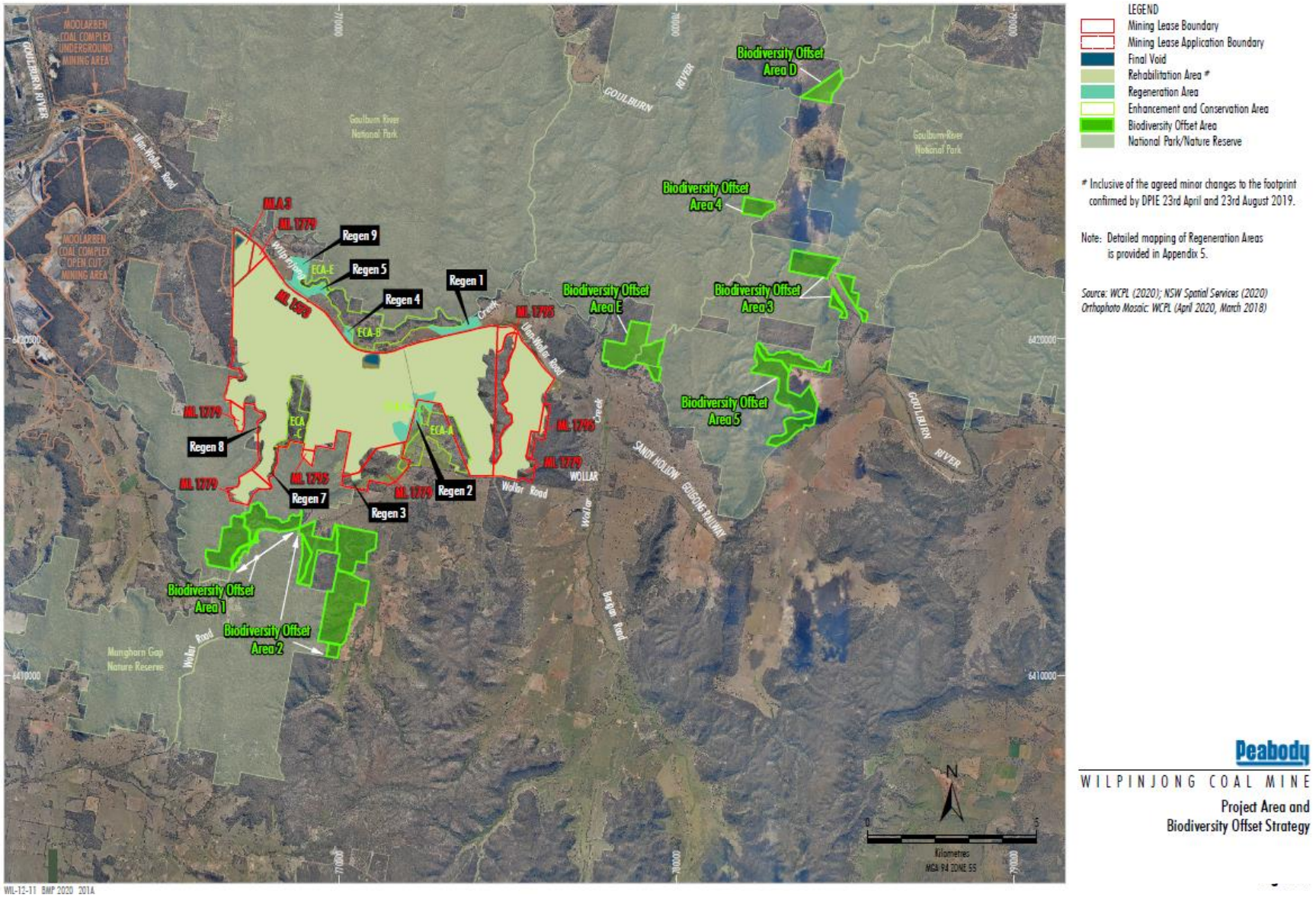
APPENDIX 5

BIODIVERSITY

Biodiversity Offset Strategy


MOOLARBEN COAL COMPLEX UNDERGROUND MINING AREA
MOOLARBEN COAL COMPLEX OPEN CUT MINING AREA
GOULBURN RIVER
Ulan-Wollar Road
Goulburn River National Park
GOULBURN RIVER
Biodiversity Offset Area D
Biodiversity Offset Area 4
Biodiversity Offset Area E
Biodiversity Offset Area 3
Biodiversity Offset Area 5
Biodiversity Offset Area 1
Biodiversity Offset Area 2
MLA 3
ML 1779
ML 1795
ML 1573
Regen 9
Regen 5
Regen 4
Regen 1
Regen 8
Regen 7
Regen 3
Regen 2
ECA-E
ECA-B
ECA-C
ECA-A
Wilpinjong Creek
Ulan-Wollar Road
WOLLAR
Wollar Road
SANDY HOLLOW GUNGAL RAILWAY
Badger Road
Munghorn Gap Nature Reserve
6420000
6410000
N
0
5
Kilometres
MGA 94 ZONE 55
LEGEND
Mining Lease Boundary
Mining Lease Application Boundary
Final Void
Rehabilitation Area *
Regeneration Area
Enhancement and Conservation Area
Biodiversity Offset Area
National Park/Nature Reserve
* Inclusive of the agreed minor changes to the footprint confirmed by DPIE 23rd April and 23rd August 2019.
Note: Detailed mapping of Regeneration Areas is provided in Appendix 5.
Source: WCPL (2020); NSW Spatial Services (2020)
Orthophoto Mosaic: WCPL (April 2020, March 2018)
Peabody
WILPINJONG COAL MINE
Project Area and
Biodiversity Offset Strategy
WIL-12-11 BMP 2020 201A

Biodiversity Reports

2020 Annual Biodiversity Monitoring Report

Wilpinjong Coal Pty Ltd

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Template 2.8.1

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Abbreviations

Abbreviation	Description
BC Act	*Biodiversity Conservation Act 2016*
BMP	Biodiversity Management Plan
BOA	Biodiversity Offset Area
BVT	BioMetric Vegetation Type
DNG	Derived native grassland
DPIE	Department of Planning, Industry and Environment
EC	Exotic Cover
ECA	Enhancement and Conservation Area
ELA	Eco Logical Australia Pty Ltd
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FL	Fallen Logs
LFA	Landscape Function Analysis
LGA	Local Government Area
LOI	Landscape Organisation Index
Microbat	Microchiroptera bat

Abbreviation	Description
ML	Mining Lease
MOP	Mine Operations Plan
MWRC	Mid-Western Regional Council
NGCG	Native Ground Cover Grass
NGCO	Native Ground Cover Other
NGCS	Native Ground Cover Shrub
NMC	Native Midstorey Cover
NOC	Native Overstorey Cover
NPWS	National Parks and Wildlife Service
NSR	Native Species Richness
NTH	Number of Trees with Hollows
OR	Overstorey Regeneration
OEH	Office of Environment and Heritage
PA	Project Approval
SSA	Soil Surface Assessment
SVS	Site Value Score
TARP	Trigger Action Response Plan
WCM	Wilpinjong Coal Mine
WCPL	Wilpinjong Coal Pty Ltd
WEP	Wilpinjong Extension Project
WSDSF	Western Slopes Dry Sclerophyll Forest
WSGW	Western Slopes Grassy Woodland

Summary of key findings

Biodiversity monitoring was undertaken at the Wilpinjong Coal Mine (WCM) during 2020, under the methodology prescribed in the WCM Biodiversity Management Plan (BMP) (WCPL 2020). Monitoring was undertaken at established sites across the WCM Management Domains, including Biodiversity Offset Areas, Enhancement and Conservation Areas, Regeneration and Rehabilitation Areas. A series of Reference sites were monitored to provide comparative results.

Reference sites were established in 2019 & 2020 in areas that conform to WCPL's targeted rehabilitation BioMetric Vegetation Types (BVTs), in accordance with Condition 36 of the Development Consent SSD 6764 for the Wilpinjong Extension Project (WEP). These sites have been established to provide comparative data for the approved Wilpinjong rehabilitation BVTs.

Vegetation monitoring was undertaken within the WCPL Rehabilitation Areas. All sites recorded improved Site Value Score (SVS), with three of the four sites meeting the Moderate to Good benchmark for the SVS, when compared against the WCPL performance criteria.

Landscape Function Analysis (LFA) monitoring was also completed within the Rehabilitation Areas. Landscape Organisation Index (LOI) scores increased compared to 2019 results, attributable to above average rainfall during 2020 resulting in increased groundcover. Stability scores continue to score highly with most of the sites reaching the relevant completion criteria. Infiltration and nutrient cycling scores are consistently below the completion criteria with some sites exhibiting an overall declining trend. All sites monitored in 2020 recorded a <5% annual improvement from the previous monitoring period in at least one Soil Surface Assessment (SSA) measure and as such, review of the relevant Trigger Action Response Plan (TARP) is required.

Fauna monitoring recorded a total species richness of 133 species, comprising of 111 birds, one (1) amphibian, nine (9) reptiles, and eleven (11) positively identified Microchiroptera (microbat) species across all Management Domains. Thirteen species (10 bird species and three positively identified microbat species) listed as threatened under the NSW *Biodiversity Conservation Act 2016* and/or the Commonwealth *Environmental Protection and Biodiversity Act 1999* were observed across the Wilpinjong Management Domains during 2020 monitoring.

A series of recommendations have been provided to ensure the continual improvement of the monitoring program. Recommendations include re-evaluating the current LFA monitoring. As part of the required TARP review for LFA results, it is recommended that consideration is given to the management aims for which LFA monitoring seeks to evaluate, and the efficacy of the LFA method to inform the achievement of these aims. A range of alternative methods are proposed for consideration.

Recommendations also include a review of the frequency and selection of sites to continue monitoring. With up to five years of both flora and fauna monitoring now completed at many sites, sufficient data has been collected across a range of sites located throughout the various WCPL management domains, which are of differing resilience, habitat structure and vegetation composition. As such, sites which do not provide either reference data for WCPL approved rehabilitation BioMetric Vegetation Types (BVT)s, representative coverage of WCPLs management domains or track the response to specific management intervention, are recommended for review. As part of the suggested review of monitoring sites, a range

of alternative fauna monitoring methods are provided for consideration, in order to capture the range of fauna species utilising the various WCPL management domains, in a more cost effective manner.

1. Introduction

Wilpinjong Coal Pty Ltd (WCPL), a wholly owned subsidiary of Peabody Energy Australia Pty Ltd (Peabody), operates the Wilpinjong Coal Mine (WCM) located in the western coalfields of NSW approximately 48 km north-east of Mudgee, within the Mid-Western Regional Council (MWRC) Local Government Area (LGA).

The WCM originally operated under Project Approval (PA) 05-0021, granted under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* on 1 February 2006. A series of modifications to Project Approval (PA) 05-0021 were approved until it was superseded by Development Consent SSD-6764, granted on 24 April 2017 for the Wilpinjong Extension Project (WEP).

A Biodiversity Offset Strategy was developed and augmented by WCPL to offset impacts on threatened species, populations or communities listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) and /or the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) in accordance with the Development Consent. The strategy comprises in excess of 4,500 ha of Management Domains including:

- **Biodiversity Offset Areas (BOAs)**: The BOAs comprise significant areas of largely undisturbed remnant vegetation and require minimal management to maintain ecological integrity. The BOAs are located next to the Goulburn River National Park and Munghorn Gap Nature Reserve with the aim that these parcels of land will be transferred to the National Parks Estate to be managed in perpetuity. Two BOAs, D and E (211 ha), were transferred in 2019 and are now under the management of the NSW National Parks and Wildlife Service (NPWS). Further biodiversity monitoring within BOAs D and E is no longer required. BOAs 1-5 (1007 ha) were added to the monitoring program in winter 2018 and will be transferred into the National Parks Estate at a later date.
- **Enhancement and Conservation Areas (ECAs)**: In 2011 WCPL entered into a Conservation Agreement with the NSW Minister for the Environment for three parcels of land surrounding Mining Lease (ML) 1573 – ECAs A, B and C. In 2018, WCPL executed a Variation Deed to the 2012 Conservation Agreement with the inclusion of two parcels of land surrounding ML 1573 – ECAs D and E. These areas have been established for conservation purposes and enhanced though weed management, revegetation and pest control.
- **Regeneration Areas:** Established on areas of WCPL owned land next to the ML, these areas were predominately cleared agricultural land in which woodland vegetation will be established through natural regeneration and implementation of proactive management actions.
- **Rehabilitation Areas**: Rehabilitation of disturbed areas is undertaken on a progressive basis in accordance with the approved Mining Operation Plan (MOP). The Development Consent allows for rehabilitation to provide biodiversity offset credits if it can be demonstrated that the target vegetation communities have been established to fulfil the offset requirement aligning with the sites Performance and Completion Criteria.

The Biodiversity Management Plan (BMP) (WCPL 2020) was developed and an annual monitoring program was implemented across all Management Domains using both the BioMetric methodology

(Gibbons et al 2009) and LFA (Tongway and Hindley 2004) for assessing ecosystem function, habitat complexity and rehabilitation progress and success.

Eco Logical Australia (ELA) was engaged by WCPL to undertake biodiversity monitoring consistent with the requirements and methods outlined in the BMP. Monitoring includes:

- BioMetric vegetation monitoring
- Landscape stability monitoring using LFA
- Terrestrial fauna monitoring.

Fifteen new reference sites were established 2019 - 2020 in accordance with Condition 36 of the Development Consent, within targeted Biometric Vegetation Types (BVT). The Rehabilitation prescribed BVT's are considered suitable habitat for the critically endangered *Anthochaera phrygia* (Regent Honeyeater):

- HU547 – Fuzzy Box Woodland
- HU697 – Mugga Ironbark-Black Cypress Pine Open Forest
- HU732 – Yellow Box Grassy Woodland
- HU824 – White Box-Black Cypress Pine Shrubby Woodland
- HU825 – Narrow-leaved Ironbark-Black Cypress Pine Grass Woodland

1.1 Objective

The objective of the biodiversity monitoring program is to assess biodiversity across all Management Domains against the relevant Completion Criteria prescribed in the BMP (WCPL 2020). Monitoring results from spring 2015 and autumn 2016 represent the baseline (Year 0) data for each monitoring site, with the 2020 results presented in this report representing Year 5 and Year 4 data for spring and autumn respectively. The Management Domains locations are listed and shown in Table 1 and Figure 1**.**

Table 1: WCPL Management Domains

Management Domain	Area (ha)	Location Description
BOA-1	201.12	Located to the south-west of ML 1573
BOA-2	417.48	Located to the south of the ML 1573
BOA-3	128.45	Located to the north-west of ML 1573, access via the Wollara Downs property
BOA-4	39.02	Located to the north-west of ML 1573, access via Mogo Road
BOA-5	221.24	Located to the west of ML 1573, access via the Wollara Downs property
ECA-A	177.32	Located to the south-east of ML 1573
ECA-B	216.38	Located to the north of ML 1573
ECA-C	96.23	Located in the south-east portion of ML 1573
ECA-D	12.24	Located to the south-east of ML 1573
ECA-E	17.21	Located to the north of ML 1573

Management Domain	Area (ha)	Location Description
Regeneration Area 1	28.12	Located adjacent to the eastern boundary of the approved disturbance area
Regeneration Area 2	59.94	Located on the western side of ECA-A
Regeneration Areas 3, 7 and 8	1.34	Located adjacent to the south and south western boundary of the approved disturbance area
Regeneration Area 4	6.53	Located on the north side of the mine, between the approved disturbance boundary and ECA-B
Regeneration Area 5	24.94	Located towards the western end of ECA-B
Regeneration Area 9	27.60	Located towards the western end of ECA-B
Rehabilitation Areas	Variable	Includes areas within the approved disturbance area for the mine, including active and future mining areas, infrastructure areas and rehabilitation of disturbed areas that is undertaken on a progressive basis in accordance with the approved WCPL MOP (WCPL 2020)

Note: Regeneration Area 6 was removed in 2017 with the approval of the WEP.

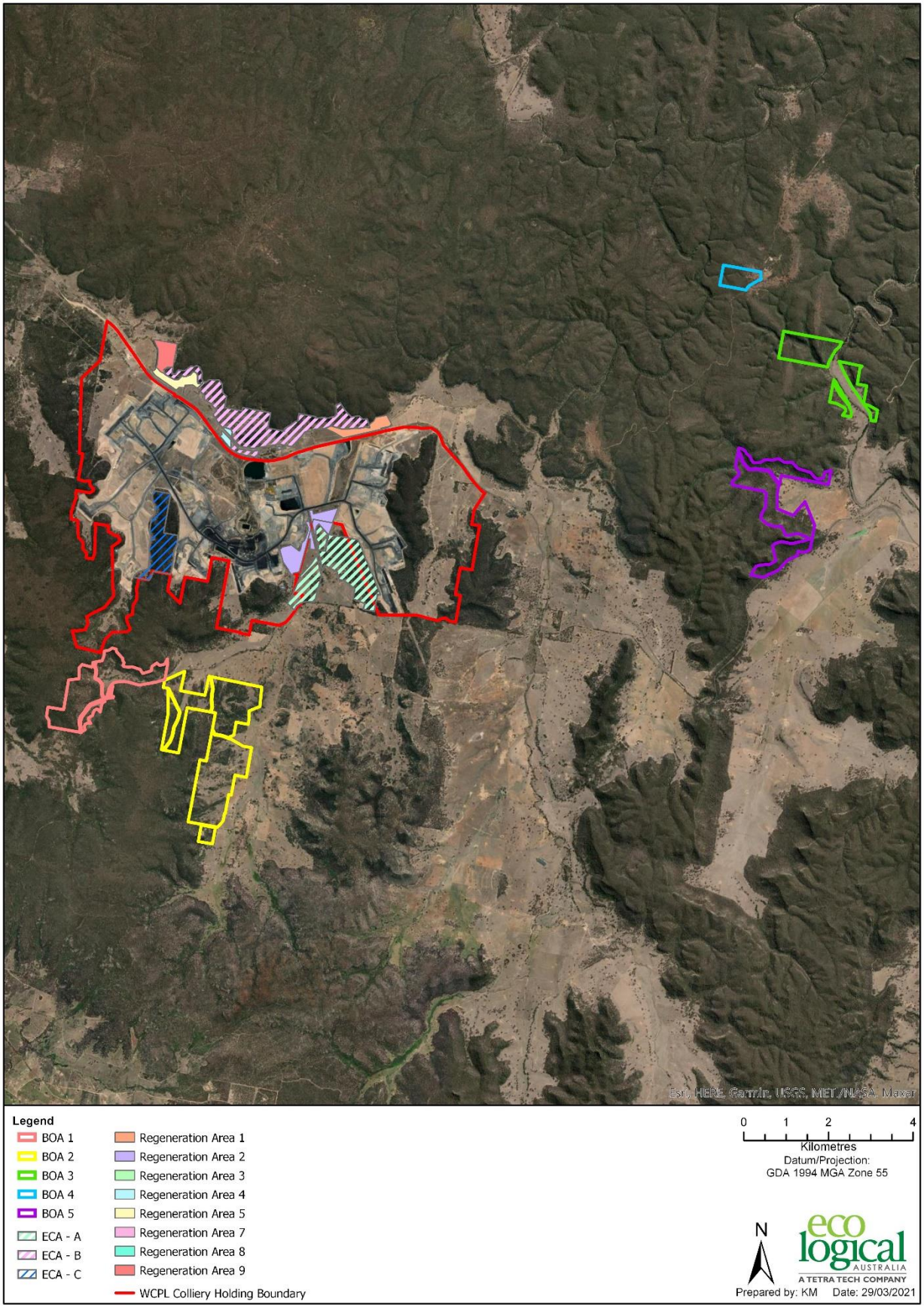


Figure 1: WCPL Management Domains

1.2 Assessment against Rehabilitation BVT Benchmarks and WCPL Performance Criteria

Interim Performance and Completion Criteria for the Rehabilitation Areas were approved by the Department of Planning, Industry and Environment (DPIE) on 23 April 2019 and incorporated into the BMP. Within this monitoring report, these performance criteria, along with benchmark attributes (Office of Environment and Heritage [OEH] 2017), were compared with the Rehabilitation Areas 2020 monitoring data. The Interim Performance and Completion Criteria will be further updated based upon data collected from newly established local Reference Sites for each specific rehabilitation BVT and in consultation with the Biodiversity, Conservation and Science Directorate (BCS).

BOAs, ECAs and Regeneration Areas have, and will continue to be monitored, although they are not comparable to the BMP Performance and Completion Criteria as these are specific to Rehabilitation Areas. BOAs and ECAs are instead be compared and monitored for resilience, with management actions to be implemented where poor resilience is determined or improvement in resilience is not occurring.

2. Methodology

The 2020 biodiversity monitoring program was undertaken in accordance with the methods and survey techniques prescribed in the BMP.

Weather conditions during the autumn, winter, spring and summer 2020 monitoring are presented in **Appendix A**. Additional information on all monitoring sites can be found in **Appendix B**.

2.1 Vegetation monitoring

Autumn vegetation monitoring was undertaken between 18 March and 20 March, by ELA ecologists Elise Keane, Kate Maslen and Cheryl O'Dwyer, at a total of twelve (12) established monitoring sites, including two (2) reference sites. Spring vegetation monitoring was undertaken between 7 September and 16 September 2020 by ELA ecologists Rebecca Croake, Elise Keane and Kate Maslen at 28 established monitoring sites[1], including 15 reference sites. The locations of vegetation monitoring sites are illustrated below in **Figure 2** to **Figure 4.**

Vegetation monitoring was undertaken utilising the BioMetric method of plot assessment prescribed in the BMP. Permanent BioMetric plots, comprising a 20 m x 20 m (0.04 ha) plot nested within a 20 m x 50 m plot, and were surveyed at each monitoring site. Within each plot, the following data was collected:

- native species richness (NSR), cover and abundance within the 20 m x 20 m plot
- native overstorey cover (NOC) and native mid-storey cover (NMS) – at regular 5 m intervals along 50 m transect (10 points),
- native ground stratum (grass, shrub, other) and exotic cover (EC) – at regular 1 m intervals along 50 m transect (50 points)
- habitat features (number of trees with hollows (NTH), length of fallen logs (FL)) and proportion of overstorey species regeneration – within 20 m x 50 m plot.

All vascular plants species were recorded and identified to the lowest taxonomic level possible, with samples of unknown species collected for further identification.

2.2 Landscape Function Analysis

LFA monitoring was undertaken at 10 monitoring sites, including nine within WCPL Management Domains and one reference site (**Figure 3** and **Figure 4**) in accordance with the methods prescribed in Tongway and Hindley (2004) and the BMP.

At each LFA site, a 50 m transect line was established downslope between transect start and end markers. The majority of LFA transects directly correspond to the 50 m BioMetric transect of the respective monitoring site. However, at several sites, the LFA transect does not align with the BioMetric transect, predominantly due to the BioMetric transect being established across slope rather than

[1]R9 was not surveyed during 2020, as there was no access to the site

downslope in these locations. Along each LFA transect, LFA attributes were assessed to monitor the Landscape Organisation Index (LOI) and Soil Surface Assessment (SSA).

