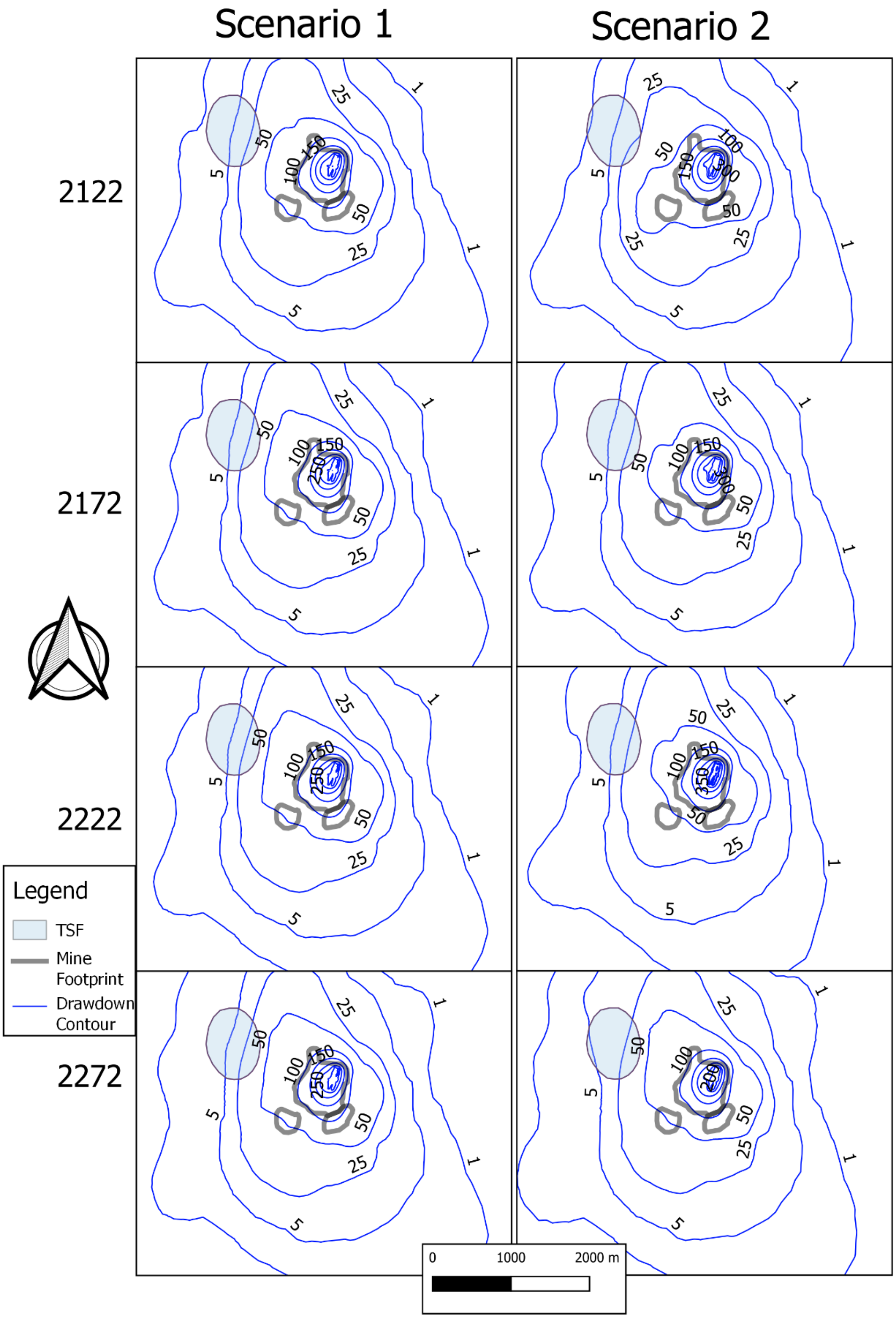

Figure 5-10: Drawdown 100-250 Years Post Mining

Table 5-5: Point Drawdown Observations

Location	Time	Scenario 1	Scenario 2	Scenario 2 Max	Scenario 2 Min
KMB003	1/05/2022	131.4	131.4	155.0	45.9
	1/05/2032	131.8	92.3	112.3	34.8
	1/05/2042	122.0	94.3	112.9	35.5
	1/05/2072	131.1	110.8	129.0	37.9
	1/05/2122	153.6	132.1	136.7	41.4
	1/05/2172	153.9	133.6	144.5	115.6
	1/05/2222	155.1	134.8	146.2	116.3
	1/05/2272	155.2	135.9	150.4	121.8
KMB007	1/05/2022	72.6	72.6	72.6	11.0
	1/05/2032	72.9	70.8	70.8	13.8
	1/05/2042	71.8	70.0	70.0	13.8
	1/05/2072	73.2	71.7	71.7	15.9
	1/05/2122	61.0	69.3	69.3	18.0
	1/05/2172	61.2	57.5	57.5	20.1
	1/05/2222	61.8	58.0	58.0	21.7
	1/05/2272	61.9	58.7	58.7	23.3
KMB008B	1/05/2022	34.3	34.3	34.3	6.7
	1/05/2032	42.2	42.5	42.5	6.8
	1/05/2042	45.1	43.6	43.6	7.0
	1/05/2072	52.9	51.1	51.1	8.4
	1/05/2122	44.1	48.8	48.8	10.1
	1/05/2172	42.5	40.0	40.0	12.0
	1/05/2222	42.4	40.1	40.1	13.5
	1/05/2272	42.5	40.2	40.2	15.3
KMB011	1/05/2022	1.6	1.6	2.0	0.9
	1/05/2032	1.8	1.7	2.0	1.0
	1/05/2042	1.9	1.8	2.2	1.0
	1/05/2072	2.6	2.5	2.5	1.0
	1/05/2122	3.6	3.1	4.4	1.1
	1/05/2172	3.8	3.8	4.8	1.1
	1/05/2222	4.2	4.2	4.9	1.2
	1/05/2272	5.5	6.0	8.0	1.3
KMB013	1/05/2022	34.3	34.3	35.1	14.4
	1/05/2032	34.7	29.5	29.5	13.0
	1/05/2042	33.2	29.5	29.5	13.3
	1/05/2072	32.5	30.4	35.0	15.7
	1/05/2122	60.2	41.1	56.6	17.6
	1/05/2172	61.4	56.1	59.2	18.4
	1/05/2222	61.9	58.0	59.4	19.6
	1/05/2272	62.3	59.5	59.6	21.0
KMB021	1/05/2022	11.2	11.2	13.6	1.0
	1/05/2032	12.0	11.3	17.5	1.1

Location	Time	Scenario 1	Scenario 2	Scenario 2 Max	Scenario 2 Min
	1/05/2042	14.5	12.4	17.9	1.4
	1/05/2072	22.9	18.5	30.9	2.7
	1/05/2122	49.3	42.0	42.0	6.4