2.2.1 Landscape organisation index

The LOI characterises and maps the spatial patterns of resource loss or accumulation at a site. The LOI provides a proportion of the transect occupied by patches (patches being landscape elements that are relatively permanent and provide stable, resource accumulating structures, such as grassy tussocks, ground cover and logs). A higher LOI implies a more stable transect that is less prone to erosion, with a LOI of 1.00 indicating that an entire transect is occupied by patches. The SSA is more in depth, providing an index (0-100) of Stability, Soil Infiltration and Nutrient Cycling for the whole of landscape (transect). Table 13 in the BMP summarises the SSA attributes that contribute to each of these indices (see Table 2 below).

According to the LFA method, patches are long-term features that obstruct or divert water flow and/or collect/filter out material from runoff and where there is evidence of resource accumulation. Inter-patches are zones where resources such as water, soil materials and litter may be mobilised and freely transported either down slope when water is the active agent or down-wind when aeolian processes are active.

The following data was recorded for each patch/inter-patch along each transect:

- Distance (m) from the start of the transect
- Patch width (cm)
- Patch/inter-patch identification.

The following patch types were defined and monitored across all monitoring sites and monitoring periods:

- Bare soil
- Litter (including annual plants)
- Rock (<5 cm diameter)
- Log (>10 cm diameter)
- Ground cover (perennial)
- Shrub/tree
- Cryptogam
- Any combinations of the above (e.g. ground cover – litter patch).

2.2.2 Soil surface assessment (SSA)

Each patch/inter-patch type identified in the landscape organisation data log was subject to a SSA. A subset of up to five occurrences of each patch/inter-patch type were monitored, and data relating to 11 Soil Surface Condition Indicators (SSCIs) were collected along the 50 m transect (Table 2).

Table 2: Soil Surface Condition Indicators used to determine the overall Soil Surface Analysis (see Table 13 BMP: WCPL 2020)

SSCI	Description
Rain splash protection	Percentage cover of perennial vegetation to a height of 0.5 m. plus rocks > 2 cm and woody material > 1 cm in diameter or other long-lived, immoveable objects.

SSCI	Description
Perennial vegetation cover	Percentage perennial vegetation cover.
Litter	Percentage cover of annual grasses and ephemeral herbage (both standing and detached) as well as detached leaves, stems, twigs, fruit, dung, etc.
Cryptogam cover	Percentage cover of algae, fungi, lichens, mosses, liverworts and fruiting bodies of mycorrhizas.
Crust brokenness	Categorises soil crusts from 0-4 where 0 refers to 'no crust present' and 4 refers to an 'intact and smooth' soil crust.
Soil erosion type and severity	Categorises the aerial extent and severity of various erosion types from 'Insignificant' to 'Severe'.
Deposited materials	Categorises the extent and depth of deposited alluvial material
Soil surface roughness	Categorises the depth of surface depressions from 'smooth' to 'deep' depressions.
Surface nature (resistance to disturbance)	Categorises the soils capacity to resist disturbance based on the soils 'hardness' or 'brittleness'.
Slake Test	Categorises the soils stability when exposed to water
Texture	Categorises the soils water infiltration capacity from 'very slow' to 'high'

Baseline data for the Slake Test and Texture SSCIs was used for the LFA analysis and was not assessed in the field in 2020. All other parameters were assigned a simple score in the field. Data was entered into the LFA calculation spreadsheets and used to calculate Soil Stability, Soil Infiltration and Nutrient Cycling indices.

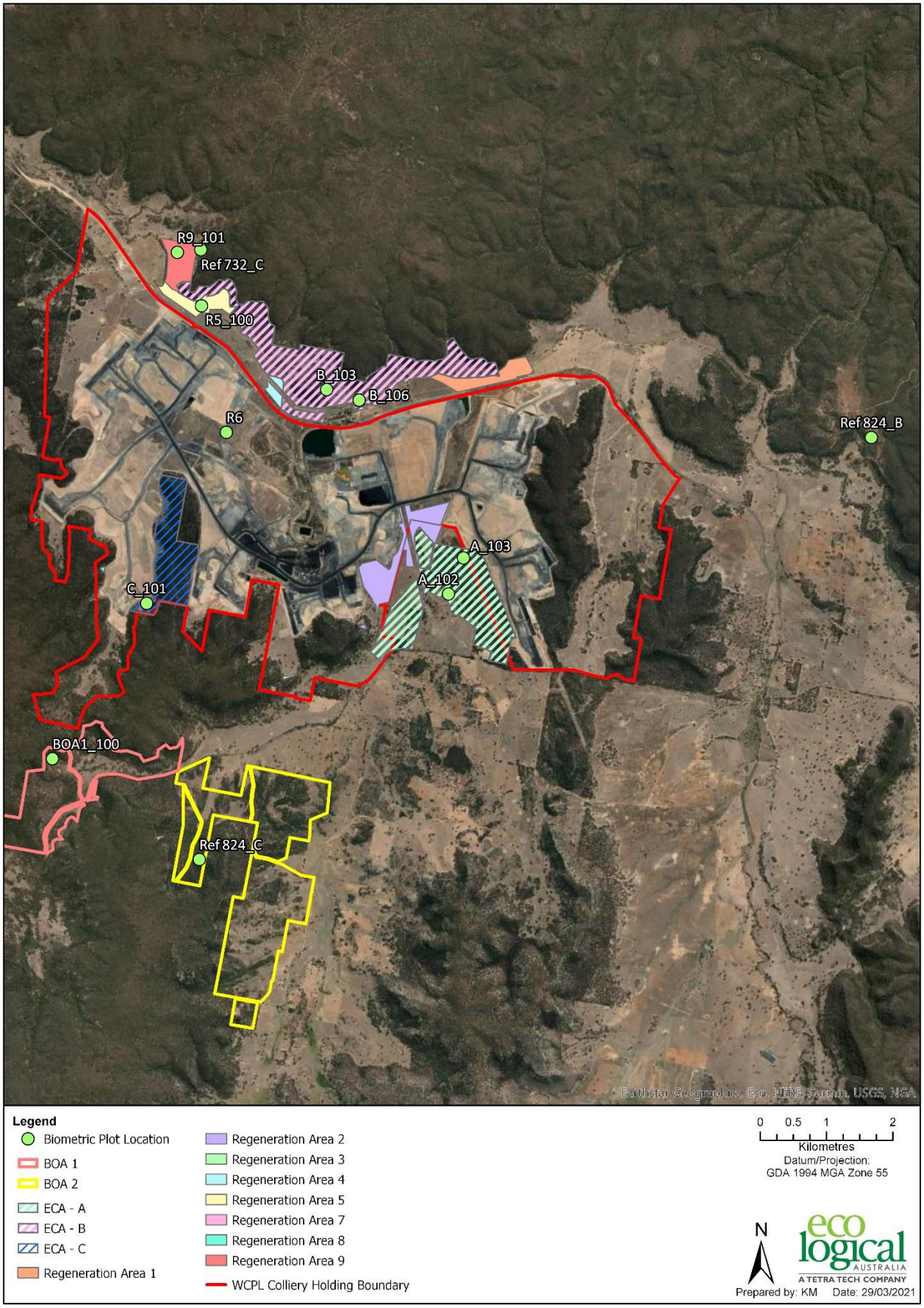


Figure 2: Autumn 2020 vegetation monitoring sites

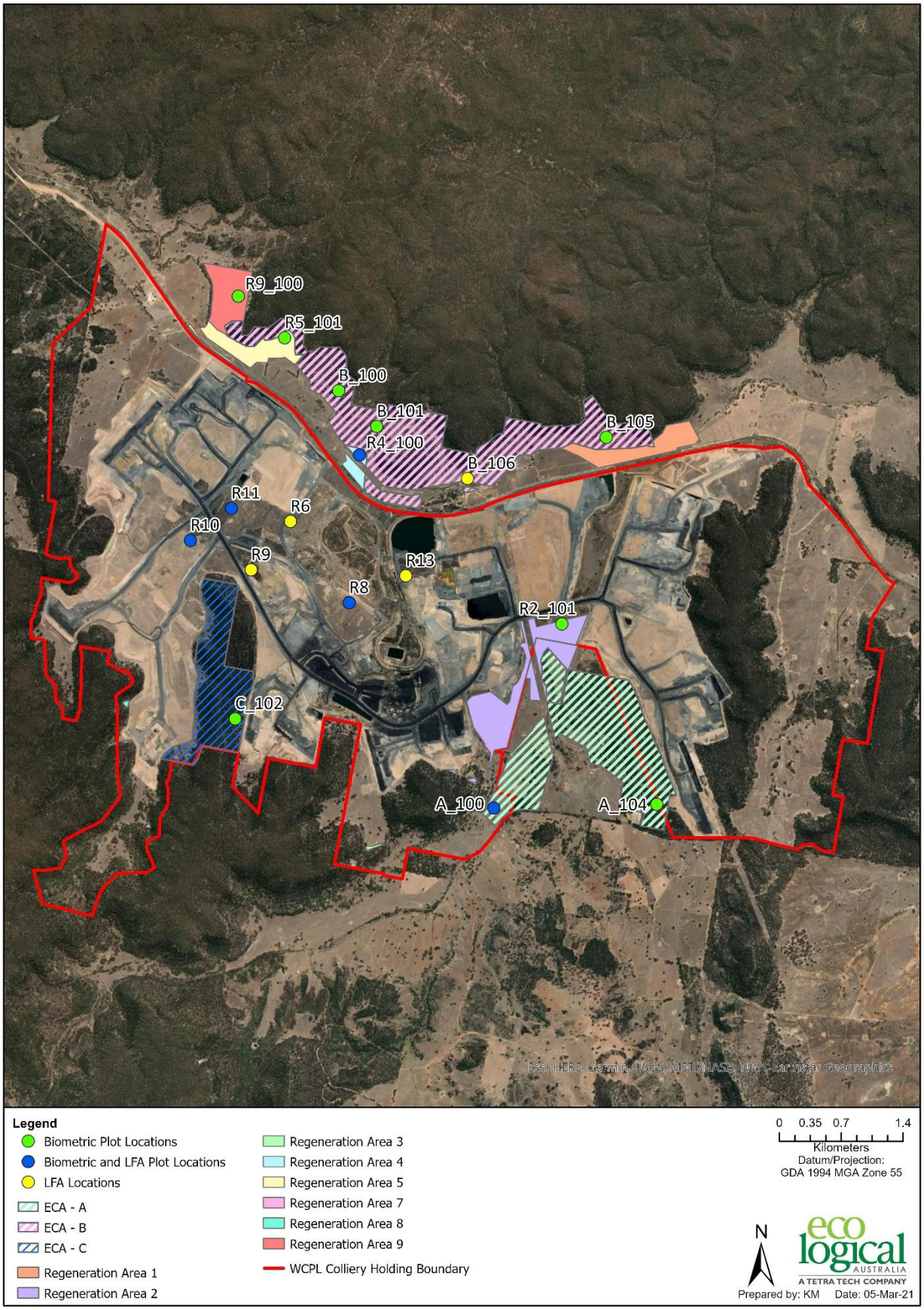


Figure 3: Spring 2020 vegetation and LFA monitoring sites

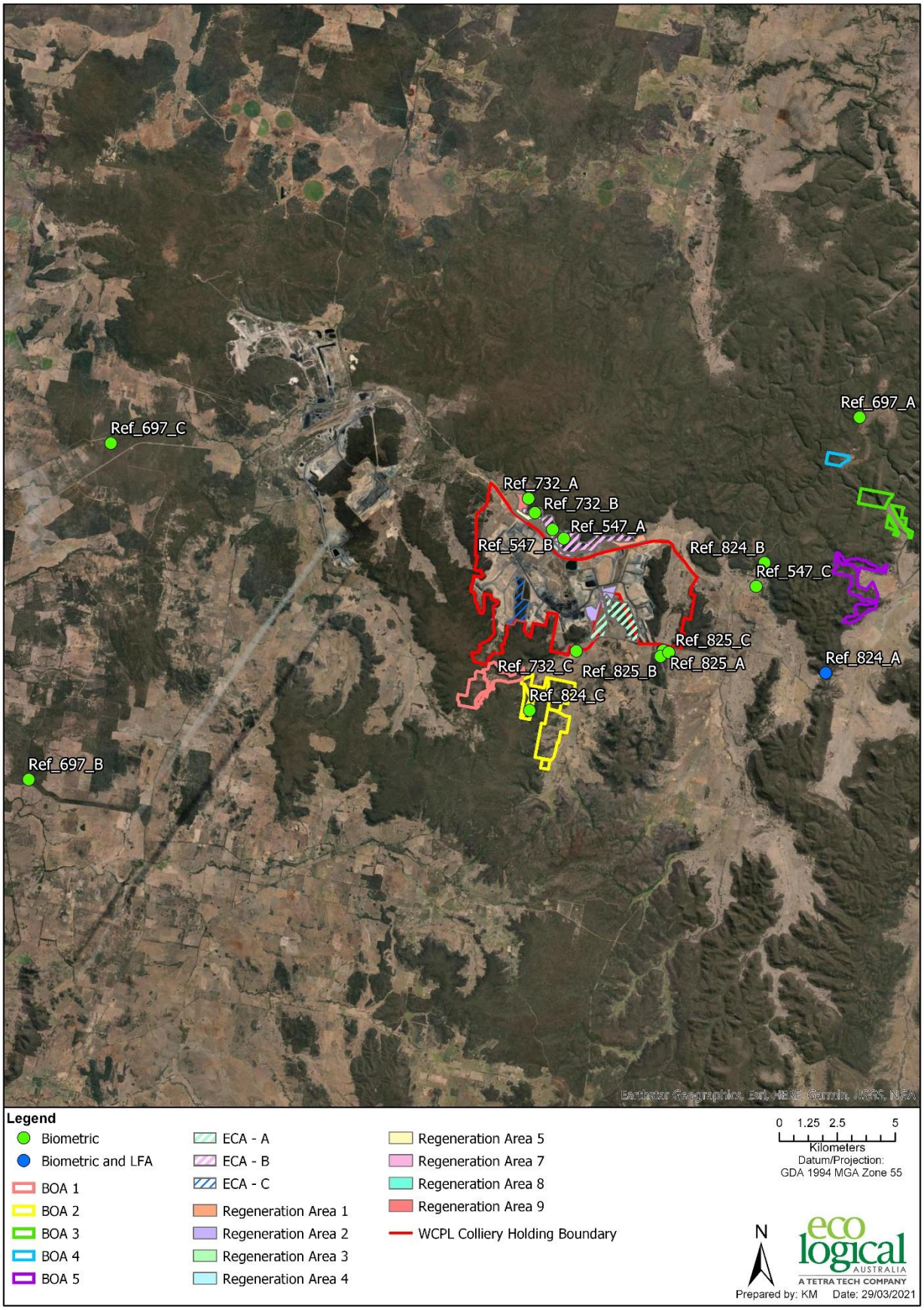


Figure 4: Spring vegetation monitoring reference sites

2.3 Fauna monitoring

Terrestrial fauna monitoring was undertaken across all Management Domains including:

- Bird monitoring across three seasons (summer, winter and spring)
- Ground fauna trapping in spring
- Microchiroptera (Microbat) monitoring in spring
- Nest box monitoring in spring.

Table 3 below outlines the methodology and survey effort for each target species per the methods prescribed within the BMP.

Table 3: Fauna monitoring methods summary

Target species	Methodology	Total Survey Effort
Birds	Bird census consisting of 10 minutes recording all birds seen/heard within 50 m radius of central plot point, and further 10 minutes recording all birds seen/heard within balance of a 2 ha plot.	80 total minutes per site (20 minutes per survey, per person, per site), over one morning and one afternoon (37 sites).
Ground fauna (amphibians, mammals, reptiles)	Pit fall/funnel trap line of 30 m drift fence and five 20 L buckets/10 funnel traps spaced 5 m apart covering both sides of the drift fence.	Twice daily inspections of traps (morning and afternoon) for four nights (23 sites).
Bats	Automated ultrasonic acoustic recording to identify all bat species occurring.	Recording for 2 nights (6pm – 6am)
All	Any sightings of fauna recorded whilst moving throughout the Project Area and located using a GPS.	Opportunistic
Mammals	Opportunistic collection of scats and observations of tree scratching's, animal tracks and paw prints.	Opportunistic

Opportunistic fauna sightings, including fauna evidence such as scats and tracks, were also recorded, where identified across all fauna monitoring sites. The locations of fauna monitoring sites are shown in **Figure 5** and **Figure 6**[2]**.**

2.3.1 Bird monitoring

Bird monitoring is undertaken across three seasons, summer, winter and spring, to provide a comprehensive measure of bird presence. Winter bird surveys are undertaken specifically to target species that feed on the blossoms of winter-flowering eucalypts and lerps. Some target winter-flowering eucalypt feed trees, including *Eucalyptus moluccana* (Grey Box), *Eucalyptus sparsifolia* (Narrow-leaved Stringybark), *Amyema miquelii* (Box Mistletoe) and *Amyema quandang*, were in flower during the winter survey period.

[2] R9 was not surveyed during summer 2020 as there was no access to the site.

Summer bird monitoring was undertaken at 25 bird monitoring sites between 19 to 25 February 2020 by ELA ecologists Elise Keane, Tomas Kelly, Kate Maslen, Cheryl O'Dwyer and Justin Russell.

Winter bird monitoring was undertaken at 39 sites, which included 13 reference sites, between 30 July to 4 August by ELA ecologists Rebecca Croake, Elise Keane, Tom Kelly, Kate Maslen and Justin Russell.

Spring bird monitoring was undertaken at 17 sites between 28 September 23 October by ELA ecologists Tomas Kelly, James King, Kate Maslen, Nicole McVicar, Cheryl O'Dwyer and Pearce Thomas in combination with ground fauna and microbat monitoring.

2.3.2 Ground fauna monitoring

Ground fauna monitoring is undertaken in spring only and was completed at 17 pitfall/funnel trap sites between 28 September and 23 October by ELA ecologists Tom Kelly, James King, Kate Maslen, Nicole McVicar, Cheryl O'Dwyer and Pearce Thomas. Traps are set and checked both in the morning and afternoon, over a four night period per site. Artificial fauna refuges have been placed around some sites and are checked daily throughout the trap check week.

2.3.3 Microbat monitoring

Microbat monitoring is undertaken using ultrasonic acoustic recording devices at eight monitoring sites in spring. Each detector was set to survey ultrasonic microbat calls passively over two consecutive nights during the survey period. A total of 16 survey nights were completed during this survey.

Acoustic analysis was undertaken by ELA ecologist Dr Rod Armistead, with the analysis report provided in **Appendix C**.

2.3.4 Nest box monitoring

Nest box monitoring is undertaken at 72 previously installed nest boxes within ECA B and Regeneration Areas 5 and 9.

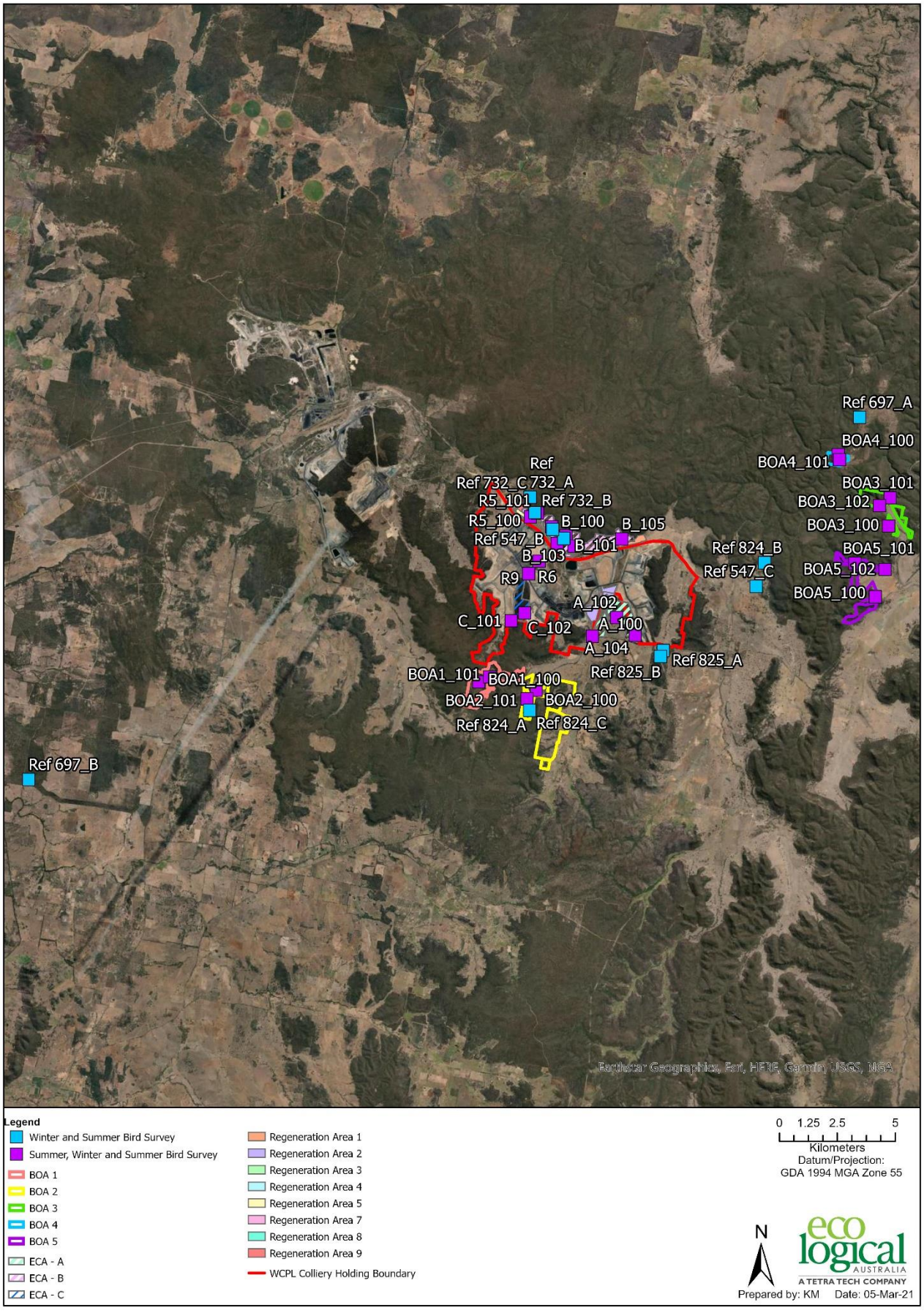


Figure 5: 2020 bird monitoring sites

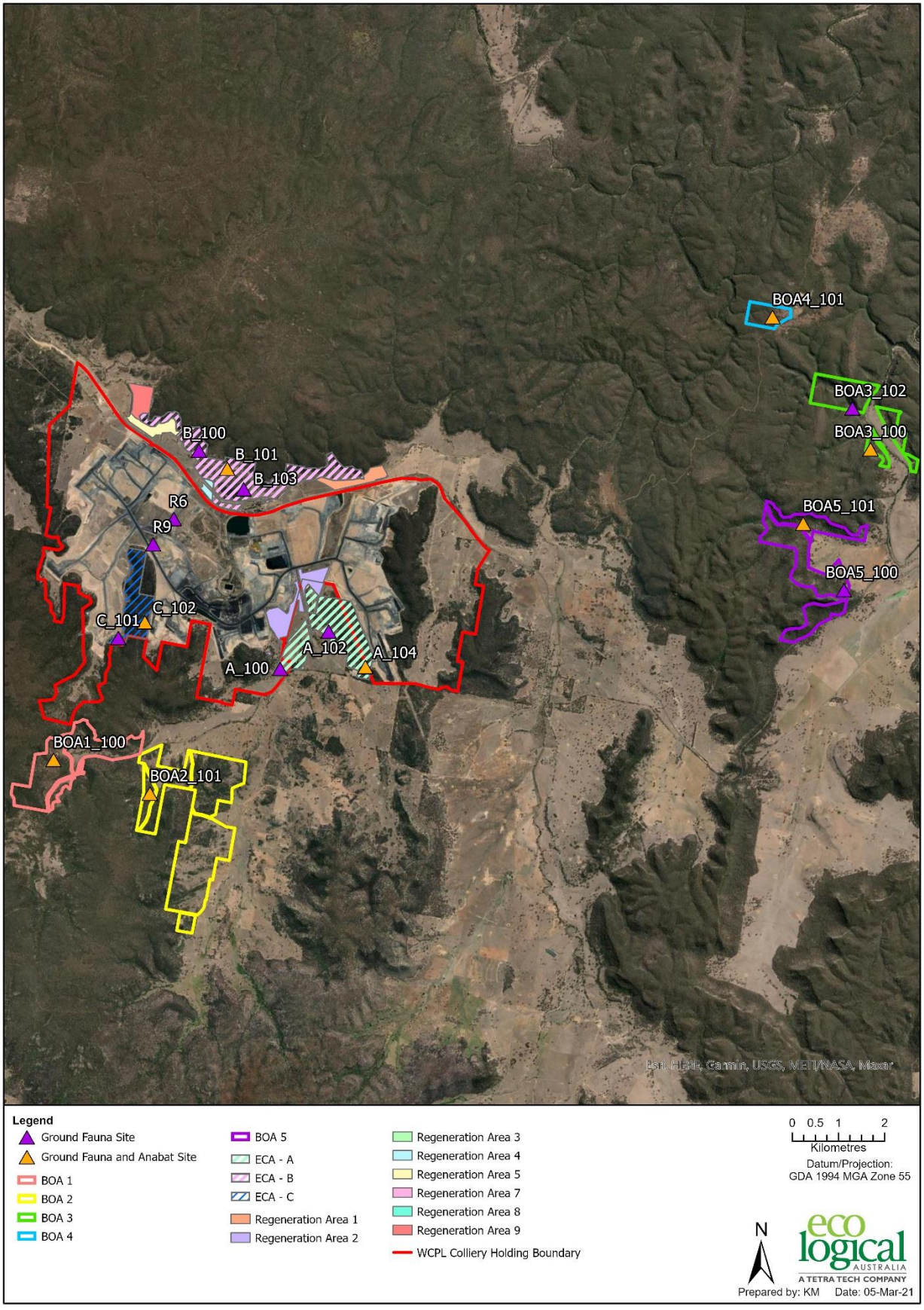


Figure 6: 2020 ground fauna and anabat monitoring sites

3. Results and Discussion

The results of the 2020 biodiversity monitoring program are presented below.

3.1 Vegetation monitoring

A total of 355 flora species were recorded across all 38 vegetation and reference sites monitored during autumn (12 sites) and spring (26 sites) 2020. Species recorded included 225 native species and 99 exotic species, with a further 31 species unable to be identified as either native or exotic as these species were only identified to genus. The total number of species has increased considerably from 250 species recorded in 2019. The full list of flora species recorded during the 2020 monitoring is included in **Appendix F**.

3.1.1 Assessment against Rehabilitation BVT Benchmarks and WCPL Performance Criteria

Vegetation monitoring results for the Rehabilitation Areas were assessed against the WCPL Rehabilitation Performance Criteria and the OEH BVT Benchmarks (see **Appendix D**). A Site Value Score (SVS) was calculated for each site using the BioMetric Tool (NSW Department Environment Climate Change and Water, DECCW 2011) which combines the quality and quantity of native vegetation by measuring ten condition variables within a plot compared to the pre-European benchmarks for the BVT.

Table 4 and **Table 5** present the individual site attribute and SVS for each 2020 rehabilitation monitoring site. **Table 4** presents comparison of sites against the approved Rehabilitation Performance Criteria and **Table 5** presents comparison of sites against the BVT Benchmarks (taken from OEH 2017). SVS which do not meet the BVT Benchmark Targets or Performance Criteria are highlighted in red – monitoring results from these sites trigger the Interim Rehabilitation Performance Criteria (Years 1 – 10) Trigger Action Response Plan (TARP) detailed in Table 19 of the BMP. Amber is not applied to the SVS as anything below the Benchmark Target or Performance Criteria is considered LOW. A colour coding system has been applied to all site attribute results.

- GREEN indicates site attributes that have met the relevant Benchmark Targets or Performance Criteria (indicating that no additional management intervention is required)
- AMBER indicates site attributes that have not met the relevant Benchmark Targets or Performance Criteria, but are within 50 - <100% of the targets
- RED indicates site attributes that are <50% of the relevant Benchmark Targets or Performance Criteria.

Table 4: Assessment against Rehabilitation Performance Criteria* for Rehabilitation Sites within their respective BVT

BVT	Season	Site	Vegetation condition	SVS	Site attributes (% cover)									
					NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH (Count)	OR	FL (M)
HU824	Autumn	R6	Mod-Good-Medium	50	15	0.2	3.2	2	0	2	14	0	0	0
	Spring	R8	Low	32	6	0	0	0	0	24	56	0	0	0
HU732	Spring	R10	Mod to Good-Good	64	15	0	0	2	2	8	34	0	0	5
	Spring	R11	Mod to Good-Poor	44	23	0	14.5	0	0	2	34	0	0	0

SVS = Site Value Score, NSR = Native Plant Species Richness, NOC = Native Overstorey Cover, NMC = Native Midstorey Cover, NGCG = Native Ground Stratum Cover (grasses), NGCS = Native Ground Stratum Cover (shrubs), NGCO = Native Ground Stratum Cover (other), EC = Exotic Plant Cover, NTH = Number of Trees with Hollows, OR = Overstorey Regeneration and FL = Length of Fallen Logs

*Rehabilitation Biometric Performance Criteria was approved by DPIE on 23 April 2019, and is incorporated into the BMP

Table 5: Assessment against OEH BVT Benchmarks* for Rehabilitation Sites within their respective BVT

BVT	Season	Site	Vegetation condition	SVS	Site attributes (% cover)									
					NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH (Count)	OR	FL (M)
HU824	Autumn	R6	Low	14	15	0.2	3.2	2	0	2	14	0	0	0
	Spring	R8	Low	14	6	0	0	0	0	24	56	0	0	0
HU732	Spring	R10	Low	19	15	0	0	2	2	8	34	0	0	5
	Spring	R11	Low	24	23	0	14.5	0	0	2	34	0	0	0

SVS = Site Value Score, NSR = Native Plant Species Richness, NOC = Native Overstorey Cover, NMC = Native Midstorey Cover, NGCG = Native Ground Stratum Cover (grasses), NGCS = Native Ground Stratum Cover (shrubs), NGCO = Native Ground Stratum Cover (other), EC = Exotic Plant Cover, NTH = Number of Trees with Hollows, OR = Overstorey Regeneration and FL = Length of Fallen Logs

*BVT Benchmarks are taken from OEH (2017)

Assessment against the Rehabilitation Performance Criteria

With the exception of one site, R8, all rehabilitation sites surveyed in 2020 met the Moderate to Good SVS. All sites met the performance criteria for Native Species Richness (NSR) and most sites met the other criteria, however, none of the sites met the benchmark for Native Overstorey Cover (NOC), which is to be expected, as canopy species present in these sites have not yet reached maturity. R8 was slightly high for exotic cover and low in native grasses, and accordingly was the only site to be classified as LOW condition in 2020. Comparison against the Rehabilitation Performance Criteria is temporary until sites are reworked to adhere to their target BVT and finalised Performance Criteria are established using locally established Reference site data.

As per the updated WCPL BMP, TARPs have been developed if SVS's are not met (colour-coded red in Table 4 above). One site, R8, did not meet its SVS in 2020, and therefore the TARP will apply (Figure 7).

Figure 7: Rehabilitation sites Site Value Scores

Assessment against the OEH BVT Benchmark Targets

None of the sites met the SVS when assessed against the relevant OEH BVT Benchmarks, with NOC, Native Ground Cover Grass (NGCG), Number of Trees with Hollows (NTH), Overstorey Regeneration (OR) and Fallen Logs (FL) not met for most sites. All sites except for R11 with a score of 56% recorded less exotic species than the maximum allowable under the benchmark. Comparison against these BVT Benchmarks is temporary until sites are reworked to adhere to their target BVT and compared against local benchmarks developed from Reference sites.

3.1.2 Reference site BioMetric assessment

BioMetric monitoring results for Reference Sites were assessed with a SVS calculated for each site using the BioMetric Tool (DECCW 2011) which determines the vegetation condition class. **Table 6** below presents the individual site attribute and SVS's for each site monitored during 2020.

Table 6: Reference Site BioMetric data

Season	Vegetation Community	Site	Condition Class	SVS	Site attributes (% cover)									
					NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH	OR	FL (m)
Autumn	HU732	Ref732_C	Mod to Good - Medium	42	25	9	0	20	2	10	4	0	0.5	6
Autumn	HU824	Ref824_B	High	84	37	30.5	9.7	12	8	20	8	1	0.5	91
Autumn	HU824	Ref824_C	Mod-Good - Medium	56	36	22.5	0.7	0	0	6	10	4	0	120
Spring	HU547	Ref_547_A	Mod to Good - Medium	48	30	7.1	0	12	0	44	38	1	0.33	46
Spring	HU547	Ref_547-B	Mod to Good - Low	40	45	16.5	0	20	0	22	32	0	0.66	16
Spring	HU547	Ref_547_C	Mod to Good - Medium	53	24	23.5	0	14	0	12	30	0	1	52
Spring	HU697	Ref_697_A	Mod to Good - Good	66	45	25	6.5	10	0	32	0	0	0.6	58
Spring	HU697	Ref_697_B	High	71	32	21.8	0	2	0	10	0	4	0.67	30
Spring	HU697	Ref_697_C	Mod to Good - Medium	54	28	21	2	10	14	0	0	0	1	14
Spring	HU732	Ref_732_A	Mod to Good - Low	36	33	13	0	18	0	22	28	0	0.33	20
Spring	HU732	Ref_732_B	Mod to Good - Low	36	28	19.5	0	42	0	4	36	1	0.5	15
Spring	HU732	Ref_732_C	Mod to Good - Low	36	31	14	0	16	0	20	20	0	0.33	15
Spring	HU824	Ref_824_A	High	72	41	17	1	12	2	24	18	3	0.33	67

Season	Vegetation Community	Site	Condition Class	SVS	Site attributes (% cover)									
					NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH	OR	FL (m)
Spring	HU824	Ref_824_B	High	73	34	17.5	3	10	0	12	56	1	0.5	91
Spring	HU824	Ref_824_C	High	76	28	17	7.5	0	0	28	0	7	0.25	90
Spring	HU825	Ref_825_A	Mod to Good - Good	66	48	21	2.5	6	4	22	4	1	0.5	68
Spring	HU825	Ref_825_B	Mod to Good - Medium	55	37	21.5	1.6	0	4	6	0	0	0.33	58
Spring	HU825	Ref_825_C	Mod to Good - Medium	51	19	1.9	28	6	34	0	0	1	0.5	11

All Reference sites have a Moderate - Good or High SVS. Consistent with monitoring in Rehabilitation Areas, exotic cover was a lower performing site attribute particularly sites in HU824, HU547, HU732. All sites but one site (Ref 824_C) showed signs of overstorey regeneration, which is typical of sites within established vegetation communities. The BioMetric data collected from Reference sites during 2020 will be used to calculate local benchmarks for the approved WCPL Rehabilitation BVTs, which is expected to be undertaken in early 2021.

3.1.3 BOA, ECA and Regeneration Biometric Assessment

The BOA, ECA and Regeneration sites are assessed against the benchmarks of their two respective Vegetation Classes (Western Slopes Dry Sclerophyll Forest (WSDSF) and Western Slopes Grassy Woodland (WSGW). The benchmarks used to calculate the SVS were described in the previous WCPL BMP (WCPL 2017) and shown in **Appendix E.** Given the BMP does not require this ongoing assessment, this will no longer be undertaken in subsequent monitoring years. **Table 7** and **Table 8** below presents the individual site attribute and SVSs for each site monitored during autumn and spring 2020.

Table 7: Assessment against Interim Performance Targets WSDSF

Management Domain	Vegetation Community	Site	Condition	SVS	Site attributes (% cover)									
					NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH	OR	FL (m)
BOA 1 - 5	WSDSF	BOA1_100	Mod-Good - Medium	52	31	24	1.7	0	0	0	24	2	0.5	125
ECA	WSDSF	B_103	Mod to Good - Medium	39	37	18.2	0.6	2	10	10	0	0	0	2
	WSDSF	B_105	Low	9	13	0	0	22	0	6	54	0	0	0
	WSDSF	C_101	Low	11	12	0	0	4	0	0	96	0	0	1
Regeneration Areas	WSDSF	R5_101	Low	17	18	0	0	30	0	8	62	0	0	0
	WSDSF	R9_100	Low	27	24	0	0	58	0	10	20	0	0	0

Table 8: Assessment against Interim Performance Targets WSGW

Management Domain	Vegetation Community	Site	Condition	SVS	Site attributes (% cover)									
					NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH	OR	FL (m)
ECA	WSGW	A_100	Low	13	5	0	0	0	0	0	88	0	1	0
	WSGW	A_102	Low	31	20	0	4.2	54	4	18	6	0	0	0
	WSGW	A_103	Mod to Good - Medium	43	31	20	0.1	4	2	6	0	4	0.33	13
	WSGW	A_104	Mod to Good - Good	59	28	14	0	0	0	20	0	0	1	68

Management Domain	Vegetation Community	Site	Condition	SVS	Site attributes (% cover)									
					NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH	OR	FL (m)
	WSGW	B_100	Mod to Good - Medium	48	64	15.1	3.5	10	0	12	14	0	0.5	10
	WSGW	B_101	Low	26	36	0	0	4	0	42	14	0	0	0
	WSGW	B_106	Low	14	21	0	0	20	0	6	52	0	0	0
	WSGW	C_101	Low	11	12	0	0	4	0	0	96	0	0	1
	WSDSF	C_102	Mod to Good - Medium	55	45	10	0	0	16	18	0	0	0.2	75
Regeneration Areas	WSGW	R2_101	Low	14	16	0	0	10	0	6	62	0	0	0
	WSGW	R4_100	Low	6	8	0	0	0	0	2	58	0	0	0
	WSGW	R5_100	Low	16	17	0	0	42	0	2	54	0	0	0
	WSGW	R9_101	Low	27	24	0	0	58	0	10	20	0	0	0

SVS = Site Value Score, NSR = Native Plant Species Richness, NOC = Native Overstorey Cover, NMC = Native Mid storey Cover, NGCG = Native Ground Stratum Cover (grasses), NGCS = Native Ground Stratum Cover (shrubs), NGCO = Native Ground Stratum Cover (other), EC = Exotic Plant Cover, NTH = Number of Trees with Hollows, OR = Overstorey Regeneration and FL = Length of Fallen Logs

Western Slopes Dry Sclerophyll forest (WSDSF)

Across the ECA areas, sites B_105 and C_101 returned a low SVS, with site attributes contributing to this score including native overstory cover (NOC), number of trees with hollows (NTH), fallen logs (FL) and overstory regeneration (OR). It will take time to improve scores for these attributes particularly as most of these sites are in previously cleared areas. Exotic cover was high at most sites, this may be due to the years of drought followed by a year of increased rainfall, increasing the number of annual species.

As seen in Figure 8 there is no clear positive or negative trend across all sites, with each site recording relatively consistent scores. Without active management sites, these sites are not expected to progress towards Mod – Good benchmarks and the value of ongoing monitoring within these sites is recommended to be reviewed (see **Section 4**).

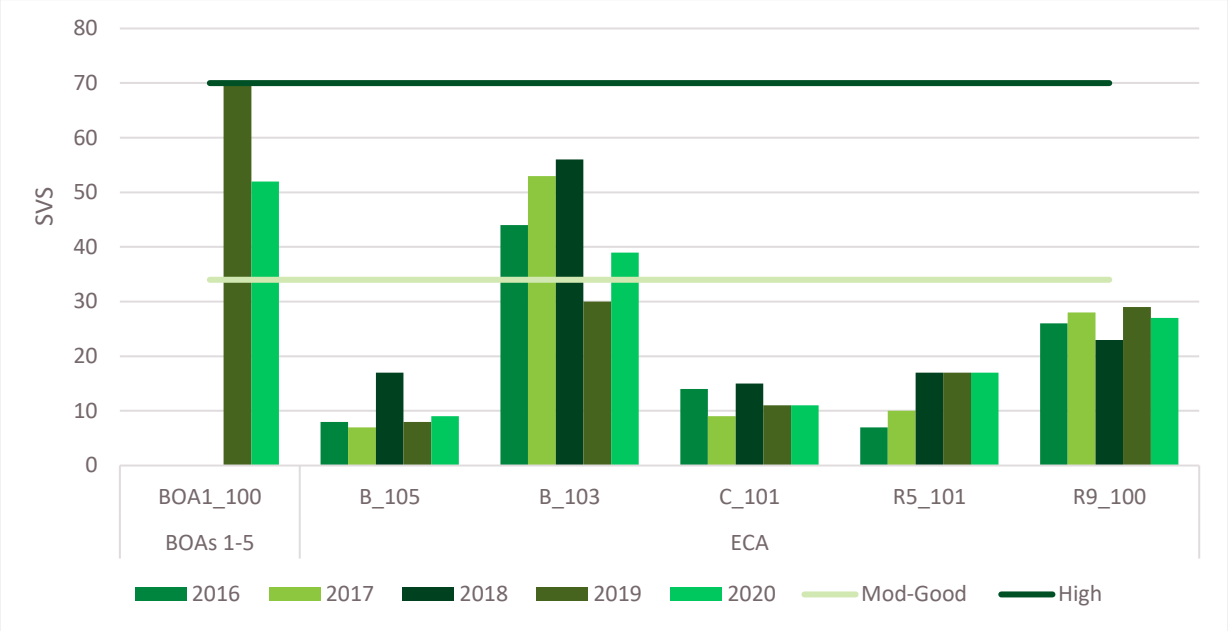


Figure 8: WSDSF Site Value Score

Western Slopes Grassy Woodland (WSGW)

Across the ECA areas, five of the nine sites returned a low SVS. The sites with a low scores consistently did not have established overstory cover. Exotic cover was high at most sites consistent with the increase in rainfall in the 2020 monitoring period compared to drought conditions in previous years.

As seen in **Figure 9** there is no clear positive or negative trend across all sites, with each site recording relatively consistent scores. Without active management sites, these sites are not expected to progress towards Mod – Good benchmarks and the value of ongoing monitoring within these sites is recommended to be reviewed (see **Section 4**).

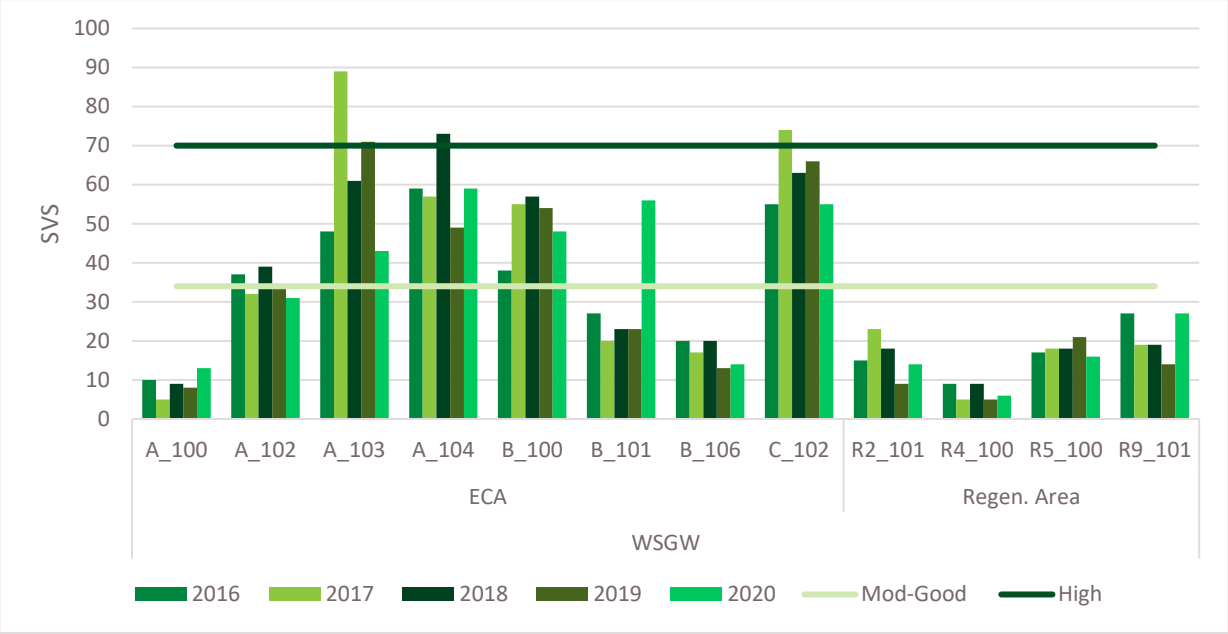


Figure 9: WSGW Site Value Score

3.1.4 Weeds

A full list of weeds classified as priority weeds under the *Central Tablelands Regional Strategic Weed Management Plan 2017 – 2022* (Central Tablelands Local Land Services 2017) were identified at several monitoring sites across the Management Domains. These priority weeds and their site locations are presented below in Table 9Error! Reference source not found..

Table 9: Priority weeds recorded during 2020

Scientific Name	Common Name	State Priority Weed	Regional Weed	Priority	Sites recorded
Heliotropium amplexicaule	Blue Heliotrope		Y		R10
Hypericum perforatum	St John's Wort		Y		R6
Xanthium spinosum	Bathurst Burr		Y		A_102, A_103, B_106, R11, R6
Opuntia sp.	Prickly Pear	Y	Y		BOA1_100, Ref 24

3.2 Landscape Function Analysis

The LOI and SSA scores calculated from spring 2020 LFA monitoring are presented in Table 10 to Table 13 below. The results are presented as a comparison to the 2019 monitoring data to provide an assessment against the LFA completion criteria.