	1/05/2172	49.4	43.4	43.4	12.6
	1/05/2222	50.2	44.6	44.6	26.6
	1/05/2272	50.5	45.4	45.4	31.1
KMB023	1/05/2022	-2.6	-2.6	-0.7	-3.2
	1/05/2032	-3.1	-3.1	-0.1	-3.1
	1/05/2042	-1.5	-2.9	0.0	-2.9
	1/05/2072	0.2	0.0	1.4	-0.7
	1/05/2122	2.7	2.5	2.5	-0.5
	1/05/2172	2.9	3.5	3.5	-0.4
	1/05/2222	3.2	3.7	3.7	-0.2
	1/05/2272	3.8	4.3	4.3	0.2
KMB024	1/05/2022	4.2	4.2	4.2	0.5
	1/05/2032	4.9	4.6	4.6	0.7
	1/05/2042	6.2	4.7	4.7	0.9
	1/05/2072	13.1	10.9	10.9	1.8
	1/05/2122	14.7	12.2	12.2	1.9
	1/05/2172	14.7	13.0	13.7	2.0
	1/05/2222	14.3	13.1	13.9	6.5
	1/05/2272	14.3	13.1	14.7	7.1
KMB031	1/05/2022	48.4	48.4	56.2	24.9
	1/05/2032	54.4	46.9	50.7	26.0
	1/05/2042	53.8	47.3	48.4	26.4
	1/05/2072	57.6	54.0	54.0	28.3
	1/05/2122	70.6	60.1	60.1	31.3
	1/05/2172	72.3	66.8	66.8	34.7
	1/05/2222	73.9	69.0	69.0	40.0
	1/05/2272	74.3	71.5	71.5	42.0

5.2.1.4 Water Budget and Mine Inflows

The model water budget at the initial Pre-2011 conditions and during the simulation of open pit mining is discussed in (Ref 23). During the 2020-2022 simulation of underground development, the cumulative inflow volume into the underground mine is shown in Table 5-6. Due to the very low hydraulic conductivity around the underground mine, the simulated groundwater inflow is small. The underground mine development is deeper than any of the open pit mine development and associated historic groundwater stress and observation used in the model calibration. So, the hydraulic conductivity of the regions close to the underground development is likely subject to greater uncertainty than the regions of model close to the pit, and predicted flow into the underground mine likely has higher uncertainty than predictions of inflow into the open pit.

Table 5-6: Underground Mine Inflow Volumes

Underground Mine Phase	Start Time	End Time	Cumulative Inflow Volume m^3
OB2	1/11/2019	1/05/2020	9
OB3U	1/05/2020	1/11/2020	193
OB3L	1/11/2020	1/05/2021	278
OB9	1/05/2021	1/11/2021	380
OB10	1/11/2021	1/05/2022	459

5.2.1.5 Pit Lake Water Level and Volume

The water level, volume and flows into the open pit during the recovery period are listed in Table 5-7 for both scenarios. In simulation 4, where no additional water was added to the pit, the water level recovers to approximately 895.6 RL within 50 years post mining and remains relatively constant for the entire 250-year recovery period. In simulation 5, where 4GL of water was added the pit, the water level rises to

93 m depth in the first few years post mining and remains around 929.0 RL for the rest of the 250-year recovery period.

Table 5-7: Mine Pit Recovery Level and Volume

Time	Pit Lake Depth				Volume (1000m^3)			
	Sc. 1 Base	Sc. 2 Base	Sc. 2 Max	Sc. 2 Min	Sc. 1 Base	Sc. 2 Base	Sc. 2 Max	Sc. 2 Min
1/05/2022	0.0	0.0	0.1	0.0	0.01	0.01	0.02	0.01
1/05/2032	0.1	93.0	93.0	60.4	0.47	1339.93	1339.94	671.30
1/05/2042	29.5	93.0	93.0	62.9	98.02	1339.94	1339.94	722.49
1/05/2072	58.9	92.4	93.0	70.1	639.12	1328.41	1339.94	869.03
1/05/2122	59.5	92.4	93.0	70.5	653.14	1326.90	1339.92	878.08
1/05/2172	59.6	91.4	93.0	70.4	653.35	1306.71	1339.91	877.07
1/05/2222	59.6	91.4	93.0	70.4	653.67	1306.57	1339.90	875.27
1/05/2272	59.6	91.4	93.0	70.3	654.16	1306.47	1339.94	873.09
Time	**Recharge in (m^3/d)**				**Evaporation out (m^3/d)**			
	Sc. 1 Base	**Sc. 2 Base**	**Sc. 2 Max**	**Sc. 2 Min**	**Sc. 1 Base**	**Sc. 2 Base**	**Sc. 2 Max**	**Sc. 2 Min**
1/05/2022	9.53	9.53	10.94	8.87	0.10	0.11	0.12	0.08
1/05/2032	9.53	9.53	10.94	8.87	0.15	140.22	140.22	86.69
1/05/2042	9.53	9.53	10.94	8.87	37.81	140.22	140.22	90.34
1/05/2072	9.53	9.53	10.94	8.87	84.32	139.25	140.22	101.17
1/05/2122	9.53	9.53	10.94	8.87	85.35	139.12	140.22	101.83
1/05/2172	9.53	9.53	10.94	8.87	85.37	137.42	140.22	101.68
1/05/2222	9.53	9.53	10.94	8.87	85.39	137.40	140.22	101.62
1/05/2272	9.53	9.53	10.94	8.87	85.43	137.40	140.22	101.46

5.2.1.6 Particle Tracking and Contaminant Transport Risk

Random walk particle tracking was conducted to assess contaminant transport risk from the historical OTD and to determine whether the pit will act as a groundwater sink and capture all contaminants migrating from the OTD. Initial particle tracking was conducted on the simulation 5 using the base calibrated model parameters. Five different particle tracking simulations were run based on the differing values of porosity and dispersivity listed in Table 5-8. Twenty four particles were seeded at each of the nodes on the base of the OTD.

Table 5-8: Random Walk Particle Tracking Settings

Simulation Name	Porosity	Molecular Diffusion	Longitudinal Dispersivity	Lateral Dispersivity
Base	0.3	1.00E-09	5	0.5
1	0.1	1.00E-09	5	0.5
2	0.05	1.00E-09	5	0.5
3	0.05	1.00E-09	100	10
4	0.05	1.00E-09	50	5

Figure 5-11 shows the results of the particle tracking simulations. All predictive simulations indicate that the pit will continue to act as a groundwater sink into the future. Particle tracking with a range of reasonable parameter values shows that the pit is likely to capture contaminants due to historic mining. Further exploration of the particle tracking uncertainty included running the particle tracking simulation with the results of three alternative flow model parameter simulations with the transport settings of simulation 3 in Table 3-1. Results of the four particle tracking simulations (including the results of the Base parameter set) are shown on Figure 5-12. Particles do not move away from the mine pit during any of the 250 year contaminant transport simulations.