A self-sustaining landform is deemed to have been achieved when SSA scores of 50 or more are recorded (the LFA Completion Criteria, expected to be achieved by Year 10 of the management cycle). Incremental improvement toward that target is expected with each year of monitoring. Failure to

achieve an increase of five in the annual LFA scores represents a trigger for implementation of the Landscape Stability LFA TARP described in Table 21 of the BMP. Comparative annual results have been colour-coded to provide a visual indicator, with green reaching or exceeding the incremental increase of five or more, and red showing an increase of less than five (or in some cases, a reduction from the previous year). Red coded cells indicate the TARP needs to be implemented. Results maintained at or above the Completion Criteria (50) have been coded green regardless of comparative incremental increase or decrease from previous monitoring.

3.2.1 Enhancement and Conservation Areas (ECAs)

Two LFA monitoring sites (site A_100 and site B_106) are located within the ECAs, both within regenerating vegetation. The LOI and SSA results for these sites are presented in **Table 10.** During 2020 monitoring, site A_100 recorded a LOI of 0.94, whilst site B_106 recorded a LOI of 1.00, with both sites comprised almost entirely of perennial ground cover and litter patches. Both sites have recorded soil infiltration and nutrient cycling scores below the Completion Criteria target of 50, consistent with previous years, but showing a decline on 2019 results.

Table 10: LOI and SSA results for ECA transects

Site	Monitoring Season	Landscape Organisation Index (%)	Soil Surface Assessment		
			Stability	Infiltration	Nutrient Cycling
A_100	Spring 2020	0.94	47.0	22.6	17.7
	Spring 2019	0.97	58.6	38	34.8
		Annual incremental increase	-11.6	-15.4	-17.1
B_106	Spring 2020	1.00	53.3	34	24.8
	Spring 2019	0.81	61.3	40.8	32.4
		Annual incremental increase	8	-6.8	-7.6

3.2.2 Regeneration Areas

One LFA monitoring site, R4_100, is located within the Regeneration Areas. The LOI and SSA results for this site are presented in Table 11. The LOI for site R4_100 increased to 0.87%, with the transects being occupied with perennial groundcover and patches of litter, with only small patches of bare soil. The soil stability and nutrient cycling scores have increased from 2019, although they have not met the 5% annual improvement.

Table 11: LOI and SSA results for Regeneration Area transects

Site	Monitoring Season	Landscape Organisation Index (%)	Soil Surface Assessment		
			Stability	Infiltration	Nutrient Cycling
R4_100	Spring 2020	0.87	45.8	31.9	24.3
	Spring 2019	0.73	44.6	27.1	23.9
		Annual incremental increase	1.2	4.8	0.4

3.2.3 Rehabilitation Areas

Six LFA monitoring sites located within Rehabilitation Areas were monitored in 2020. The LOI and SSA results for the sites are presented in **Table 12.**

Spring 2020 monitoring results indicate that all Rehabilitation Area transects with exception to R11 experienced an increase in LOI scores in comparison to 2019 results. Increases are likely the result of greater perennial ground cover resulting from increased rainfall in 2020. The Soil Stability scores recorded at sites R6, R8, R9, R10, R11 and R13 exceeded the Completion Criteria. The Soil Infiltration and Nutrient cycling scores for all the Rehabilitation Area transects were below the Completion Criteria, although R11 and R13 recorded increases in 2020.

Table 12: LOI and SSA results for Rehabilitation Area transects

Site	Monitoring Season	Landscape Organisation Index (%)	Soil Surface Assessment		
			Stability	Infiltration	Nutrient cycling
R6	Spring 2020	0.69	51.7	27.5	24.3
	Spring 2019	0.31	58.6	30.2	29.7
		Annual incremental increase	-6.9	-2.7	-5.4
R8	Spring 2020	0.96	63.0	20.9	14.6
	Spring 2019	0.80	54.7	21.8	18.1
		Annual incremental increase	8.3	-0.9	-3.5
R9	Spring 2020	0.98	48.1	26.2	22.7
	Spring 2019	0.81	55.7	28.8	26.3
		Annual incremental increase	-7.6	-2.6	-3.6
R10	Spring 2020	0.79	52.3	25.3	22.6
	Spring 2019	0.71	57.8	27.2	23.9
		Annual incremental increase	-5.5	-1.9	-1.3
R11	Spring 2020	0.86	55.6	25.3	23.3
	Spring 2019	0.94	48.3	22.3	19.1
		Annual incremental increase	7.3	3	4.2
R13	Spring 2020	0.95	52.5	30.1	27.8
	Spring 2019	0.81	63.3	26.4	26.7
		Annual incremental increase	-10.8	3.7	1.1

3.2.4 Reference sites

LFA monitoring was undertaken at one Reference site, Ref 824_A in 2020. The LOI and SSA scores for the Reference site transect is presented in Table 13**.**

During spring 2020 monitoring, a high LOI score of 1.00 was recorded, indicating the site is entirely occupied with patches of perennial ground cover and litter, resulting in a stable landform. The soil surface stability, soil Infiltration and nutrient cycling scores have declined compared to 2019.

Table 13: LOI and SSA results for reference sites

Site	Monitoring Season	Landscape Organisation Index (%)	Soil Surface Assessment		
			Stability	Infiltration	Nutrient cycling
Ref 824_A	Spring 2020	1.00	49.5	38.5	32.2
	Spring 2019	1.00	62.2	44.8	39.5
		Annual incremental increase	-12.7	-6.3	-7.3

3.2.5 Discussion of LFA monitoring results

Most sites recorded relatively high LOI scores (>.80), indicating stable, functioning landform covered predominantly by perennial vegetation cover. LOI scores below 0.80 were recorded at sites R6 and R10, although R6 has more than doubled compared to 2019 (**Table 12**).

High LOI scores are reflective of high perennial vegetation and litter ground cover across most sites, leading to a more stable landscape, less susceptible to erosion. Within each of the Management Domains, the dominant patch types were perennial groundcover, litter and a mixture of perennial groundcover and litter.

All sites with exception to A_100, R9 and R4_100, met the Completion Criteria target for Stability. The Stability scores across the monitoring sites were comparable and mostly exceed that recorded at the Reference site in 2020. The changes in Stability scores may be attributed to greater increases in ground cover recorded at mostly cleared sites within WCPL management domains, compared to the relative stability of ground cover at Reference sites of remnant vegetation condition. Stability score show little variability, with all sites reaching the Completion Criteria for the majority of monitoring years (**Figure 10**).

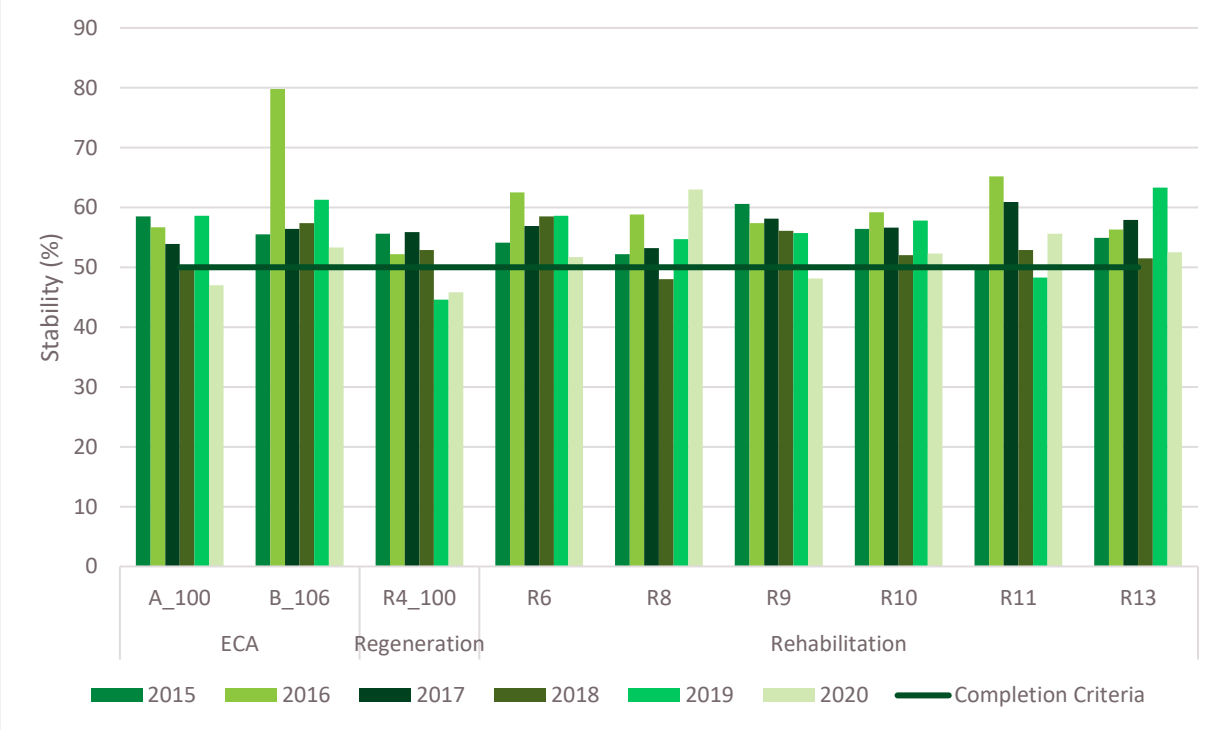


Figure 10: Stability LFA scores

Infiltration and Nutrient cycling indices were lower, with no site achieving the Completion Criteria target. Sites R13, R11 and R4_100 achieved the annual incremental increase for Infiltration, with site R11 also meeting the annual incremental increase for Nutrient cycling.

Infiltration is affected by litter decomposition, surface roughness and surface nature, whilst nutrient cycling is affected by perennial vegetation cover, litter cover and extent of litter decomposition, cryptogam cover and soil surface roughness. Whilst many LFA sites have moderate to dense cover of perennial vegetation (i.e. grasses) and/or high litter cover, there was limited litter decomposition observed and largely uniform soil micro topography. Additionally, the proportion of annual exotic vegetation cover increased in 2020 due to above average rainfall which likely influenced results.

Low infiltration and nutrient cycling scores may be due to historical clearing and livestock usage across the ECAs and Regeneration sites. Low scores recorded within the Rehabilitation sites may be due to the compacted artificial soils on which the Rehabilitation Areas are located and relatively lower levels of perennial vegetation. Most sites have not yet met the Completion Criteria for Infiltration and Nutrient cycling across any monitoring year and exhibit an overall declining trend Figure 11 and Figure 12. A decline was also recorded in the Reference site monitored in 2020, suggesting the results are likely correlated with seasonal changes. The results for these measures across years, indicates that they are subject to seasonal and observer variability and as such, may not be the most appropriate measures to track site progression or inform management.

Figure 11: Infiltration LFA scores

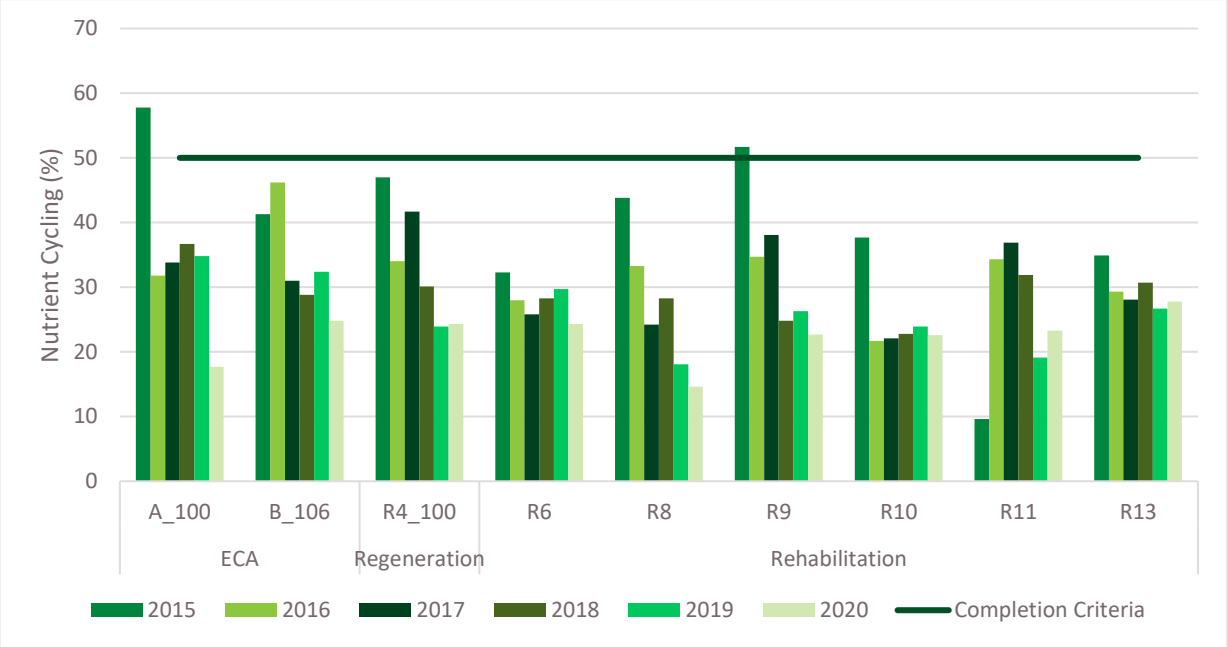


Figure 12: Nutrient Cycling LFA scores

3.2.6 Review of LFA results against Trigger Action Response Plan (TARP)

As per the updated WCPL BMP, TARPs have been developed in the event that LFA results are not incrementally improving towards the respective Completion Criteria. The TARP provides a plan to review and monitor these sites and increase remedial actions to address declining scores. As per the TARP, a review of these scores is required to be undertaken. It is recommended that this review include a consideration of the management aims for which LFA monitoring seeks to address and the efficacy of the LFA method to inform the achievement of these aims.

3.3 Fauna Monitoring

Fauna monitoring was undertaken during summer, winter and spring in 2020 across 39 sites (25 in summer, 39 in winter and 39 in spring). A total species richness of 133 species was recorded in 2020 comprising of 111 birds, one (1) amphibian, 9 reptiles, 1 mammal and 11 positively identified microbat species.

These include 13 threatened species:

- *Artamus cyanopterus cyanopterus* (Dusky Woodswallow)
- *Calyptorhynchus lathami* (Glossy Black-Cockatoo)
- *Chalinolobus dwyeri* (Large-eared Pied Bat)
- *Chthonicola sagittata* (Speckled Warbler)
- *Climacteris picumnus victoriae* (Brown Treecreeper (eastern subspecies))
- *Daphoenositta chrysoptera* (Varied Sittella)
- *Glossopsitta pusilla* (Little Lorikeet)
- *Hirundapus caudacutus* (White-throated Needletail)
- *Melanodryas cucullata cucullata* (Hooded Robin)
- *Melithreptus gularis gularis* (Black-chinned Honeyeater)

- *Miniopterus orianae oceanensis* (Large Bent-winged Bat)
- *Stagonopleura guttata* (Diamond Firetail)
- *Vespadelus troughtoni* (Eastern Cave Bat).

A full list of all fauna species recorded during the 2020 monitoring program is included in **Appendix G**.

3.3.1 Bird Monitoring

Bird monitoring results and species richness across all management domains was comparable with previous monitoring years, with a total of 109 species recorded within winter and spring 2020, compared to 114 species recorded within winter and spring 2019.

Bird species richness across the BOAs has generally increased in 2020 compared to 2019 results as seen below in Figure 13. Bird species richness across the ECAs and Rehabilitation Areas has fluctuated throughout monitoring years. With five years of monitoring data collected from these sites and little active management intervention undertaken, it is recommended that the program of ongoing annual monitoring is reviewed (see **Section 4**).

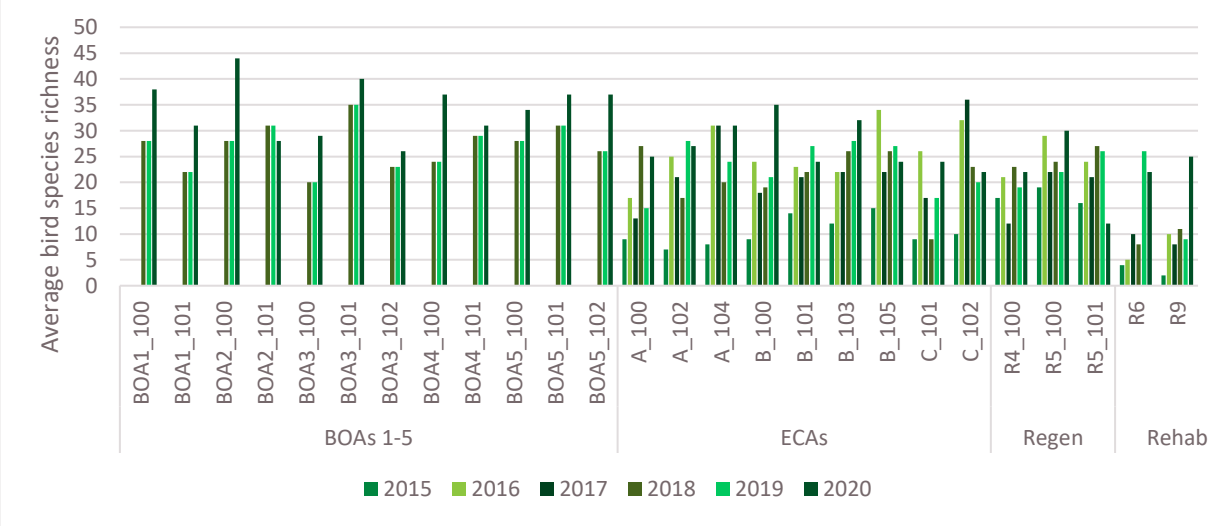


Figure 13: Average bird species richness

Rehabilitation Areas

Rehabilitation sites R6 and R9 recorded relatively high species richness counts, compared to previous years, and are an exception to the general trend of bird monitoring results across the other Management Domains. This provides a positive indication that increasing diversities of bird species will continue to be recorded across Rehabilitation sites as suitable habitat continues to develop.

There are two fauna sites within the Rehabilitation Areas, both of which have developed a moderately dense shrub layer and developing canopy layer. One threatened bird species, Speckled Warbler, was recorded at site R9.

The results of bird monitoring within the Rehabilitation Areas are shown in **Table 14**Error! Reference source not found..

Table 14: Rehabilitation Area bird monitoring results

Season	R6	R9*
Summer	10	
Winter	10	18
Spring	18	16
Overall bird richness	26	25

* BIRD SURVEY WAS NOT COMPLETED IN SUMMER 2020 AS THERE WAS NO ACCESS

Reference sites

Reference sites are scattered around the region in areas of remnant vegetation representing one of five approved WCPL Rehabilitation BVT's, HU547, HU697 HU732, HU824 and HU825. The sites were established in 2019 – 2020 and the 2020 monitoring represents Year 1. Bird monitoring results within the reference sites is shown in **Table 15**.

Table 15: Reference sites bird monitoring results

Season	Ref 547_A	Ref 547_B	Ref 547_C	Ref 697_A	Ref 697_B	Ref 732_A	Ref 732_B	Ref 732_C	Ref 824_A	Ref 824_B	Ref 824_C	Ref 825_A	Ref 825_B
Winter	18	14	18	27	26	22	29	32	19	25	22	24	12
Spring	12	21	25	29	23	20	23	29	25	33	13	14	28
Overall bird richness	22	29	31	41	32	32	39	43	34	44	26	26	32

Biodiversity Offset Areas

There are two fauna sites within BOA 1, both located within a woodland / forested area. The results of bird monitoring within BOA 1 are shown in **Table 16.**

Overall, both monitoring sites recorded similar and relatively high species richness, however, noticeably fewer species were recorded during spring surveys. There were three threatened bird species listed as vulnerable under the BC Act recorded within BOA 1 in 2020. These species were Dusky Woodswallow, Speckled Warbler and Little Lorikeet. White-throated Needletail, listed as vulnerable under the EPBC act was also observed within BOA 1.

Table 16: BOA 1 bird monitoring results

Season	BOA1_100	BOA1_101
Summer	32	31
Winter	32	24

Season	BOA1_100	BOA1_101
Spring	21	14
Overall bird richness	47	46

There are two fauna sites within BOA 2, both located within woodland / forest habitat. The results of bird monitoring within BOA 2 are shown in **Table 17.**

Overall, both monitoring sites recorded similar and relatively high species richness, however, noticeably fewer species were recorded during spring surveys. There were three threatened bird species listed as vulnerable under the BC Act recorded within BOA 2, Brown Treecreeper, Varied Sittella and Black-chinned Honeyeater.

Table 17: BOA 2 bird monitoring results

Season	BOA2_100	BOA2_101
Summer	25	37
Winter	40	25
Spring	14	10
Overall bird richness	49	45

There are three fauna sites within BOA 3, located within woodland / forest areas. The results of bird monitoring within BOA 3 are shown in **Table 18**.

Overall, site BOA3_101 recorded considerably higher species richness compared to the other two monitoring sites. There were two bird species listed as vulnerable under the BC Act recorded within BOA 3, Brown Treecreeper and Speckled Warbler. Both species were recorded during both spring and summer monitoring.

Table 18: BOA 3 bird monitoring results

Season	BOA3_100	BOA3_101	BOA3_102
Summer	10	24	12
Winter	21	22	11
Spring	17	28	19
Overall bird richness	30	47	30

There are two fauna sites within BOA 4, located within woodland / forest areas. The results of bird monitoring within BOA 4 are shown in **Table 19**.

Overall, both monitoring sites recorded similar species richness, however, noticeably fewer species were recorded during summer surveys. Three bird species listed as vulnerable under the BC Act were recorded within BOA 4 - Dusky Woodswallow, Varied Sittella and Speckled Warbler.

Table 19: BOA 4 bird monitoring results

Season	BOA4_100	BOA4_101
Summer	10	17
Winter	23	19
Spring	22	21
Overall bird richness	41	39

There are three fauna sites located within BOA 5, located within woodland / forest areas. The results of bird monitoring within BOA 5 are shown in **Table 20.**

Overall, all monitoring sites recorded similar species richness, however, winter surveys recorded a noticeably higher species richness compared to both summer and spring. There were four bird species listed as vulnerable under the BC Act recorded within BOA 5, Brown Treecreeper, Dusky Woodswallow, Glossy Black-Cockatoo and Speckled Warbler.

Table 20: BOA 51 bird monitoring results

Season	BOA5_100	BOA5_101	BOA5_102
Summer	15	17	18
Winter	25	32	27
Spring	17	18	22
Overall bird richness	38	42	42

Enhancement and Conservation Areas

There are three fauna sites located within ECA-A, two of which are located within woodland / forest areas whilst one is located in Derived Native Grassland (DNG). The results of bird monitoring within ECA-A are shown in **Table 21**.

There were two bird species listed as vulnerable under the BC Act recorded within ECA-A, Dusky Woodswallow and Speckled Warbler.