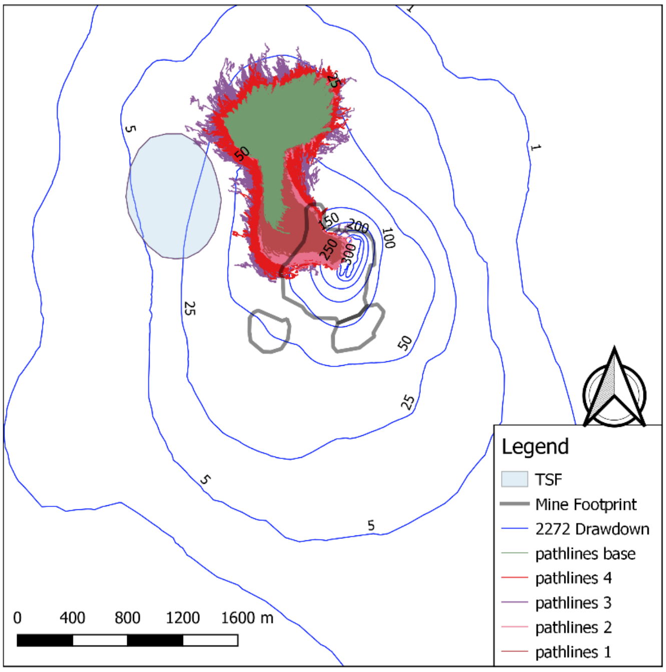

Figure 5-11: Scenario 5 Particle Tracking Results

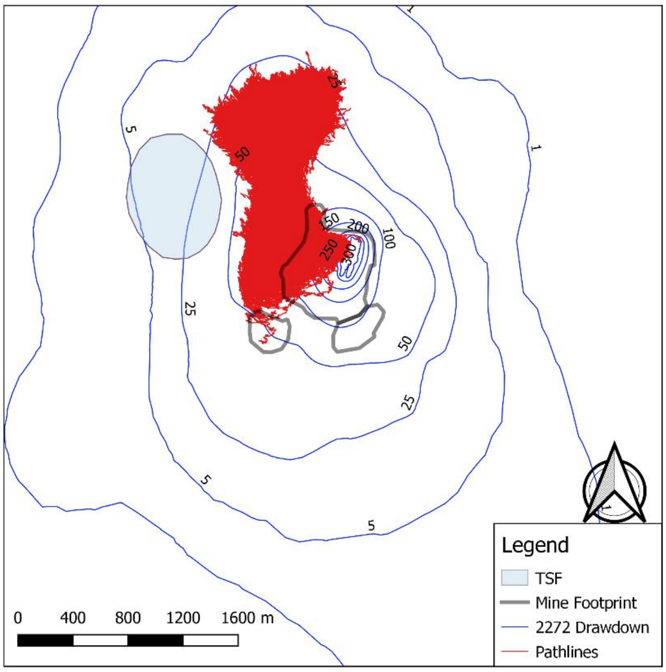

Figure 5-12: Scenario 2 Particle Tracking Results

5.2.2 Results of the Geochemical Simulation

The mixing of source waters has been qualitatively simulated to produce a water body in the Kanmantoo MP. The source waters include groundwater, evaporated pit water and untreated RWS water.

For the initial Scenarios 1 and 1a, recovering groundwater and evaporated pit water contribute to exceedances of GMO values. In Scenarios 2 and 2a, RWS water becomes the dominant component and is responsible for the exceedances of GMO values.

Results for the modelled scenarios summarized below are presented in Table 5-9.

- **Scenario 1 (average groundwater concentrations) & 1a (maximum groundwater concentrations)** – groundwater recovery
- **Scenario 2 (average groundwater concentrations) & 2a (maximum groundwater concentrations)** – groundwater recovery, untreated RWS 4GL (between Year 0 and 5)

Table 5-9: Summary of Scenarios and Water Quality

Scenario	Source Water	Volume Year 2272 (m3)	Analytes Exceeding GMO Values	GMO Values (mg/L)
1	Groundwater mean quality	654,163	Aluminium (0.39mg/L)	0.13
			Cobalt (2.49mg/L)	0.14

Scenario	Source Water	Volume Year 2272 (m3)	Analytes Exceeding GMO Values	GMO Values (mg/L)
	Evaporated pit water		Copper (0.33mg/L)	0.031
			Iron (107mg/L)	11
			Manganese (13mg/L)	3.7
			Nickel (0.48mg/L)	0.1
1a	Groundwater maximum quality Evaporated pit water		Aluminium (5.67mg/L)	0.13
			Cadmium (0.04mg/L)	0.009
			Cobalt (26.31mg/L)	0.14
			Copper (10.09mg/L)	0.031
			Iron (1,019mg/L)	11
			Manganese (186mg/L)	3.7
			Mercury (0.0004mg/L)	0.0003
			Nickel (6.06mg/L)	0.1
			Zinc (1.94mg/L)	0.94
			pH (5.04)	between 6 and 8.5
			Total nitrogen (65.24mg/L)	21.8
			Total phosphorus (25.66mg/L)	3.82
2	Groundwater mean quality Evaporated pit water RWS untreated	1,306,468	Aluminium (0.39mg/L)	0.13
			Cobalt (2.44mg/L)	0.14
			Copper (0.32mg/L)	0.031
			Iron (105mg/L)	11
			Manganese (12.72mg/L)	3.7
			Nickel (0.47mg/L)	0.1
2a	Groundwater maximum quality Evaporated pit water RWS untreated		Aluminium (5.56mg/L)	0.13
			Cobalt (25.82mg/L)	0.14
			Copper (9.9mg/L)	0.031
			Iron (1,000mg/L)	11

Scenario	Source Water	Volume Year 2272 (m3)	Analytes Exceeding GMO Values	GMO Values (mg/L)
			Manganese (182mg/L)	3.7
			Nickel (5.94mg/L)	0.1
			Zinc (1.9mg/L)	0.94
			Total phosphorus (25mg/L)	3.82
			pH (5.04)	between 6 and 8.5

Note: Detailed simulations results are presented in Appendix D.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Groundwater Flow and Transport Model

This numerical groundwater modelling project was conducted to aid decision-making and support a groundwater impact assessment of the proposed PHES operation by providing quantitative estimates of groundwater levels around the Giant Pit, both pre- and post-operation. Additionally, predictions of pore pressure and infiltration rate variations due to rapid drawdown associated with the scheme were made. Particle tracking and transport modelling was required to determine whether the rapid drawdowns and changes in local flow systems could mobilise contaminants associated with legacy mining at the OTD.

Four predictive simulations were conducted as part of the project. Simulations supporting PHES operation decision-making, such as initial post mining pit lake recovery and pressure levels, were run on alternative parameter sets to assess predictive uncertainty. Long term PHES operation and recovery levels were simulated with one parameter set. Assessment of predictive scenarios with multiple alternative parameter sets should be an area of future work, once the concept study for the PHES is finalised and pit level and groundwater recovery data is obtained (this information is required to assess which of the parameters set is matching the recovery curve with more accuracy). Similarly, the preliminary assessment of contaminant transport risk should be expanded in future work to consider several of the alternative parameter sets available. Both random walk particle tracking and full ADE simulation of mass transport were conducted with equivalent interpretations.

6.1.1 Summary of PHES Simulation Findings

6.1.1.1 Simulation 1 - Mining Activities, Final Giant Pit Design, and Pit Lake Recovery (2011 – 2021)

The predictive period for this scenario ranges from 2011 to 2021. From when mining finishes (to a pit level of about 836m RL), pit water level recovery was simulated by terminating all the fixed head boundary conditions used to simulate pit dewatering, which allowed hydraulic head levels in the pit to rise.

Giant Pit recovery levels in 2021 were calculated for each of the 50 parameter sets shown in Figure 5-1. A level of 866 m RL corresponding to the maximum count was considered for the pit volume calculations for the geochemical analysis.

The ranges of recoveries are presented in Figure 5-2. This chart plots the results of recovery post mining (May 2019) considering three of the 50 parameters sets (calibrated set, fast response parameters set and slow response parameters set). The pit level recovery at the end of 2021 is estimated to range between 852 m RL (slow parameter set) and 892 m RL (fast parameters set).

It is most likely that the recovery would be around 866 m RL but the above range could apply. It is noted that in the case of higher rainfall over the 2019 – 2021 period, recovery of the pit could exceed these values.

6.1.1.2 Simulation 2 - Giant Pit Filling with Water and Detailed Daily Rapid Drawdown due to PHES Operation (2021-2022)

In this predictive scenario, the proposed operation of the PHES scheme was simulated from 2021 to 2022.

The simulation was based on the scenario that in 2021, water will be pumped into the Giant Pit until head levels reach 1,000 m RL. At night, water will be pumped from the pit to the upper pond until levels drop to 940 m RL. During the day, pit levels will increase back to 1,000 m RL due to filling from PHES power generation.

Diurnal water level oscillations were represented by a sinusoidal curve which defined the fixed head boundary in the pit with a daily frequency and head range of 60 m. Initial conditions used the 2021 recovery levels from predictive simulation Scenario 1. The parameter set producing the highest and lowest 2021 pit lake recovery levels were selected as two alternative scenarios. Hydraulic head levels around the Giant Pit at the full (1,000 m RL) stage and the empty (940 m RL) stage after one year of simulation have been exported for both parameter sets and used as input for geotechnical modelling.