Table 21: ECA-A bird monitoring results

Season	A_100	A_102	A_104
Summer	8	12	9
Winter	18	22	25
Spring	12	12	15
Overall bird richness	27	31	35

There are four fauna sites located within ECA-B, two of which are located within woodland / forest areas whilst two are located in DNG. The results of bird monitoring within ECA-B are shown in **Table 22**.

There were four bird species listed as vulnerable under the BC Act recorded within ECA-B, Dusky Woodswallow, Speckled Warbler, Hooded Robin and Varied Sittella.

Table 22: ECA-B bird monitoring results

Season	B_100	B_101	B_103	B_105
Summer	12	13	16	17
Winter	25	13	25	14
Spring	22	14	19	15
Overall bird richness	39	31	38	31

There are two fauna sites located within ECA-C, with one each located within woodland / forest areas and DNG. The results of bird monitoring within ECA-C are shown in **Table 23**.

There was one bird species listed as vulnerable under the BC Act recorded within ECA-C, Brown Treecreeper, which was recorded during summer surveys.

Table 23: ECA-C bird monitoring results

Season	C_101	C_102
Summer	20	15
Winter	16	18
Spring	15	11
Overall bird richness	33	28

Regeneration Areas

There is one fauna site located within Regeneration Area 4, located within DNG which has undergone tubestock planting in 2020. The results of bird monitoring within Regeneration Area 4 are shown in **Table 24**.

Table 24: Regeneration Area 4 bird monitoring results

Season	R4_100
Summer	8
Winter	18
Spring	11
Overall bird richness	23

There are two fauna sites located within Regeneration Area 5, both located within DNG. The results of bird monitoring within Regeneration Area 5 are shown in **Table 25**.

One bird species listed as vulnerable under the BC Act was recorded, Little Lorikeet.

Table 25: Regeneration Area 5 bird monitoring results

Season	R5_100	R5_101
Summer	14	11
Winter	19	10
Spring	21	9
Overall bird richness	35	19

3.3.2 Microbats

Microbat monitoring was undertaken in spring 2020 across all Management Domains. The microbat monitoring results are presented below in **Table 26**, with the full ultrasonic analysis report in **Appendix C**.

There were a total of 1,316 call sequences recorded across all sites. Of these, 1,134 (86.17%) were deemed useful, because these call profiles were of sufficient quality and/or length to enable positive identification of a bat species. The remaining 182 (13.83%) call sequences were either too short or were of low quality, thus preventing positive identification of bat species.

There were at least eleven (11) and up to eighteen (18) species recorded during this 2020 monitoring. Three threatened microbat species were positively identified from the call profiles:

- *Chalinolobus dwyeri* (Large-eared Pied Bat) – vulnerable BC Act; vulnerable EPBC Act
- *Miniopterus orianae oceanensis* (Large Bent-winged Bat) – vulnerable BC Act
- *Vespadelus troughtoni* (Eastern Cave Bat) – vulnerable BC Act .

Two further threatened species were also identified from probable call profiles:

- *Nyctophilus corbeni* (Corben's Long-eared Bat) - vulnerable BC Act; vulnerable EPBC Act
- *Saccolaimus flaviventris* (Yellow-bellied Sheath-tailed Bat) – vulnerable BC Act.

During the 2020 surveys, calls attributed to the Large-eared Pied Bat were recorded at six of the survey sites including BOA1, BOA3, BOA4, BOA5, ECA-B B101, ECA-C C102 and potentially at a seventh site ECA-A A104 . Only five calls attributed to *Nyctophilus* spp. (and therefore potentially Corben's Long-eared Bat) were recorded across three of the eight survey sites, including BOA3, BOA5 and ECA-B B101. Calls attributed to the Eastern Cave Bat were recorded at five of the eight sites. This includes potential calls recorded at BOA1 and definite calls recorded at BOA3, BOA4, BOA5 and ECA-B B101. The Yellow-bellied Sheath-tailed Bat was only potentially recorded at ECA-B B101. The Large Bent-winged Bat was recorded at five sites including BOA2, BOA3, BOA4, BOA5 and ECA-C C102, with potential calls also recorded at a further two sites; BOA1 and ECA-B B101. These results indicate that the WCPL management domains continue to provide suitable habitat and/or are within range to suitable habitat for a range of threatened microbat species.

Table 26: Microbat monitoring results

Scientific name	Common name	BOA					ECA		
		BOA1	BOA2	BOA3	BOA4	BOA5	A_104	B_101	C_102
Austronomus australis	White-striped Free-tailed Bat	D	-	-	D	D	D	D	-
Chalinolobus dwyeri	Large-eared Pied Bat	D	-	D	D	D	P	D	D
Chalinolobus gouldii	Gould's Wattled Bat	D	P	D	P	D	D	D	P
Chalinolobus morio	Chocolate Wattled Bat	D	D	D	-	D	-	D	-
Miniopterus orianae oceanensis	Large Bent-winged Bat	P	D	D	D	D	-	P	D
Nyctophilus corbeni	Corben’s Long-eared Bat	-	-	P	-	P	-	P	-
Nyctophilus geoffroyi	Lesser Long-eared Bat	-	-	P	-	P	-	P	-
Nyctophilus gouldii	Gould’s Long-eared Bat	-	-	P	-	P	-	P	-
Ozimops petersi	Inland Free-tailed Bat	D	D	D	D	D	D	D	D
Ozimops ridei	Ride's Free-tailed Bat	D	D	D	D	D	D	D	D
Ozimops planiceps	South-eastern Free-tailed Bat	D	D	D	D	D	D	D	D
Rhinolophus megaphyllus	Eastern Horseshoe Bat	D	-	D	D	D	D	-	D
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat	-	-	-	P	P	-	P	-
Scotorepens balstoni	Inland Broad-nosed Bat	-	-	D	D	D	-	D	-
Vespadelus darlingtoni / Vespadelus vulturnus	Large Forest Bat / Little Forest Bat	-	-	-	-	-	-	P	-
Vespadelus regulus	Southern Forest Bat	P	P	P	P	P	-	P	-
Vespadelus troughtoni	Eastern Cave Bat	P	P	D	D	D	-	D	-
Vespadelus vulturnus	Little Forest Bat	P	D	D	D	D	-	D	-

Scientific name	Common name	BOA					ECA		
		BOA1	BOA2	BOA3	BOA4	BOA5	A_104	B_101	C_102
Total		**8**	**6**	**11**	**10**	**12**	**6**	**10**	**6**

D = Definitely recording; P = Potentially recorded

3.3.3 Ground Fauna

Ground fauna monitoring was undertaken at 17 pitfall/funnel trap sites over a period of one week per site. Artificial habitat refuges placed around some sites were also checked daily. Reptiles were the most abundant group captured during 2020, with nine different reptile species recorded across all monitoring sites. Only one mammal, the introduced *Mus Musculus* (House Mouse) was observed during 2020 monitoring.

The results of ground fauna monitoring on the BOAs is shown below in **Table 27.** One species, *Varanus varius* (Lace Monitor), was observed opportunistically (i.e. not caught in a trap).

Table 27: BOA ground fauna monitoring results

Scientific Name	Common Name	BOA1_100	BOA2_101	BOA3_100	BOA4_101	BOA5_100	BOA5_101
Diplodactylus vittatus	Eastern Stone Gecko			1			
Mus musculus	House Mouse	1					
Varanus varius	Lace Monitor				1		1
Furina diadema	Red-naped Snake		1				
Anomalopus leuckartii	Two-clawed Worm skink	1					1
Liopholis whitii	White's Skink					1	
Demansia psammophis	Yellow-faced Whipsnake		1				1
Total		**2**	**2**	**1**	**1**	**1**	**3**

Ground fauna monitoring results from the ECAs is shown below in **Table 28**.

Table 28: ECA ground fauna monitoring results

Scientific Name	Common Name	A_100	A_102	B_100	B_101	B_103
Diplodactylus vittatus	Eastern Stone Gecko		1			
Mus musculus	House Mouse	3	2			
Morethia boulengeri	Boulenger's Snake-Eyed Skink			2		
Carlia tetradactyla	Southern Rainbow Skink				1	
Diporiphora nobbi	Common Nobbi Dragon					1

Scientific Name	Common Name	A_100	A_102	B_100	B_101	B_103
Demansia psammophis	Yellow-faced Whipsnake			1		
Total		**1**	**2**	**2**	**1**	**1**

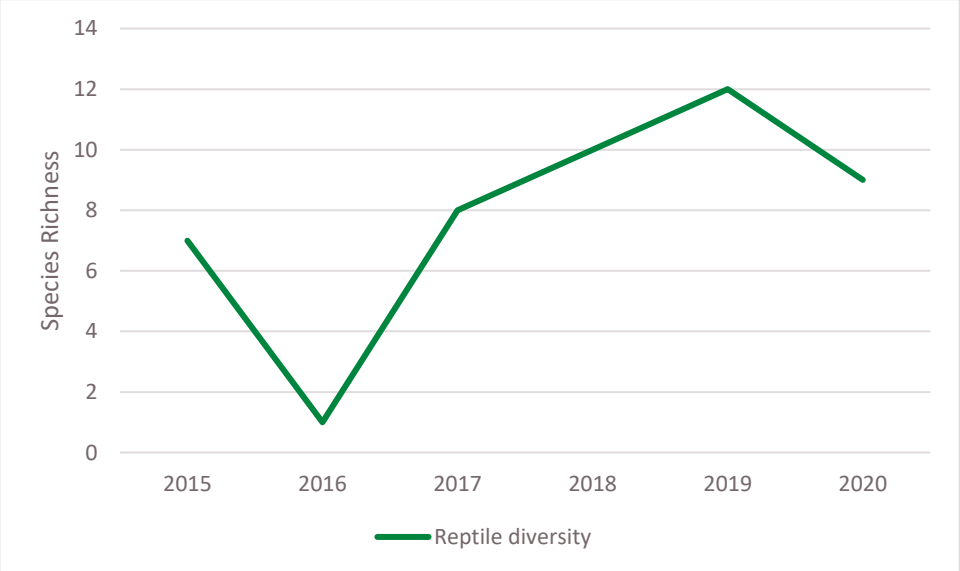
Ground fauna monitoring results from the Rehabilitation Areas is shown below in **Table 29**.

Table 29: Rehabilitation Areas ground fauna monitoring results

Scientific Name	Common Name	R6	R9
Litoria caerulea	Green Tree Frog	1	
Carlia tetradactyla	Southern Rainbow Skink	1	
Species richness		**2**	**0**

The nine reptile species recorded in 2020 was a decline from the 12 species recorded during 2019, however, was relatively high across all monitoring years (**Figure 14**). A total of 25 reptile species (inclusive of opportunistically recorded species) have been recorded across WCPL management domains since the commencement of monitoring in 2015, representing a good overall diversity, however, the abundance of reptiles has been consistently low, with typically only one to three individuals of each species recorded. The recording of one mammal species and one amphibian species in 2020 is largely consistent with previous years with only a total of three mammal species and five amphibian species recorded since the commencement of monitoring in 2015. Alternative survey methods such as nocturnal spotlighting, would likely record an increased abundance of both amphibian and mammal species (see **Section 4**).

Figure 14: Reptile species richness across monitoring years, 2015 - 2020



3.3.4 Nest Box Monitoring

Sixty-nine nest boxes were monitored during 2020, with three boxes unable to be located. Nine boxes demonstrated signs of use; with seven of these nest boxes containing nests or nesting material and were determined to have been used recently, based upon the apparent freshness of nesting material (e.g. leaves) and scats present. All 69 nest boxes monitored were deemed fit for use.

Only one resident fauna species in the form of *Sturnus vulgaris* (Common Starlings) eggs, were observed in one nest box. The summarised results of the nest box monitoring are shown in **Table 30**.

Table 30: Nest Box monitoring results from 2020

Installation Area	Condition			Fauna present (%)	Signs of use		
	Fit (%)	Repair (%)	Unserviceable (%)		Nest / nesting material (%)	Chewing present (%)	Other (e.g. feathers, down) (%)
ECA B	100	0	0	2	6.1	4.1	0
Regen 5	100	0	0	0	66.7	0	0
Regen 9	100	0	0	0	0	0	0

4. Recommendations and conclusion

4.1 BioMetric monitoring

BioMetric monitoring was undertaken within all Management Domains and selected Reference sites prescribed by the BMP during 2020.

SVSs in the Rehabilitation Areas have all improved compared to 2019. When assessed against the WCPL Interim Performance Criteria, three of the four rehabilitation sites are above the Moderate to Good SVS. The development of local benchmarks from reference sites is expected to be undertaken in early 2021 which will inform the final WCPL Rehabilitation Completion Criteria in which Rehabilitation monitoring sites will be compared during subsequent monitoring years.

In the ECA and Regeneration Areas, the SVSs for most sites have remained consistent, outside of minor seasonal variation, with no clear trends visible despite five years of annual surveys. Most of these sites have not been subject to active management intervention and as such, there is little value to continue ongoing annual monitoring. A revision of these sites is recommended and detailed in **Section 4.4**.

Given the focus of the WCPL rehabilitation BVTs and their respective Reference sites is largely based on providing habitat for Regent Honeyeater, it is proposed that additional data for mistletoe and eucalypt presence, flowering and budding is collected during BioMetric monitoring.

4.2 Landscape Function Analysis monitoring

The LOI data captured during 2020 observed increases indicating an improvement in ground cover across all sites, likely due to vegetation growth from above average rainfall in 2020. A higher LOI represents better site stability and less susceptibility to erosion. All sites except for A_100, R9 and R4_100 meet the stability completion criteria, this indicates that stability is high and levels of erosion within the majority of sites are low and consistent with previous monitoring seasons. Infiltration and Nutrient cycling within all management domains did not meet the completion criteria, which is consistent with previous results and results obtained at reference sites in 2020. These results have triggered the relevant TARP and it is recommended that the TARP review include a consideration of the management aims for which LFA monitoring seeks to address and the efficacy of the LFA method to inform the achievement of these aims.

There is evidence that LFA generated scores do not adequately reflect the functional success of rehabilitated coal mine lands (Erskine et al. 2015), do not provide useful annual inter-site comparisons and that alternative methods are available to better monitor rehabilitation establishment and stability. The use of remote sensing (e.g. LiDAR and Digital Elevation Models (DEMs)) can be used to assess slope, gradient and erosion at high resolution across rehabilitated areas in addition with erosion and stability transects which can mirror the BioMetric transects currently utilised for floristic monitoring. It is considered timely to undertake a review of the current LFA method, in line with the recently approved WCPL rehabilitation BVTs and their associated changes.

4.3 Fauna monitoring

With up to five years of fauna monitoring data collected, there is a sufficient quantum of data available to have an understanding of the fauna assemblages present across the various WCPL management

domains. As such, a review of the fauna monitoring program is recommended, with an updated monitoring program focusing on sites which specifically provide either reference data for WCPL approved rehabilitation BVTs, representative coverage of WCPLs management domains or track the response to specific management intervention. The sites proposed to be discontinued / altered in monitoring frequency are detailed below in **Section 4.4**.

As part of the suggested review of monitoring sites, it is recommended that a range of alternative fauna monitoring methods such as the following are considered, in order to capture the range of fauna species utilising the various WCPL management domains, in a more cost-effective manner. It is recommended that the following methods would be used in place of the current pit fall and funnel surveys currently undertaken.

- Remote Cameras
- 20-minute targeted searches (including of artificial habitat refuges) for ground fauna e.g. reptiles, mammals
- Nocturnal surveys.

4.4 Monitoring program revision

With up to five years of data collected from monitoring sites across the various WCPL management domains, a revision of the monitoring sites and scheduled is warranted. As described above, the following sites are not considered to address any specific requirement of the BMP or provide useful insight for ongoing monitoring and/or management aims, and as such, are suggested to be discontinued or revised in their monitoring frequency:

- A_100
- A_102
- A_103
- A_104
- B_101
- B_105
- B_103
- B_106
- C_101
- R2_101
- R4_100
- R5_100
- R5_101
- R9_100
- R9_101
- BOA1_101
- BOA2_101
- BOA3_102
- BOA4_101
- BOA5_101.

- R8
- R10

A review of the monitoring results and recommendations to inform future monitoring and assist progression toward Completion Criteria is presented below in **Table 31**.

Table 31: Summary of recommendations

Monitoring	Comment	Recommendation
BioMetric monitoring		
Rehabilitation sites	All sites recorded an improvement in SVS compared to 2019 monitoring.	Continue monitoring as per the BMP, with additional data recorded for mistletoe and eucalypt flowering
ECA, BOA 1- 5 and Regeneration sites	No clear trend observed across all sites. As seen within **Figure 8** and **Figure 9**, the variability between years is mostly attributed to seasonal variation. Long term trends are unlikely to be observed unless active management is implemented.	Complete a review of current monitoring sites to determine which sites will be monitored as part of the future monitoring program
Reference sites	First year these sites have been monitored as part of Wilpinjong annual monitoring program.	Continue monitoring as per the BMP, with additional data recorded for mistletoe and eucalypt flowering
Landscape Function Analysis (LFA)		
ECA and Regeneration Area sites	The three ECA and Regeneration Area LFA sites consistently record high LOI and meet the Stability completion criteria. Infiltration and Nutrient cycling attributes, however, are consistently not meeting the completion criteria and there is no clear trend for either of these attributes.	LFA can be used to inform mine site rehabilitation, however, where active management is not being undertaken it is not a reliable indicator of ongoing stability. It is recommended that monitoring is discontinued at the three ECA and Regeneration Area sites: • A_100 • B_106 • R4_100
Rehabilitation sites	All sites except for R11 recorded an increase in the LOI which can be attributed to an increase in total ground cover. All sites except for R9 meet the Annual incremental increase or the completion criteria for stability. No sites have met the completion criteria for Infiltration and Nutrient cycling in 2020, as seen within **Figure 11** and **Figure 12**.	A review of the current LFA program is recommended to determine: • The management actions sought to be measured by LFA monitoring • The efficacy of the current LFA method to inform the achievement of these management actions. The use of remote sensing (e.g. LiDAR and Digital Elevation Models (DEMs)) can be used to assess slope, gradient and erosion at high resolution across rehabilitated areas in addition with erosion and stability transects which can mirror the BioMetric transects utilised for floristic monitoring.
Fauna		
Bird Monitoring	Rehabilitation sites R6 and R9 recorded relatively high species richness counts, compared to previous years, and are an	Increasing bird species diversity and species richness recorded at Rehabilitation Area sites indicates that management actions are

Monitoring	Comment	Recommendation
	exception to the general trend of bird monitoring results across the other Management Domains. This provides a positive indication that increasing diversities of bird species will continue to be recorded across Rehabilitation sites as suitable habitat continues to develop. Bird species richness across the BOAs has generally increased in 2020 compared to 2019 results, but has fluctuated throughout monitoring years.	improving biodiversity and habitat. Monitoring should continue at these sites. Fluctuating results with no clear trends after five years of monitoring at other Management Domain sites indicates the value of ongoing bird monitoring at its current frequency is limited. With the WCPL rehabilitation BVTs and their respective Reference sites now approved, bird monitoring can focus on both Rehabilitation and Refence sites with more targeted methodology (such as 5-minute call playback) aimed at recording Regent Honeyeater and/or surrogate nectarivorous species.
Ground Fauna	Species are limited to reptiles and occasional small marsupials.	A review of the WCPL fauna monitoring program is recommended, to increase the level of species diversity using less onerous methods. The following methods are our initial suggestions: • Remote Cameras • 20-minute ground fauna search • Nocturnal surveys. These methods could be implemented for BOA sites until such time that they are transferred to the National Parks Estate, along with ECA and Regeneration sites. Implementing these methods at Rehabilitation and Reference sites will be considered once habitat for ground fauna at Rehabilitation sites has developed sufficiently.
Nest Box	Common Starling eggs were observed in one (1) nest box, with signs of fauna use observed in nine nest boxes.	Continue to monitor to provide data on whether nest boxes are inhabited by resident fauna.
Microbat Monitoring		A review of the microbat monitoring program including the frequency and survey effort in each WCPL management domain is recommended.

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Appendix A – Weather conditions

Table A – 1: 2020 Monthly mean and historical average weather conditions

Month	2020			Historical Averages		
	Min Temp (°C)	Max Temp (°C)	Total Rainfall (mm)	Min Temp (°C)	Max Temp (°C)	Rainfall Mean (mm)
January	20.2	34.4	27.2	17.0	31.4	66.5
February	18.3	27.9	127	16.4	30.0	62.6
March	14.8	24.7	92	13.8	27.5	53.5
April	10.3	22.3	117	9.9	23.5	39.5
May	5.6	17.8	16	6.3	19.1	37.5
June	4.1	15.9	23.4	3.7	15.5	43.7
July	3.4	15.6	70	2.6	14.9	42.3
August	3.6	15.6	36.4	3.3	16.6	40.8
September	7.2	20.5	77.2	6.1	19.9	41.5
October	10.5	24.0	150.6	9.4	23.9	51.3
November	13.5	28.4	17.4	12.4	26.9	55.4
December	16.2	26.9	161.6	15.0	29.9	60.7

Source: WCPL (2020 data); Bureau of Meteorology, 2020 (Historical averages) Temperature data from Gulgong Post Office weather station number 62013. Rainfall from Wollar (Barrigan St) Weather station number 62032.

Table A – 2: Monthly Rainfall from 2013 – 2020 (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2013	73.6	54.2	61.4	12.2	17.4	77.9	20.8	6.6	33.0	8.8	78.6	27.6	472.1
2014	15.6	60.0	112.6	62.8	13.8	29.8	28.6	28.8	14.6	15.4	24.4	126.7	533.1
2015	127.6	11.6	9.4	108.4	42.8	42.8	38.0	53.8	7.8	61.0	59.0	118.4	680.6
2016	152.1	7.2	23.5	14.8	66.8	104.2	101.1	40.9	198.7	86.6	51.9	90.6	938.4
2017	27.8	34.2	146	23	32.4	10.4	5.8	25.2	3	28.4	92.6	102.6	531.4
2018	24.4	77	24.6	42.2	12.4	21.6	1.2	43.8	39.6	56.8	47.4	91.2	482.2
2019	54.8	7.4	108.8	0	17.6	10.6	2.6	10.2	23	5.6	22	3	265.6
2020	27.2	127	92	117	16	23.4	70	36.4	77.2	150.6	17.4	161.6	915.8
Historical Mean	66.5	62.6	53.5	39.5	37.5	43.7	42.3	40.8	41.5	51.3	55.4	60.7	595.3

Source: WCPL and Bureau of Meteorology, 2017 (Historical averages) Wollar (Barrigan St) Weather station number: 62032.