Daily operations have been simulated and only minor pore water pressure changes have been recorded under a rapid drawdown scenario. These have been incorporated into a 3D stress analysis, Completed by Mining One (Ref. 26).

6.1.1.3 Simulation 3 - Long Term Fifty-year PHES Operation and Two-hundred-year Recovery (2021-2271)

The third predictive scenario simulated 50 years of PHES operation from 2021 to 2071, followed by a 200-year recovery period. At the end of the 50-year PHES operational period, fixed head boundary conditions holding the pit level constant were removed. The initial linear increase from 2021 pit levels to 1,000 m RL was unchanged.

Evaporation from surface water in the Giant Pit during the 200 years of recovery was included in the model using well boundary conditions near the base of the pit.

To account for draining of the current TSF, the Cauchy boundary condition simulating leakage was removed after 50 years.

An analysis of the rate of loss out of the unlined upper pond has been completed for the 50 years of simulated PHES operation using a Zone Budget delimited to the pond footprint. The total budget for the constant head nodes representing the unlined pond had a volume of 3.8E6 m^3, corresponding to about 76,000 m^3/year (or 76 ML/year).

The impact to groundwater of a series of construction options for the Upper Pond were simulated (current TSF, OTD unlined, OTD lined, upstream OTD lined and unlined). Options were simulated using both the constantly full and constantly empty pit level scenarios. Construction of an unlined pond was only simulated under the constantly empty pit scenario to provide a conservative estimate of the impact on groundwater from pond leakage. Seven predictive scenarios were produced. Scenarios for 250-year pit level predictions show a minimal difference in final pit head levels between the Upper Pond options (Table 5-1).

According to the evaporation assumptions and the simulation results, the pit level varies between 925 m RL, considering an empty pit option (i.e., the level would drop from 940 to 925 m RL after 250 years), and 966 m RL, considering a full pit option (i.e., the level would drop from 1000 to 966 m RL after 250 years).

For both options, and under the current modelled evaporation scenario, the pit would continue to act as a general hydraulic sink for the next 250 years. A reduction in rainfall/evaporation ratio would lower the final pit lake level further. An increase of this ratio is expected to contribute to an increase in pit lake level recovery. However, considering the strong gradient observed at the end of the simulation, it is expected that the groundwater sink effect would be maintained.

It is therefore noted that the combined very slow recovery of the natural groundwater system (lower pond) and the lining of the upper pond reduces substantially the risk of having any significant impact from the PHES operations over the 2021-2071 period.

6.1.1.4 Simulation 4 - Particle Tracking and Contaminant Transport (2021-2271)

A particle tracking and contaminant mass transport simulation was conducted due to concern about the potential migration of COPC from the OTD toward offsite receptors. To simulate long term potential impacts, particle tracking analysis was based upon the results of predictive simulation 3.

Particle path lines over a 250-year simulation were generated for each of the 7 long term PHES scenarios shown in Table 5-1. Path lines were found to be similar for all 7 scenarios, with flow trending southward and converging in a zone of high hydraulic conductivity at the base of the OTD. The high hydraulic conductivity zone controlling local flow patterns trends in a north-south direction west of the Giant Pit and extends from the OTD to the southern edge of the DSA. The furthest distance any particle travelled from the edge of the OTD was a lateral distance of 300 m. Vertically, the particles generally shifted downwards as they travelled south, following the trend of the water table.

The contours of the mass transport simulation support the same conclusions as the random walk simulation, which is a capture of the OTD groundwater drainage COPCs by the steep hydraulic gradient towards Giant Pit.

However, it is noted that localised spikes recorded at KMB011 and KMB012 are not reflected in the model. It is understood that the COPC concentrations recorded at these wells are a result of migration from the leachate pond located at the toe of the OTD, rather than originating from vertical migration from the base of the OTD.

Generally speaking, groundwater flowpaths within the mine lease are captured by Giant Pit inward gradient for the duration of the simulation. In case of stormwater events, it is expected that the leachate pond may overflow, and that leachate may migrate downstream, before percolating into the ground and reaching perched lenses (as recorded at KMB011 and KMB012 bores).

6.1.2 Summary of Underground Mining Simulation Findings

6.1.2.1 Predictive Simulation 1, 2 & 3: Baseline simulation covering the open pit activities until mid-2019, followed by recovery until late 2023, Impact of underground and TSF at 1,266mRL & Particle Tracking (2019 – 2021

This numerical groundwater modelling was conducted to aid decision-making and to support a groundwater impact assessment of the proposed underground operation by providing quantitative estimates of groundwater levels around the Giant Pit and the TSF.

To evaluate the impact of underground mining on the surrounding groundwater and a long-term inward gradient identified in the 2018 model, the existing groundwater model was refined to represent underground mining and TSF level increase.

The simulations conducted included and excluded underground mining after open pit completion. The differences between these simulations are as follows:

- Water table decreases due to underground mining exceeding 25m are laterally contained within the existing mine footprint.

- Simulated water table changes due to underground mining outside the existing mine footprint are less than 25 m in magnitude, exceed 5 m only on the east side of the pit, and are contained within 800 m of the main pit.
- It is noted that recovery will commence upon cessation of mining. It is understood that mine inflow discharged, and waste rock placed into the pit will maintain the in-pit water above the water table until reconnection of the pit lake with groundwater. The waste going into the pit is likely to be PAF material but any chance to the chemistry of the in-pit water will not affect the surrounding groundwater because it will remain a long-term sink.
- Simulated increases in watertable due to the increase in final TSF levels are only 1-2 m and occur close to the TSF.
- Particle tracking shows that some groundwater flow paths under the TSF liner heads southward. If the liner were to break there would be some potential for some contaminant to flow towards the south. Draining the TSF on closure would significantly reduce the driving head of that unlikely scenario.

6.1.2.2 Predictive Simulation 4 & 5: Mining Activities, Including Underground Development, Followed by 250 Years of Natural Recovery With No Additional Water Added to the Mine Pit. And Mining Activities, Including Underground Development, Followed by 250 Years of Natural Recovery, With 4 GL of Water Added to the Main Pit Between 2022 and 2024

The predictions are highly influenced by the very low hydraulic conductivity in the model surrounding the pit and proposed underground mine phases. The model simulations predict localized drawdown with a 1m drawdown staying within approximately 4km of the pit through the 250 year simulation. A very slow recovery is also predicted with a large amount of desaturation due to underground activity still present after 250 years of recovery. Relatively low flow rates and small volumes are predicted for mine inflows, and all particle tracking shows capture of particles by the open pit even under a range of model flow and transport parameter values.

The injection of 4GL of the RWS into the pit reduces the groundwater drawdown by 5 to 20m for the bores situated directly adjacent to the pit. The impact of the top up is less noticeable for the bores situated away from the pit as a large portion of the make-up water is absorbed in priority by the unsaturated media around the pit.

The numerical model is predicting very strong hydraulic gradients in the area of the underground pits with up to 300m of change in hydraulic head in less than 20 lateral meters. The numerical model was refined in the area of the underground phases as part of this work; however it is recommended that any further work simulating underground mine development include a full rebuild of the numerical model mesh to improve the simulation stability with a 3D fully unstructured approach considered. The model parameterization used in the development of the model was designed to answer questions about the open pit mining and does not necessarily include enough parameterization in deeper parts of the model to fully explore the parameter uncertainty at the depth range of the underground mine development. It is recommended that further model development and recalibration phases include a fully three-dimensional spatially variable parameterization instead of the current approach of a two dimensional spatially variably field with multipliers applied in shallow and deep layers.

6.1.3 Recommendations

Future management recommendations include:

1. Pit level monitoring should be undertaken as soon as mining operations are terminated to identify the matching recovery curve and narrow down the likely levels and make up water requirements post-2021.
2. Ongoing water quality monitoring (groundwater wells and pit water) shall be undertaken to build up a post-dewatering dataset, informing the geochemistry response of the groundwater system to the recovery stress.
3. The transport model developed can be locally refined to further the understanding of the localised leachate migration from the leachate pond, should a detailed assess of closure and mitigation options for the OTD leachate pond be required.
4. It is also important to note that the simulation does not analyse any potential migration from sources other than the OTD (RWS or plant and facilities). Site specific modelling should be conducted to assess the potential risk and mitigation measures, if required. It is noted however that the TSF, RWS and all the plant ponds are fully lined and that these will be closed out before operating the PHES.

6.2 Geochemical Simulation

6.2.1 Summary of PHES Geochemical Simulation

Geochemical modelling has been used to explore the changes in water quality when different sources of water are mixed in varying volumes. RWS water, which is elevated in dissolved metals and has a low pH could be used for the PHES if commercially viable. If RWS water is being used, amendment with calcium hydroxide to increase pH (to within the GMO range) and reduce the solubility of metals is advised. Untreated and treated RWS water has also been used as a mixing water.

It is noted that the GMO was setup as a reference for comparison with regional groundwater values. Groundwater modelling shows that the pit is acting as a sink with an inward groundwater flow. Considering that the upper pond will be lined, it is understood that the local system will be functioning as a closed loop and is not expected to interact with the surrounding environment for the foreseeable future. Exceedances against the GMO are therefore only provided as a guidance for durability considerations.