Appendix B – 2020 Biodiversity monitoring sites

Table B – 1: Autumn 2020 BioMetric Monitoring sites

Domain	Site	Management Domain	Condition	Keith Vegetation Class	Vegetation Community	Easting	Northing
BOA 1 – 5	BOA1_100	BOA_1	Native Vegetation	WSDSF	White Box Shrubby Woodland	766944	6414592
	BOA2_100	BOA_2	Native Vegetation	WSDSF	White Box Shrubby Woodland	769159	6413073
ECA	A_102	ECA-A	Regeneration	WSGW	Box-Gum Grassy Woodland on Valley Floors (DNG)	772917	6417079
	A_103	ECA-A	Native vegetation	WSGW	Blakely's Red Gum Woodland	773142	6417621
	B_103	ECA-B	Native vegetation	WSDSF	Grey Gum – Narrow-leaved Stringybark Forest	771079	6420160
	B_106	ECA-B	Regeneration	WSGW	Yellow Box Woodland (DNG)	771570	6420003
	C_101	ECA-C	Regeneration	WSDSF	White Box Shrubby Woodland (DNG)	768365	6416938
	R5_100	Regeneration Area 5	Regeneration	WSGW	Rough-barked Apple Woodland (DNG)	769194	6421424
	R9_101	Regeneration Area 9	Regeneration	WSGW	Rough-barked Apple Woodland (DNG)	768829	6422231
Rehabilitation	R6	Rehabilitation	Rehabilitation	WSDSF	NA	769566	6419516
	R9	Rehabilitation	Rehabilitation	WSDSF	NA	769120	6418969
	Ref_23	Goulburn River National Park	Native vegetation	WSGW	Yellow Box Grassy Woodland	769183	6422270
	Ref_24	BOA-E	Native vegetation	WSGW	White Box Shrubby Woodland	779295	6419440

Table B – 2: Spring 2020 BioMetric monitoring sites

Domain	Site	Management Domain/Location	Condition	Keith Vegetation Class	Vegetation Community	Easting	Northing
ECA	A_100	ECA-A	Regeneration	WSGW	DNG – other native (non-EEC)	771861	6416276
	A_104	ECA-A	Native Vegetation	WSGW	Narrow-leaved Ironbark Forest	773695	6416293

Domain	Site	Management Domain/Location	Condition	Keith Vegetation Class	Vegetation Community	Easting	Northing
	B_100	ECA-B	Native Vegetation	WSGW	Sandstone Ranges Shrubby Woodland	770111	6420997
	B_101	ECA-B	Regeneration	WSGW	DNG – other native (non-EEC)	770542	6420592
	B_105	ECA-B	Regeneration	WSDSF	DNG – other native (non-EEC)	773141	6420468
	C_102	ECA-C	Native Vegetation	WSGW	Shrubby White Box Woodland	768940	6417281
Regeneration Area	R2_101	Regeneration Area 2	Regeneration	WSGW	DNG – other native (non-EEC)	772639	6418355
	R4_100	Regeneration Area 4	Regeneration	WSGW	DNG – other native (non-EEC)	770347	6420268
Rehabilitation Area	R8	Rehabilitation Area	Rehabilitation – Grassland	WSGW	N/A	770231	6418596
	R10	Rehabilitation Area	Rehabilitation – Grassland	WSGW	N/A	768433	6419301
Reference Site	Ref 824_A	Reference site				6414688	781932
	Ref 732_C	Reference site				6422269	769182
	Ref 824_B	Reference site				6419440	779295
	Ref 824_C	Reference site				6413073	769159
	Ref 547_A	Reference site				6420489	770637
	Ref 547_B	Reference site				6420878	770151
	Ref 547_C	Reference site				6418422	778934
	Ref 697_A	Reference site				6425717	783397
	Ref 697_B	Reference site				6410089	747549
	Ref 697_C	Reference site				6424600	751095
	Ref 732_A	Reference site				6422270	769183
	Ref 732_B	Reference site				6421602	769389
	Ref 825_A	Reference site				6415657	774926

Domain	Site	Management Domain/Location	Condition	Keith Vegetation Class	Vegetation Community	Easting	Northing
	Ref 825_B	Reference site				6415400	774805
	Ref 825_C	Reference site				6415573	775162

Table B – 3: LFA monitoring sites

Site	Management Domain	Easting	Northing	Zone	Type
A_100	ECA-A	771861	6416276	55H	BioMetric and LFA
B_106	ECA-B	771571	6420001	55H	LFA
R10	Rehabilitation Area	768433	6419301	55H	BioMetric and LFA
R11	Rehabilitation Area	768896	6419664	55H	BioMetric and LFA
R13	Rehabilitation Area	770872	6418901	55H	LFA
R4_100	Regeneration Area 4	770347	6420268	55H	BioMetric and LFA
R6	Rehabilitation Area	769562	6419517	55H	LFA
R8	Rehabilitation Area	770231	6418596	55H	BioMetric and LFA
R9	Rehabilitation Area	769118	6418973	55H	LFA
Ref_8	Goulburn River National Park	781932	6414688	55H	BioMetric and LFA

Table B – 4: Fauna monitoring sites

Area	Site ID	Coordinates		Management Zone	Vegetation Class	Survey		
		Easting	Northing			Fauna	Bats	Birds only
ECA-A	A_100	771861	6416276	Regeneration (poor resilience)	Western Slopes Grassy Woodland	Y		
	A_102	772926	6417078	Regeneration (moderate resilience)	Western Slopes Grassy Woodland	Y		
	A_104	773695	6416293	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y	Y	
BOA-1	BOA1_100	766963	6414300	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y	Y	
	BOA1_101	767441	6414516	Regeneration (moderate resilience)	Western Slopes Grassy Woodland			Y
BOA-2	BOA2_100	769440	6413937	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y	Y	

Area	Site ID	Coordinates		Management Zone	Vegetation Class	Survey		
		Easting	Northing			Fauna	Bats	Birds only
	BOA2_101	769050	6413570	Native vegetation (good resilience)	Western Slopes Grassy Woodland			Y
BOA-3	BOA3_100	784649	6421025	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y	Y	
	BOA3_101	784714	6422246	Native vegetation (good resilience)	Western Slopes Grassy Woodland			Y
	BOA3_102	784258	6421909	Native vegetation (good resilience)	Dry Rainforest	Y		
BOA-4	BOA4_100	782475	6424100	Native vegetation (good resilience)	Western Slopes Grassy Woodland			Y
	BOA4_101	782527	6423888	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y	Y	
BOA-5	BOA5_100	784073	6417976	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y	Y	
	BOA5_101	783192	6419415	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y		
	BOA5_102	784493	6419150	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest			Y
ECA-B	B_100	770111	6420997	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y		
	B_101	770542	6420592	Regeneration (moderate resilience)	Western Slopes Grassy Woodland	Y	Y	
	B_103	771072	6420157	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y		
	B_105	773141	6420468	Regeneration (moderate resilience)	Western Slopes Dry Sclerophyll Forest			Y
ECA-C	C_101	768377	6416929	Regeneration (moderate resilience)	Western Slopes Dry Sclerophyll Forest	Y		

Area	Site ID	Coordinates		Management Zone	Vegetation Class	Survey		
		Easting	Northing			Fauna	Bats	Birds only
	C_102	768940	6417281	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y	Y	
Regeneration Area 4	R4_100	770347	6420268	Regeneration (no resilience)	Western Slopes Grassy Woodland			Y
Regeneration Area 5	R5_100	769191	6421422	Regeneration (moderate resilience)	Western Slopes Grassy Woodland			Y
	R5_101	769500	6421595	Regeneration (moderate resilience)	Western Slopes Dry Sclerophyll Forest			Y
Regeneration Area 6	R6_101	767406	6420303	Regeneration (no resilience)	Western Slopes Grassy Woodland			
Rehabilitation	R6	769562	6419517	Rehabilitation - Woodland	Western Slopes Dry Sclerophyll Forest	Y		
	R9	769118	6418973	Rehabilitation - Woodland	Western Slopes Dry Sclerophyll Forest	Y		
Reference sites	Ref 824_A	6414688	781932	N/A	HU824			Y
	Ref 732_C	6422269	769182	N/A	HU732			Y
	Ref 824_B	6419440	779295	N/A	HU824			Y
	Ref 824_C	6413073	769159	N/A	HU824			Y
	Ref 547_A	6420489	770637	N/A	HU547			Y
	Ref 547_B	6420878	770151	N/A	HU547			Y
	Ref 547_C	6418422	778934	N/A	HU547			Y
	Ref 697_A	6425717	783397	N/A	HU697			Y
	Ref 697_B	6410089	747549	N/A	HU697			Y
	Ref 697_C	6424600	751095	N/A	HU697			Y
	Ref 732_A	6422270	769183	N/A	HU732			Y
	Ref 732_B	6421602	769389	N/A	HU732			Y
	Ref 825_A	6415657	774926	N/A	HU825			Y
	Ref 825_B	6415400	774805	N/A	HU825			Y
	Ref 825_C	6415573	775162	N/A	HU825			Y

Appendix C – Microbat Ultrasonic Analysis Report

PROJECT BACKGROUND AND SITE DESCRIPTION

Eco Logical Australia Pty Ltd (ELA) was engaged by WCPL to analyse ultrasonic microchiropteran bat call data collected from a number of locations associated with their offset sites. This data forms part of an ongoing annual biodiversity monitoring program.

This report outlines the methodology used and results of the data analysis.

METHODS

Four (4) Anabat Swift (AS) (Titley Electronics) ultrasonic detectors were set at eight locations between 28 September and the 20 October 2020 within the WCPL study area. Table 1 provides an overview of when the recordings were undertaken, a description of survey effort, and the identification number of the detector used to conduct each survey. Each detector was set to survey ultrasonic microbat calls passively over two consecutive nights during the survey period. A total of 16 survey nights were completed during this survey.

Table 1 The WCPL survey site numbers, survey dates, survey effort and Anabat Swift detector identification number

Offset Area	Site	Survey dates	Survey effort	Detector identification number
BOA	BOA1_100	19 – 20 October 2020	Two survey nights	ABS1
	BOA2_101	19 – 20 October 2020	Two survey nights	ABS3
	BOA3_100	12 – 13 October 2020	Two survey nights	ABS3
	BOA4_101	12 – 13 October 2020	Two survey nights	ABS2
	BOA5_101	12 – 13 October 2020	Two survey nights	ABS4
ECA-A	A_104	19 – 20 October 2020	Two survey nights	ABS4
ECA-B	B_101	12 – 13 October 2020	Two survey nights	ABS1
ECA-C	C_102	28 – 29 September 2020	Two survey nights	ABS1

DATA ANALYSIS

The ultrasonic call data was recorded passively on Anabat Swift detectors (AS) (Titley Electronics). Microbat calls recorded on the Anabat Swift detectors are recorded as WAV sound files. These WAV files were viewed using the software program Anabat Insight (Version 1.9.2-0g2fd2328) (Titley Scientific) in either zero crossing (ZC) format or full spectrum formats.

Call identifications were made by Rodney Armistead from ELA using regional based guides to the echolocation calls of microbats in New South Wales (Pennay et al 2004); and south-east Queensland and

north-east New South Wales (Reinhold et al 2001) and the accompanying reference library of over 200 calls from Sydney Basin, NSW (which is available at http://www.forest.nsw.gov.au/research/bats/default.asp). Species identification was guided by considering probability of occurrence based upon the general distribution information that is provided in Churchill (2008); Pennay et al. (2011), Van Dyck and Strahan (2008), Van Dyck et al. (2013) and on the Australian Bat Society web page (Australian Bat Society Inc (2018)). A technical review of this report and a sample of the calls was performed by Alicia Scanlon also from ELA. Alicia has over 14 years of experience in the identification of ultrasonic call recordings.

To ensure reliable and accurate results the following protocols (adapted from Lloyd et al. 2006) were applied:

- Search phase calls are used preferentially when analysing the data because they contain more diagnostic features, rather than cruise phase calls or feeding buzzes (McKenzie et al. 2002).
- Recorded calls containing less than three pulses are not analysed as they are often too short to confidently determine the identity of the species making the call (Law et al. 1999). These short sequences were either removed manually or were labelled as unidentifiable.
- For those calls that are able to be used to identify the species making the call, two categories of confidence are used (Mills et al. 1996):
- Definitely present – the quality and structure of the call profile is such that the identity of the bat species making the calls is not in doubt.
- Potentially present – the quality and structure of the call profile is such that there is some / low probability of confusion with species that produce similar calls profiles.
- Calls made by bats that cannot be used for identification purposes such as social calls, short and low-quality calls, cruise and approach phase calls were removed from the data.
- *Nyctophilus* spp. (Long-eared bats) are difficult to identify or separate confidently to species level based upon their recorded calls. Therefore, we have made no attempt to identify any *Nyctophilus* spp. calls recorded during this survey to species level (Pennay et al. 2004). There are three potential Nyctophilus species that could occur in the WCPL offset study area. Two are non-threatened species, *N. geoffroyi* (Lesser Long-eared Bat) and *N. gouldii* (Gould's Long-eared Bat). Both of these species are relatively common and widely distributed across NSW. However, the third species, *N. corbeni* (Corben's Long-eared Bat) is listed as vulnerable under the NSW *Biodiversity Conservation Act 2016* (BC Act) and *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). According to Churchill (2008), Penny et al. (2011) and the Department of the Environment and Energy (DoEE) Species Profile and Threats Database, Corben's Long-eared Bat is likely to occur within the locality. Where *Nyctophilus* spp. calls were recorded, we have included this threatened microbat species as potentially being present. To confirm the presence / absence of Corben's Long-eared Bat within the study area, further survey effort would be required that involves the use of mist or harp traps to conduct live capture and release. These surveys would need to fulfil the survey requirements present in Commonwealth of Australia (2010) Survey Guidelines for Australia's threatened bats. For further information regarding the distribution of this species, please refer to the following link, http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=83395.
- The Free-tailed Bats (previously referred to as the genus *Mormopterus or Tadarida*) have recently undergone taxonomic revision (Reardon et al. 2014) and now comprise four separate

genus; *Austronomus*, *Micronomus, Ozimops* and *Setirostris* (Table). This report uses nomenclature for Free-tailed Bat species as referred to in Jackson and Groves (2015). The correlation between nomenclature used in this report and that used in NSW State legislation is presented in Table below. Published reference calls for the genus *Ozimops* (Pennay et al. 2004) are believed to contain errors (Greg Ford pers comm.). Because of this uncertainty, all Free-tailed Bats in the new genus *Ozimops* recorded within the survey area will be referred to as being part of the *Ozimops* species complex.

- Jackson & Groves (2015) list the Eastern Bent-winged Bat (*Miniopterus schreibersii oceanensis*) under the new name of *M. orianae* (Large Bent-winged Bat). However, we follow the NSW Department of Planning, Industry and Environment (DPIE) nomenclature as it applies to the eastern form of the species which occurs in NSW as a distinct sub-species; *M. o. oceanensis* (Large Bent-winged Bat) (see https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10534) (NSW Department of Planning, Industry and Environment (formerly the Office Environment and Heritage).
- Sequences not attributed to microbat echolocation calls (e.g. insect buzzes, wind, train and vehicle movement) were dismissed from the analysis.

Table 2 Correlations between current and previous nomenclature for the Free-tailed bats of NSW

Jackson and Groves 2015	Previously known as	Common Name	BC Act
Austronomus australis	*Tadarida australis*	White-striped Free-tailed Bat	
Micronomus norfolkensis	*Mormopterus norfolkensis*	Eastern Coastal Free-tailed Bat	Vulnerable
Ozimops petersi	*Mormopterus* species 3 (small penis)	Inland Free-tailed Bat	
Ozimops planiceps	*Mormopterus* species 4 (long penis eastern form)	South-eastern Free-tailed Bat	
Ozimops ridei	*Mormopterus* species 2	Ride's Free-tailed Bat	
Setirostris eleryi	*Mormopterus* species 6	Bristle-faced Free-tailed Bat	Endangered

RESULTS

There were 1,316 call sequences recorded during this survey. Of these, 1,134 (86.17%) were deemed useful, because these call profiles were of sufficient quality and/or length to enable positive identification of a bat species. The remaining 182 (13.83%) call sequences were either too short or were of low quality, thus preventing positive identification of bat species.

There were at least eleven (11) and up to eighteen (18) species recorded during this survey (Table 3 – 4). This includes up to five (5) species that are listed as Vulnerable under the NSW *Biodiversity Conservation Act 2016* (BC Act). Based on the call profiles, three Vulnerable species under the BC Act were deemed to have been definitely present within the study area, including:

- *Chalinolobus dwyeri* (Large-eared Pied Bat)
- *Miniopterus orianae oceanensis* (Large Bent-winged Bat)

- *Vespadelus troughtoni* (Eastern Cave Bat)

Two (2) other threatened species which are also listed as Vulnerable under the BC Act could also be present within the study area.

- *Nyctophilus corbeni* (Corben's Long-eared Bat)
- *Saccolaimus flaviventris* (Yellow-bellied Sheath-tailed Bat)

This is based upon the recording of calls that could potentially be attributed to these species, as well as the presence of suitable habitat for these species. In this part of NSW, the calls of Corben's Long-eared Bat overlap with those of other more common *Nyctophilus* species which also occur in the area. Similarly, calls of the Yellow-bellied Sheath-tailed Bat can overlap with those of the more common *Austronomus australis* (White-striped Free-tailed Bat) which was recorded in this survey. Consequently, these species were labelled as being potentially present only.

The Large-eared Pied Bat and Corben's Long-eared Bat are also listed as Vulnerable under the EPBC Act. During the 2020 surveys, calls attributed to the Large-eared Pied Bat were recorded at six (6) of the survey sites including BOA1, BOA3, BOA4, BOA5, ECA-B B101, ECA-C C102 and potentially at a seventh (7) site ECA-A A104. Only five (5) calls attributed to *Nyctophilus* spp. (and therefore potentially Corben's Long-eared Bat) were recorded across three (3) of the eight (8) survey sites, including BOA3, BOA5 and ECA-B B101. Calls attributed to the Eastern Cave Bat were recorded at five (5) of the eight (8) sites. This includes potential calls recorded at BOA1 and definite calls recorded at BOA3, BOA4, BOA5 and ECA-B B101. The Yellow-bellied Sheath-tailed Bat was only potentially recorded at ECA-B B101. The Large Bent-winged Bat was recorded at five (5) sites including BOA2, BOA3, BOA4, BOA5 and ECA-C C102, with potential calls also recorded at a further two (2) sites; BOA1 and ECA-B B101

SPECIES DIVERSITY, ACTIVITY AND FORAGING

As stated, at least eleven (11) and up to eighteen (18) species were recorded during this survey.

The species diversity did not vary dramatically across the survey sites. The following species were definitely recorded within at least six of the eight survey sites; Large-eared Pied Bat, *Rhinolophus megaphyllus* (Eastern Horseshoe Bat), the *Ozimops* species (Free-tailed Bat) complex and the *Vespadelus* species (*V. darlingtoni* (Large Forest Bat)*, V. regulus* (Southern Forest Bat) and *Vespadelus vulturnus* (Little Forest Bat) complex. In contrast, *the Nyctophilus* species complex was recorded at just three surveys sites (BOA3, BOA5 and ECA-B B101), potential calls for *V. darlingtoni* (Large Forest Bat) were recorded at only ECA-B B101 and potential Yellow-bellied Sheath-tailed Bat (in combination with White-striped Free-tailed Bat) calls were recorded at ECA-B B101.

The most commonly recorded species within the study area included a complex consisting of three *Vespadelus* species (Forest Bats), the threatened Large Bent-winged Bat and the *Ozimops* species complex (either individually or in combination with other species). Collectively, there were 818 (72.01 %) usable calls attributed to species and species complexes listed above.

General microbat activity was regarded as being very low to moderate across each of the survey sites. Activity levels at BOA1, BOA2, BOA3, ECA-A A104 and ECA-C C102 were considered to be very low with approximately one call recorded every ten minutes, or less, on average throughout the survey period. Sites BOA4 and BOA5 recorded low levels of activity with single calls recorded every five minutes or less,

on average throughout the survey period. Moderate microbat activity was recorded at sites ECA-B B101 with at least one call being recorded every four minutes on average throughout the survey period.

Table 3 Microbat species diversity recorded ultrasonically at WPCL survey sites during the 2020 Spring surveys.

Scientific Name	Common Name	Presence
Austronomus australis	White-Striped Free-tailed Bat	D
*Chalinolobus dwyeri*1*	Large-eared Pied Bat	D
Chalinolobus gouldii	Gould's Wattled Bat	D
Chalinolobus morio	Chocolate Wattled Bat	D
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	D
Nyctophilus geoffroyi	Lesser Long-eared Bat	P
Nyctophilus gouldi	Gould's Long-eared Bat	P
*Nyctophilus corbeni*1*	Corben's Long-eared Bat	P
Ozimops petersi	Inland Free-tailed Bat	P
Ozimops planiceps	South-eastern Free-tailed Bat	P
Ozimops ridei	Ride's Free-tailed Bat	P
Rhinolophus megaphyllus	Eastern Horseshoe Bat	D
*Saccolaimus flaviventris**	Yellow-bellied Sheath-tailed Bat	P
Scotorepens balstoni	Inland Broad-nosed Bat	D
Vespadelus darlingtoni	Large Forest Bat	P
Vespadelus regulus	Southern Forest Bat	P
*Vespadelus troughtoni**	Eastern Cave Bat	D
Vespadelus vulturnus	Little Forest Bat	D

D = DEFINITELY RECORDED, P = POTENTIALLY RECORDED. *LISTED AS THREATENED UNDER THE BC ACT AND 1 LISTED AS THREATENED UNDER THE EPBC ACT

Table 4 2020 Spring monitoring microbat species and species combinations lists by site, as derived from ultrasonic call results for each WCPL offset survey sites

Species Name	Common Name	Property							
		BOA					ECA		
		BOA1	BOA2	BOA3	BOA4	BOA5	A_104	B_101	C_102
Austronomus australis	White-striped Free-tailed Bat	D	-	-	D	D	D	D	-
*Chalinolobus dwyeri*1*	Large-eared Pied Bat	D	-	D	D	D	P	D	D
Chalinolobus gouldii	Gould's Wattled Bat	D	P	D	P	D	D	D	P
Chalinolobus morio	Chocolate Wattled Bat	D	D	D	-	D	-	D	-
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	P	D	D	D	D	-	P	D
*Nyctophilus corbeni*1*	Corben's Long-eared Bat	-	-	P	-	P	-	P	-
Nyctophilus geoffroyi	Lesser Long-eared Bat	-	-	P	-	P	-	P	-
Nyctophilus gouldii	Gould's Long-eared Bat	-	-	P	-	P	-	P	-
Ozimops petersi	Inland Free-tailed Bat	D	D	D	D	D	D	D	D
Ozimops ridei	Ride's Free-tailed Bat	D	D	D	D	D	D	D	D
Ozimops planiceps	South-eastern Free-tailed Bat	D	D	D	D	D	D	D	D
Rhinolophus megaphyllus	Eastern Horseshoe Bat	D	-	D	D	D	D	-	D
*Saccolaimus flaviventris**	Yellow-bellied Sheath-tailed Bat	-	-	-	P	P	-	P	-
Scotorepens balstoni	Inland Broad-nosed Bat	-	-	D	D	D	-	D	-
Vespadelus darlingtoni / Vespadelus vulturnus	Large Forest Bat / Little Forest Bat	-	-	-	-	-	-	P	-
Vespadelus regulus	Southern Forest Bat	P	P	P	P	P	-	P	-
*Vespadelus troughtoni**	Eastern Cave Bat	P	P	D	D	D	-	D	-
Vespadelus vulturnus	Little Forest Bat	P	D	D	D	D	-	D	-

D = DEFINITELY RECORDED, P = POTENTIALLY RECORDED. *LISTED AS THREATENED UNDER THE BC ACT AND 1 LISTED AS THREATENED UNDER THE EPBC ACT

SURVEY LIMITATIONS

Calls were only positively identified when the defining characteristics were present and there was no chance of confusion between species with overlapping and/or similar calls. In this survey, there were some call sequences that could not be positively identified to species level. Further, some species recorded in this survey can have call profiles that overlap with other species.

When overlap occurs, species with similar call profiles are assigned to multi species groups of two or three potential species depending on the characteristics displayed in the recorded call sequences.

The species recorded in this survey with overlapping call profiles are described below.

The calls of *Chalinolobus gouldii* (Gould's Wattled Bat), *Scotorepens balstoni* (Inland Broad-nosed Bat) and the *Ozimops* species complex (Free-tailed Bats) can be difficult to separate. Calls were identified as *Ozimops* species complex when the call shape was flat (slope S1 of less than 100 OPS generally) and the frequency was between 24 – 36 kHz. Gould's Wattled Bat was distinguished by a frequency of 27.5 – 32.5 kHz and alternation in call frequency between pulses. Inland Broad-nosed Bat calls have a slope of greater than 200 OPS, are non-alternating and fall between 29 and 34 kHz. When no distinguishing characteristics were present calls were assigned to multi-species groups.

In this geographic region, calls of Eastern Cave Bat, Large Bent-winged Bat, Little Forest Bat and *Chalinolobus morio* (Chocolate Wattled Bat) overlap in the range 47 – 53 kHz. Chocolate Wattled Bat and Large Bent-winged Bat calls have a down-sweeping tail whereas Eastern Cave Bat and Little Forest Bat calls have an up-sweeping tail. Large Bent-winged Bat calls were distinguished by the following characteristics: a down-sweeping tail and the pulse shape and time between calls was variable (43 – 48.5 kHz). Chocolate Wattled Bats generally display a more even pulse shape and time between calls than the Large Bent-winged Bat and the calls are generally separated by higher characteristics frequencies (48.5 – 51 kHz). Calls of the Eastern Cave Bat (49 – 53.5 kHz) were separated from those of Little Forest Bat (42.5 -48 kHz) only at frequencies above 50 kHz. When no distinguishing characteristics were present calls were assigned to multi-species groups or characterized as unidentifiable.

The calls of Large Bent-winged Bat overlap in frequency with those of Southern Forest Bat and Little Forest Bat between 44 and 48.5 kHz and with Large Forest Bat at frequencies of 44 kHz. Large Bent-winged Bat calls were distinguished by the following characteristics: a down-sweeping tail and the pulse shape and time between calls was variable (43 – 48.5 kHz). Southern Forest Bat (43 – 46.5 kHz), Large Forest Bat (40 – 43 kHz) and Little Forest Bat calls (42.5 – 48 kHz) are curved, have a regular pulse shape and generally up-sweeping tails. Large Forest Bat calls often have a longer characteristic section than Little or Southern Forest Bats. When no distinguishing characteristics were present calls were assigned to multi-species groups.

Furthermore, calls produced by different bat species differ in fundamental ways related to the foraging mode / activity of each species. Calls of different species and the different types of calls produced by each species (cruise, search, social, approach, attack) are not equally recorded by ultrasonic detectors. Weather and climatic conditions affect the quality and quantity of recorded data as well as the availability of insect prey and therefore the suitability of each site at a given time as foraging habitat.

RESULTS TABLES FOR EACH ANABAT SWIFT

Table 5 Microbat species diversity and number of calls recorded ultrasonically at WCPL BOA1-100 between 19 and 20 October 2020.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Austronomus australis	White-Striped Free-tailed Bat	2	0	2
*Chalinolobus dwyeri*1*	Large-eared Pied Bat	1	1	2
Chalinolobus gouldii	Gould's Wattled Bat	2	0	2
Chalinolobus gouldii / Ozimops species complex. In this region the O. petersi, O. ridei and O. planiceps are likely to be present	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	2	2
Chalinolobus morio	Chocolate Wattled Bat	0	4	4
Chalinolobus morio / Vespadelus vulturnus	Chocolate Wattled Bat / Little Forest Bat	0	3	3
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	0	1	1
Miniopterus orianae oceanensis / Vespadelus regulus / Vespadelus vulturnus*	Large Bent-winged Bat / Southern Forest Bat / Little Forest Bat	0	15	15
Miniopterus orianae oceanensis / Vespadelus vulturnus*	Large Bent-winged Bat / Little Forest Bat	0	3	3
Ozimops species complex. In this region the O. petersi, O. ridei and O. planiceps are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	3	3
Rhinolophus megaphyllus	Eastern Horseshoe Bat	2	0	2
Vespadelus regulus / Vespadelus vulturnus	Southern Forest Bat / Little Forest Bat	0	3	3
*Vespadelus vulturnus / Vespadelus troughtoni**	Little Forest Bat / Eastern Cave Bat	0	2	2
Unidentifiable				**19**
Useable calls				**44**
Total Calls				**63**
Percentage usable calls				**69.84**

*LISTED AS THREATENED UNDER THE BC ACT AND 1 LISTED AS THREATENED UNDER THE EPBC ACT

Table 6 Microbat species diversity and number of calls recorded ultrasonically at WCPL BOA2-101 between 19 and 20 October 2020.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Chalinolobus gouldii / In this region the O. *petersi, O. ridei* and *O. planiceps* are likely to be present.	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	1	1
Chalinolobus morio	Chocolate Wattled Bat	1	1	2
Chalinolobus morio / Miniopterus orianae oceanensis / Vespadelus vulturnus*	Chocolate Wattled Bat / Large Bent-winged Bat / Little Forest Bat	0	1	1
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	3	1	4
Miniopterus orianae oceanensis / Vespadelus regulus / Vespadelus vulturnus*	Large Bent-winged Bat / Southern Forest Bat / Little Forest Bat	0	11	11
Miniopterus orianae oceanensis / Vespadelus vulturnus*	Large Bent-winged Bat / Little Forest Bat	0	8	8
Vespadelus regulus / Vespadelus vulturnus	Southern Forest Bat / Little Forest Bat	0	1	1
Vespadelus troughtoni / Vespadelus vulturnus*	Eastern Cave Bat / Little Forest Bat	0	1	1
Vespadelus vulturnus	Little Forest Bat	2	0	2
Unidentifiable				**8**
Useable calls				**31**
Total Calls				**39**
Percentage usable calls				**79.49**

*LISTED AS THREATENED UNDER THE BC ACT

Table 7 Microbat species diversity and number of calls recorded ultrasonically at WCPL BOA3-100 between 12 and 13 October 2020.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
*Chalinolobus dwyeri*1*	Large-eared Pied Bat	10	0	10
Chalinolobus gouldii	Gould's Wattled Bat	0	3	3
Chalinolobus gouldii / Ozimops species complex. In this region the *O. petersi,*	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	8	8

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
O. ridei and *O. planiceps* are likely to be present.				
Chalinolobus gouldii / Ozimops species complex. In this region the *O. petersi, O. ridei and O. planiceps* are likely to be present / *Scotorepens balstoni*	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present / Inland Broad-nosed Bat	0	3	3
Chalinolobus gouldii / Scotorepens balstoni	Gould's Wattled Bat / Inland Broad-nosed Bat	0	1	1
Chalinolobus morio	Chocolate Wattled Bat	2	0	2
*Chalinolobus morio / Vespadelus troughtoni**	Chocolate Wattled Bat / Eastern Cave Bat	0	1	1
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	1	0	1
Miniopterus orianae oceanensis / Vespadelus regulus / Vespadelus vulturnus*	Large Bent-winged Bat / Southern Forest Bat / Little Forest Bat	0	21	21
Miniopterus orianae oceanensis / Vespadelus vulturnus*	Large Bent-winged Bat / Little Forest Bat	0	7	7
Nyctophilus spp., in this region include *N. geoffroyi, N. gouldi* with the threatened *N. corbeni*1,* also likely to be present.	In this region Lesser, Gould's and the threatened Corben's Long-eared Bat species are all likely to be present.	0	1	1
Ozimops species complex. In this region the *O. petersi, O. ridei and O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	12	12
Rhinolophus megaphyllus	Eastern Horseshoe Bat	5	0	5
Scotorepens balstoni	Inland Broad-nosed Bat	1	0	1
Vespadelus regulus / Vespadelus vulturnus	Southern Forest Bat / Little Forest Bat	0	21	21
*Vespadelus troughtoni**	Eastern Cave Bat	1	0	1
Vespadelus troughtoni / Vespadelus vulturnus*	Eastern Cave Bat / Little Forest Bat	0	5	5
Vespadelus vulturnus	Little Forest Bat	2	2	4
Unidentifiable				**10**
Useable calls				**107**
Total Calls				**117**

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Percentage usable calls				**91.45**

*LISTED AS THREATENED UNDER THE BC ACT AND [1] LISTED AS THREATENED UNDER THE EPBC ACT.

Table 8 Microbat species diversity and number of calls recorded ultrasonically at WCPL BOA4-101 between 12 and 13 October 2020.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Austronomus australis	White-Striped Free-tailed Bat	5	0	5
*Chalinolobus dwyeri*1*	Large-eared Pied Bat	12	1	13
Chalinolobus gouldii	Gould's Wattled Bat	0	1	1
Chalinolobus gouldii / *Ozimops* species complex. In this region the *O. petersi, O. ridei* and *O. planiceps* are likely to be present.	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	5	5
Chalinolobus gouldii / *Ozimops* species complex - In this region the *O. petersi, O. ridei* and *O. planiceps* are likely to be present / *Scotorepens balstoni*	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present / Inland Broad-nosed Bat	0	4	4
Chalinolobus gouldii / *Scotorepens balstoni*	Gould's Wattled Bat / Inland Broad-nosed Bat	0	10	10
Chalinolobus morio	Chocolate Wattled Bat	5	3	8
Chalinolobus morio / *Miniopterus orianae oceanensis** / *Vespadelus vulturnus*	Chocolate Wattled Bat / Large Bent-winged Bat / Little Forest Bat	0	3	3
Chalinolobus morio / *Vespadelus troughtoni** / *Vespadelus vulturnus*	Chocolate Wattled Bat / Eastern Cave Bat / Little Forest Bat	0	7	7
Chalinolobus morio / *Vespadelus vulturnus*	Chocolate Wattled Bat / Little Forest Bat	0	1	1
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	5	3	8
*Miniopterus orianae oceanensis** / *Vespadelus regulus* / *Vespadelus vulturnus*	Large Bent-winged Bat / Southern Forest Bat / Little Forest Bat	0	37	37

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Ozimops species complex. In this region the *O. petersi, O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	59	59
Rhinolophus megaphyllus	Eastern Horseshoe Bat	2	0	2
Scotorepens balstoni	Inland Broad-nosed Bat	7	0	7
Vespadelus regulus / Vespadelus vulturnus	Southern Forest Bat / Little Forest Bat	0	10	10
*Vespadelus troughtoni**	Eastern Cave Bat	1	0	1
Vespadelus troughtoni / Vespadelus vulturnus*	Eastern Cave Bat / Little Forest Bat	0	1	1
Vespadelus vulturnus	Little Forest Bat	4	0	4
Unidentifiable				**41**
Useable calls				**186**
Total Calls				**227**
Percentage usable calls				**81.94**

*LISTED AS THREATENED UNDER THE BC ACT AND [1] LISTED AS THREATENED UNDER THE EPBC ACT.

Table 9: Microbat species diversity and number of calls recorded ultrasonically at WCPL BOA5-101 between 12 and 13 October 2020.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Austronomus australis	White-Striped Free-tailed Bat	1	0	1
*Chalinolobus dwyeri*1*	Large-eared Pied Bat	93	1	94
Chalinolobus gouldii	Gould's Wattled Bat	3	3	6
Chalinolobus gouldii / Ozimops species complex. In this region the *O. petersi, O. ridei* and *O. planiceps* are likely to be present.	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	9	9
Chalinolobus gouldii / Ozimops species complex. In this region the *O. petersi, O. ridei and O. planiceps* are likely to be present / *Scotorepens balstoni*	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present / Inland Broad-nosed Bat	0	8	8
Chalinolobus gouldii / Scotorepens balstoni	Gould's Wattled Bat / Inland Broad-nosed Bat	0	2	2
Chalinolobus morio	Chocolate Wattled Bat	2	1	3

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Chalinolobus morio / Miniopterus orianae oceanensis / Vespadelus vulturnus*	Chocolate Wattled Bat / Large Bent-winged Bat / Little Forest Bat	0	1	1
*Chalinolobus morio / Vespadelus troughtoni**	Chocolate Wattled Bat / Eastern Cave Bat	0	3	3
Chalinolobus morio / Vespadelus vulturnus	Chocolate Wattled Bat / Little Forest Bat	0	1	1
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	2	1	3
Miniopterus orianae oceanensis / Vespadelus regulus / Vespadelus vulturnus*	Large Bent-winged Bat / Southern Forest Bat / Little Forest Bat	0	28	28
Nyctophilus spp., in this region include *N. geoffroyi, N. gouldi* with the threatened *N. corbeni*1,* also likely to be present.	In this region Lesser, Gould's and the threatened Corben's Long-eared Bat species are all likely to be present.	0	1	1
Ozimops species complex. In this region the *O. petersi, O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	10	10
Rhinolophus megaphyllus	Eastern Horseshoe Bat	3	0	3
Scotorepens balstoni	Inland Broad-nosed Bat	2	0	2
Vespadelus regulus / Vespadelus vulturnus	Southern Forest Bat / Little Forest Bat	0	24	24
*Vespadelus troughtoni**	Eastern Cave Bat	2	0	2
Vespadelus vulturnus	Little Forest Bat	1	1	2
Unidentifiable				**24**
Useable calls				**203**
Total Calls				**227**
Percentage usable calls				**89.43**

*LISTED AS THREATENED UNDER THE BC ACT AND [1] LISTED AS THREATENED UNDER THE EPBC ACT.

Table 10 Microbat species diversity and number of calls recorded ultrasonically at WCPL ECA-A-104 between 19 and 20 October 2020.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Austronomus australis	White-Striped Free-tailed Bat	1	0	1
*Chalinolobus dwyeri*1*	Large-eared Pied Bat	0	1	1

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Chalinolobus gouldii	Gould's Wattled Bat	1	2	3
Chalinolobus gouldii / *Ozimops* species complex. In this region the *O. petersi, O. ridei* and *O. planiceps* are likely to be present.	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	11	11
Ozimops species complex. In this region the *O. petersi, O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	18	18
Rhinolophus megaphyllus	Eastern Horseshoe Bat	1	0	1
Unidentifiable				**9**
Useable calls				**35**
Total Calls				**44**
Percentage usable calls				**79.55**

*LISTED AS THREATENED UNDER THE BC ACT AND [1] LISTED AS THREATENED UNDER THE EPBC ACT.

Table 11 Microbat species diversity and number of calls recorded ultrasonically at WCPL ECA-B-101 between 12 and 13 October 2020.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Austronomus australis	White-Striped Free-tailed Bat	84	1	85
Austronomus australis / *Saccolaimus flaviventris**	White-Striped Free-tailed Bat / Yellow-bellied Sheath-tailed Bat	0	6	6
Chalinolobus dwyeri	Large-eared Pied Bat	9	1	10
Chalinolobus gouldii	Gould's Wattled Bat	8	8	16
Chalinolobus gouldii / *Ozimops* species complex. In this region the *O. petersi, O. ridei and O. planiceps* are likely to be present.	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	24	24
Chalinolobus gouldii / *Ozimops* species complex. In this region the *O. petersi, O. ridei and O. planiceps* are likely to be present / *Scotorepens balstoni*	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present / Inland Broad-nosed Bat	0	8	8
Chalinolobus gouldii / *Scotorepens balstoni*	Gould's Wattled Bat / Inland Broad-nosed Bat	0	5	5
Chalinolobus morio	Chocolate Wattled Bat	1	2	3

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Chalinolobus morio / Miniopterus orianae oceanensis / Vespadelus vulturnus*	Chocolate Wattled Bat / Large Bent-winged Bat / Little Forest Bat	0	2	2
Chalinolobus morio / Vespadelus troughtoni / Vespadelus vulturnus*	Chocolate Wattled Bat / Eastern Cave Bat / Little Forest Bat	0	7	7
Chalinolobus morio / Vespadelus vulturnus	Chocolate Wattled Bat / Little Forest Bat	0	18	18
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	0	1	1
Miniopterus orianae oceanensis / Vespadelus regulus / Vespadelus vulturnus*	Large Bent-winged Bat / Southern Forest Bat / Little Forest Bat	0	29	29
Miniopterus orianae oceanensis / Vespadelus vulturnus*	Large Bent-winged Bat / Little Forest Bat	0	1	1
Nyctophilus spp., in this region include *N. geoffroyi, N. gouldi* with the threatened *N. corbeni*1,* also likely to be present.	In this region Lesser, Gould's and the threatened Corben's Long-eared Bat species are all likely to be present.	3	0	3
Ozimops species complex. In this region the *O. petersi, O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	123	123
Scotorepens balstoni	Inland Broad-nosed Bat	4	2	6
Vespadelus darlingtoni / Vespadelus regulus / Vespadelus vulturnus	Large Forest Bat / Southern Forest Bat / Little Forest Bat	0	3	3
Vespadelus regulus / Vespadelus vulturnus	Southern Forest Bat / Little Forest Bat	0	76	76
*Vespadelus troughtoni**	Eastern Cave Bat	13	0	13
Vespadelus troughtoni / Vespadelus vulturnus*	Eastern Cave Bat / Little Forest Bat	0	3	3
Vespadelus vulturnus	Little Forest Bat	57	16	73
Unidentifiable				**71**
Useable calls				**515**
Total Calls				**586**
Percentage usable calls				**87.88**

*LISTED AS THREATENED UNDER THE BC ACT AND [1] LISTED AS THREATENED UNDER THE EPBC ACT

Table 12 Microbat species diversity and number of calls recorded ultrasonically at WCPL ECA-C-102 between 28 and 29 September 2020.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Chalinolobus dwyeri	Large-eared Pied Bat	1	0	1
Chalinolobus gouldii / *Ozimops* species complex - In this region the *O. petersi, O. ridei* and *O. planiceps* are likely to be present	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	6	6
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	3	0	3
Ozimops species complex. In this region the *O. petersi, O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	2	2
Rhinolophus megaphyllus	Eastern Horseshoe Bat	1	0	1
Unknown				**0**
Useable calls				**13**
Total Calls				**13**
Percentage usable calls				**100**

*LISTED AS THREATENED UNDER THE BC ACT

EXAMPLE CALL PROFILES

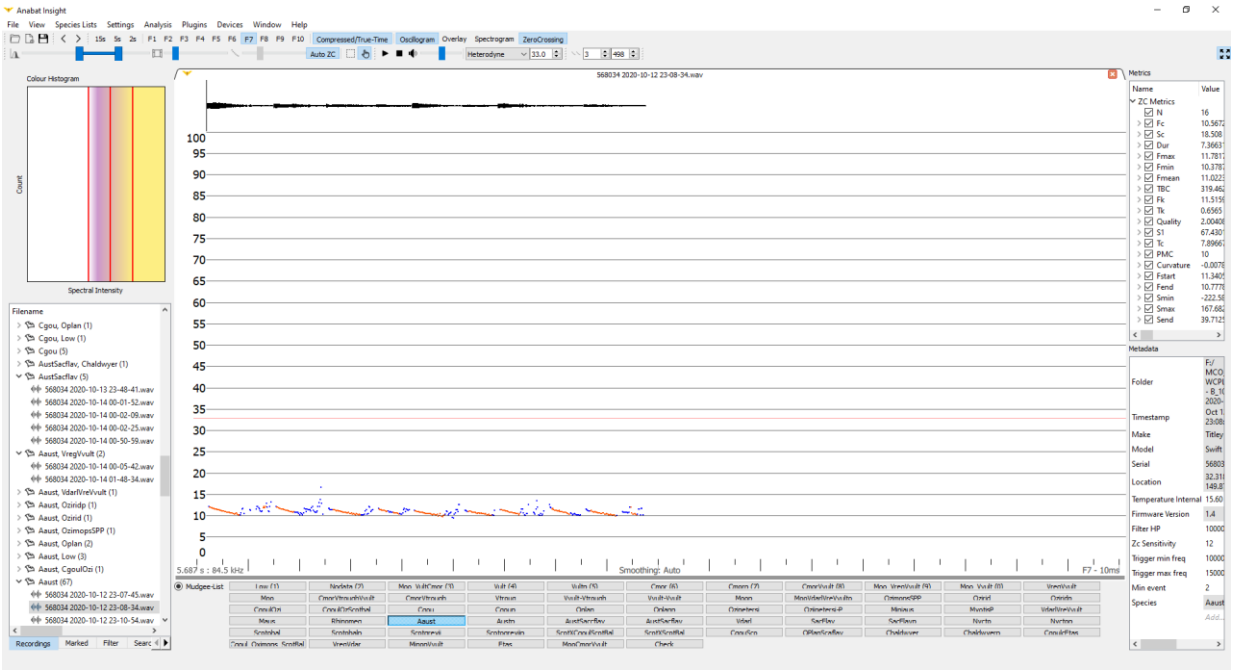

Figure 1 Call profile for Austronomus australis (White-striped Free-tailed Bat) recorded on the ECA-B101 at 2308 (11:08 p.m.) on 12 October 2020.