6.2.1.1 Summary of Scenario Findings

The outcome of the geochemical modelling illustrates the influence the source waters have on the resulting chemistry of the mixed water. As summarised in Section 4.3.1, most water sources (except Mount Barker) report exceedances of metals in comparison to the GMO values. Treatment of waters reporting elevated metal concentrations and low pH, using calcium hydroxide may need to be considered.

This review has considered the amendment of RWS water using calcium hydroxide. However, it is evident that groundwater and River Murray water may also benefit from treatment using calcium hydroxide to lower aluminium, iron and manganese concentrations, increase pH and possibly enhance sorption potential to reduce the concentrations of cobalt, copper, nickel and zinc.

6.2.1.2 Potentially Corrosive Parameters (Ph, Chloride And Sulphate) Have Been Compared Against AS2159 (2009[1]) Guideline To Reduce The Risk Of Chemical Attack On Concrete. Scenarios 2 And 2a Which Use Untreated RWS Water Indicate Ph Values Which Could Potentially Cause A Deterioration Of Concrete. Recommendations

Future management recommendations include:

1. To support the future alkaline amendment, total acidity measurements should be added to the analytical suites for all source waters prior to the finalisation of the dosing rate.
2. Alkaline amendment should occur ex-situ of the Giant Pit. As part of the alkaline amendment, super-saturation and precipitation of minerals will occur. These mineral phases will require flocculation and removal to reduce the possibility of scaling of the PHES system and/or precipitation of mineral phases within Giant Pit.
3. It is assumed that the PHES is a closed loop scheme and although treatment of RWS is proposed to reduce metal solubility, other sources of water report elevated metal concentrations. Therefore, alkalinity amendment should be considered to all source waters.
4. If the proponent of the PHES decides to treat the RWS source as per geochemical simulations scenarios 3 and 3a, calcium hydroxide is proposed. Ex-situ alkaline amendment should comprise:
   - Calcium hydroxide dosing;
   - Preliminary dosing rate of 105 tonnes per GL water; and
   - Flocculation and removal of insoluble mineral phases (sludge).

It should be noted that the long-term water quality of the water body within Giant Pit after the cessation of the PHES, will be mainly controlled by the quality of the source waters used to make up the 5.1 GL water body volume (or 1,000 m RL). However, this report does not account for changes in water quality that can occur from side wall runoff. Acid rock drainage will continue to occur from the side walls into the water body and evaporation has the potential to increase the salinity of the water.

Long term evaporation and water losses in a case of an unlined upper pond may require supplementing the system on an annual basis. The supplement of fresh water will assist in maintaining the overall water quality elevated.

Hydrogeological modelling has demonstrated that Giant Pit will act as a groundwater sink for the foreseeable future and presents a low risk to surrounding groundwater quality.

6.2.2 Summary Underground Mining and recovery Geochemical Simulation

Geochemical modelling has been used to explore the changes in water quality when different sources of water are mixed in varying volumes.

6.2.2.1 Summary of Scenario Findings

The outcome of the geochemical modelling illustrates the influence the source waters have on the resulting mixed water chemistry. As summarised in Section 5.2 of Mining One's modelling report (Ref 23), groundwater and RWS water report exceedances of metals in comparison to the GMO values. The worst-case scenario using maximum values of groundwater are unlikely to be realised as these concentrations are reported from groundwater monitoring wells KMB010, KMB011 and KMB013, which are assumed to be outside the catchment zone and separated from the remaining wells by a groundwater divide The water quality signatures from these areas will be diluted by groundwater from other areas within the catchment zone which discharges to the GP. The water quality of each Scenario has been summarised in Table 5-9**,** which details the source waters and the analytes which exceed the GMO within each Scenario.

Hydrogeological modelling has demonstrated that the GP will act as a groundwater sink for the foreseeable future and presents a low risk to surrounding groundwater quality.

It is noted that the impact of draining the untreated RWD into the pit within the first 5 years post closure is negligible after 250 years of simulation, with eth exception of marginal concentration changes for some analytes.

It is noted that if the PHES is implemented and fresh water is added to the pit, the quality of the in-pit water will be improved. Similarly, if the water from the RWS was treated prior to injection into the pit, the overall quality would be improved.

6.2.3 Recommendations

Future management recommendation includes:

- Additional monitoring is suggested to further develop the conceptual model. This includes the collection of field parameters and total acidity measurements. The pit lake water should also be sampled and analysed (at varying depths), to provide information on the magnitude of acidity production as groundwater is oxidised.

It should be noted that the long-term water quality of the water body within the Giant Pit, will be mainly controlled by the quality of the source waters used to make up the water body volume. However, this report does not account for changes in water quality that can occur from side wall runoff. Oxidation of the groundwater inflow will release acidity, as hydrolysed minerals dissociate. Acid rock drainage will continue to occur from the side walls into the water body and evaporation has the potential to increase the salinity of the water.

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