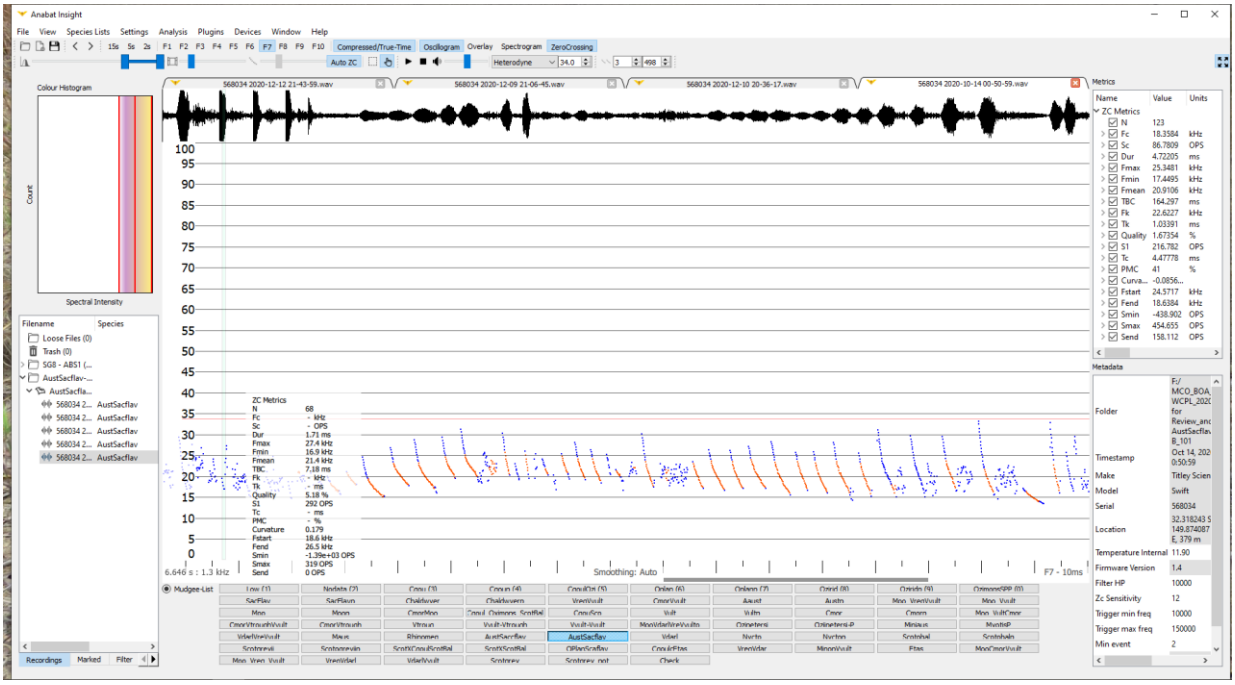

Figure 2 Potential call profile for Austronomus australis (White-striped Free-tailed Bat) and Saccolaimus flaviventris (Yellow-Bellied Sheath-tailed Bat) recorded on the ECA-B101 at 0050 (12:50 a.m.) on 14 October 2020.

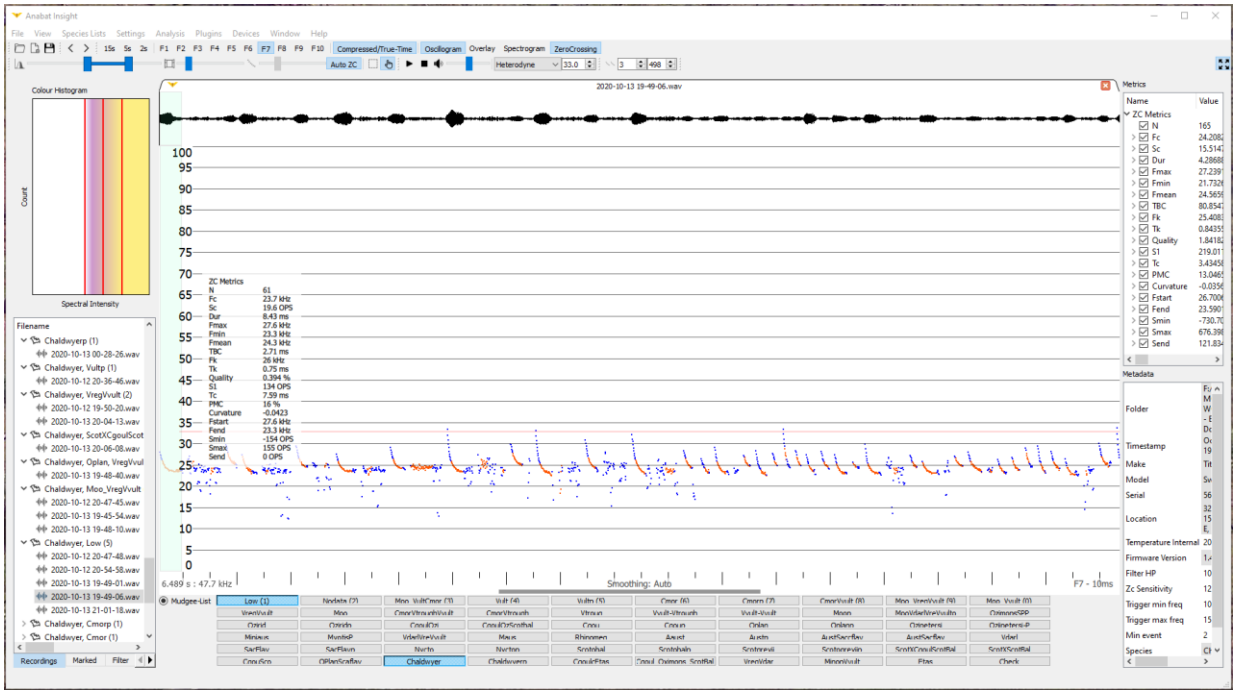

Figure 3 Call profile for *Chalinolobus dwyeri* (Large-eared Pied Bat) recorded at BOA5-101 at 1946 (7.46 p.m.) 13 October 2020.

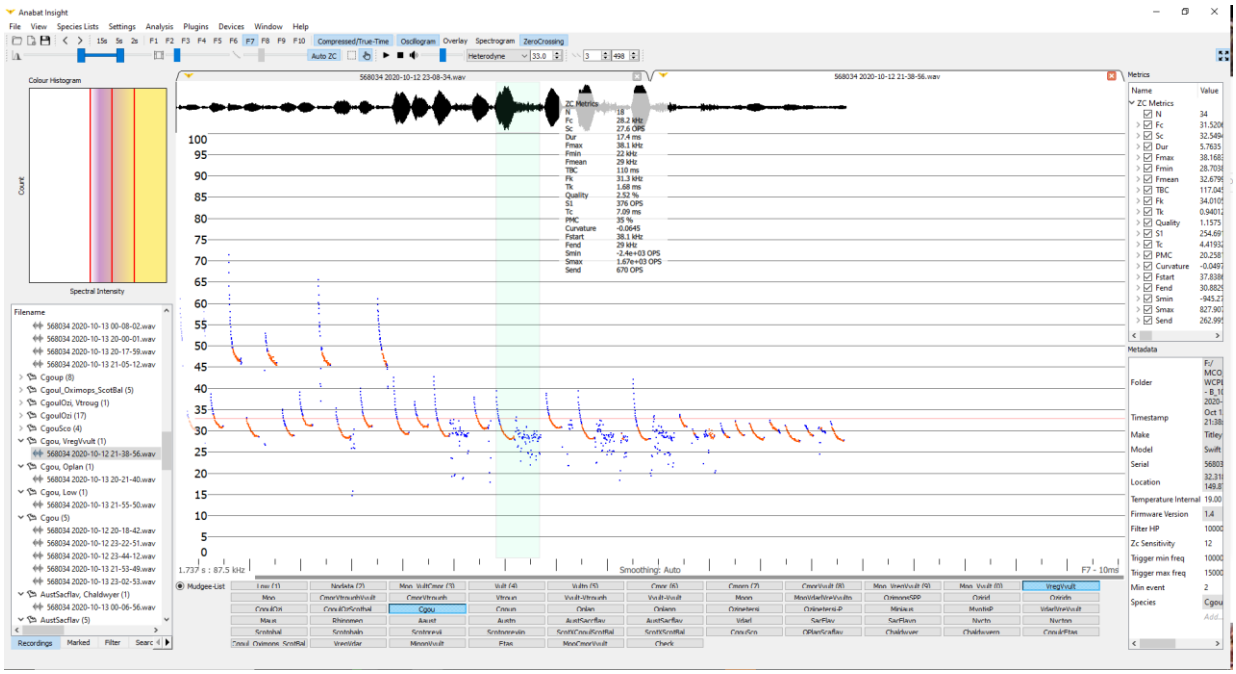

Figure 4 Call profile for *Chalinolobus gouldii* (Gould's Wattled Bat) (lower call with alternating pulses at ~30 – 35 kHz) and *Miniopterus orianae oceanensis* (Large Bent-winged Bat) / *Vespadelus regulus* (Southern Forest Bat) / *Vespadelus vulturnus* (Little Forest Bat) (call with higher characteristic frequency at ~ 45 kHz) recorded at ECA-B101 at 2138 (9.38 p.m.) 12 October 2020.

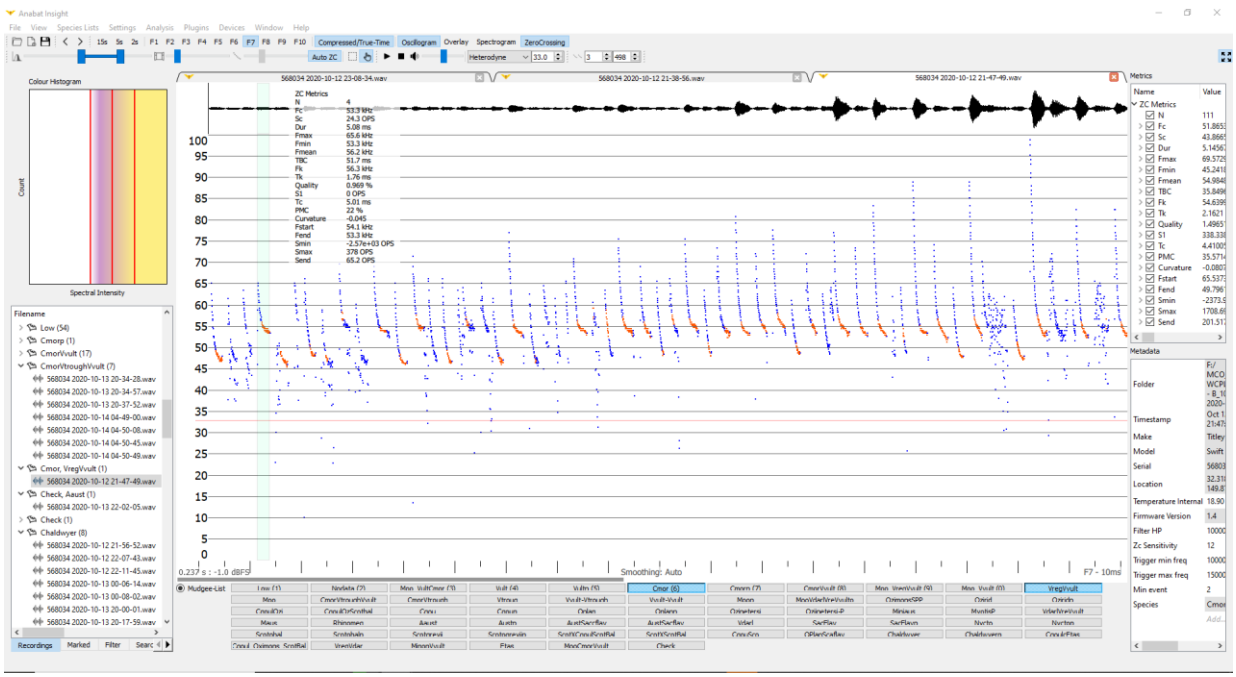

Figure 5 Call profile for *Chalinolobus morio* (Chocolate Wattled Bat) (upper call with characteristic frequency between ~50 – 55 kHz) and *Vespadelus regulus* (Southern Forest Bat) or *Vespadelus vulturnus* (Little Forest Bat) (lower call with characteristic frequency at ~ 45 kHz) recorded at ECA-B101 at 2147 (9.47 p.m.) 12 October 2020.

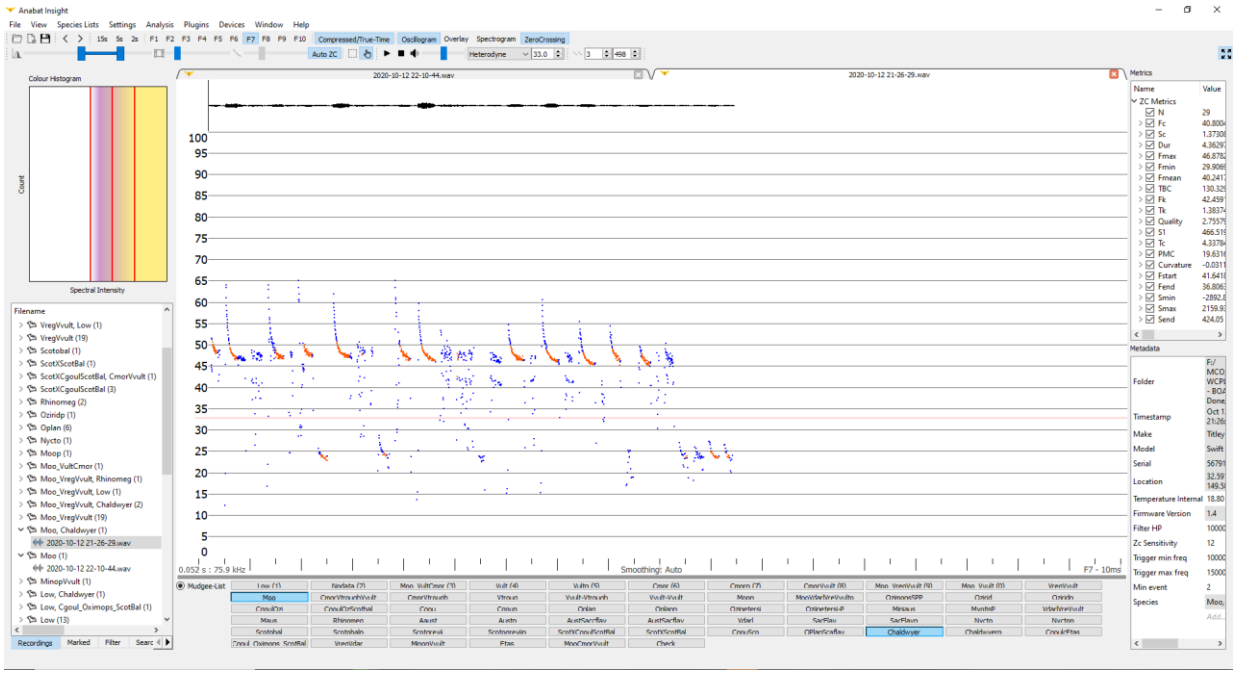

Figure 6 Call profile for Miniopterus orianae oceanensis (Large Bent-winged Bat) (upper call with frequency at ~45 kHz) with Chalinolobus dwyeri (Large-eared Pied Bat) (lower call with frequency at ~25 kHz) recorded at BOA5-101 at 2126 (9:26 p.m.) on 12 October 2020.

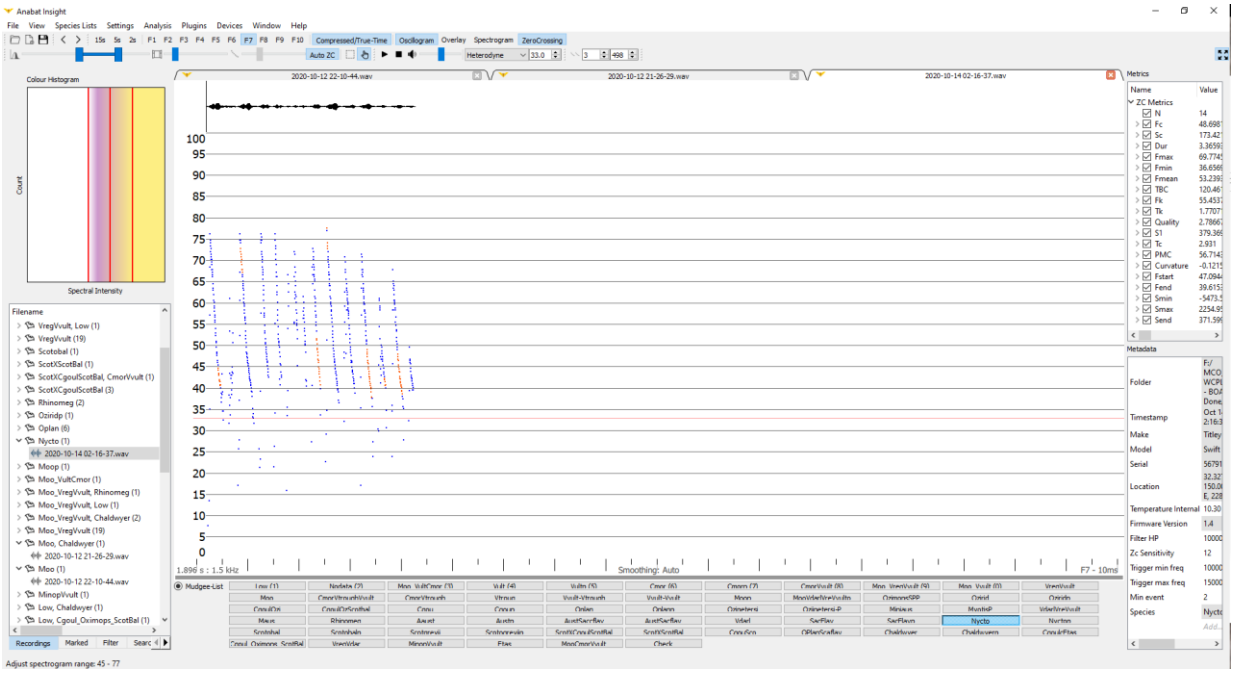

Figure 7 Potential call profile for *Nyctophilus corbeni* (Corben's Long-eared Bat) / *Nyctophilus gouldi* (Gould's Long-eared Bat) / *Nyctophilus geoffroyi* (Lesser Long-eared Bat) recorded at BOA5-101 at 0216 (2:16 p.m.) on 14 October 2020.

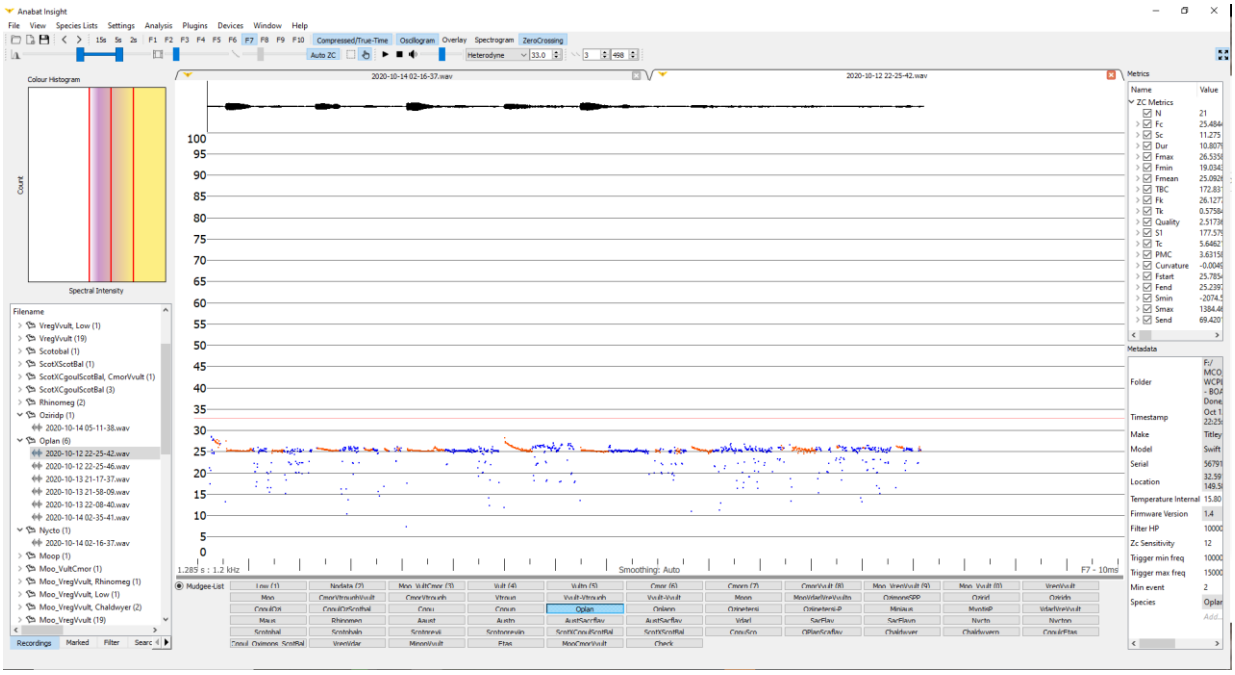

Figure 8 Call profile for *Ozimops* species complex (this is a call profile that can be attributed to *Ozimops planiceps* (South-eastern Free-tailed Bat)) recorded at BOA5-101 at 2225 (8:25 p.m.) on 12 October 2020.

Figure 9 Call profile for *Rhinolophus megaphyllus* (Eastern Horseshoe Bat) recorded at BOA5-101 at 1952 (7:52 p.m.) on 12 October 2020.

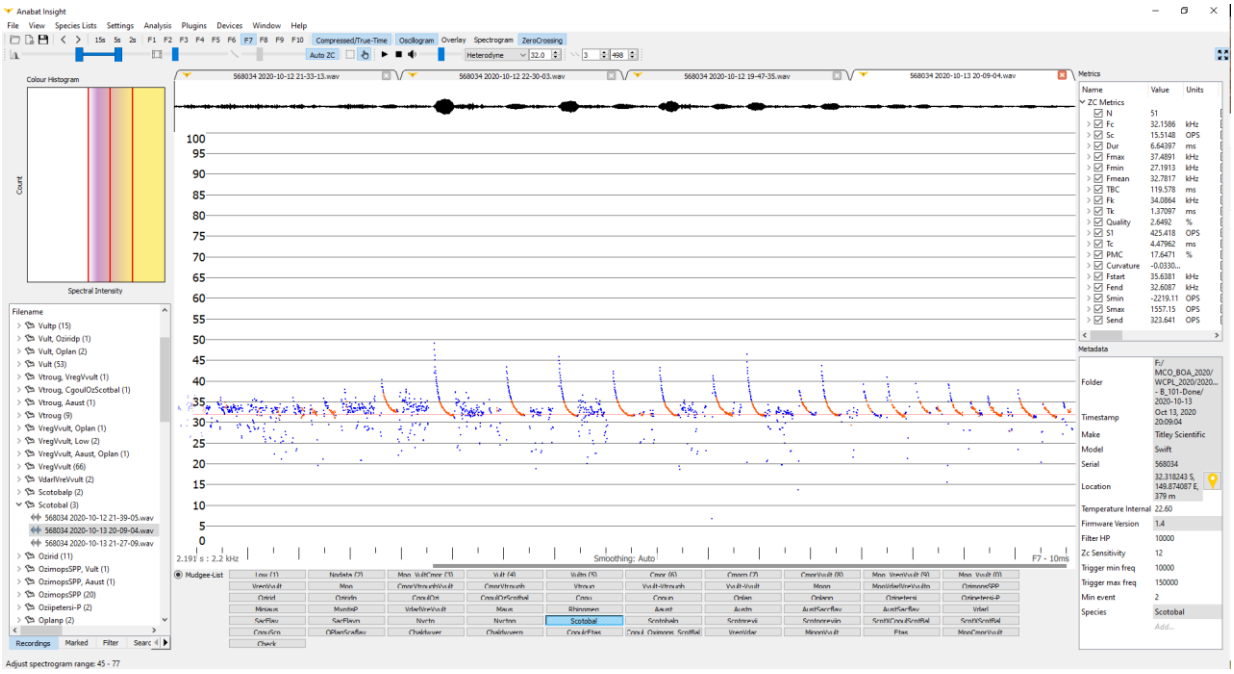

Figure 10 Call profile for *Scotorepens balstoni* (Inland Broad-nosed Bat) recorded at ECA-B101 at 2009 (8:09 p.m.) on 13 October 2020.

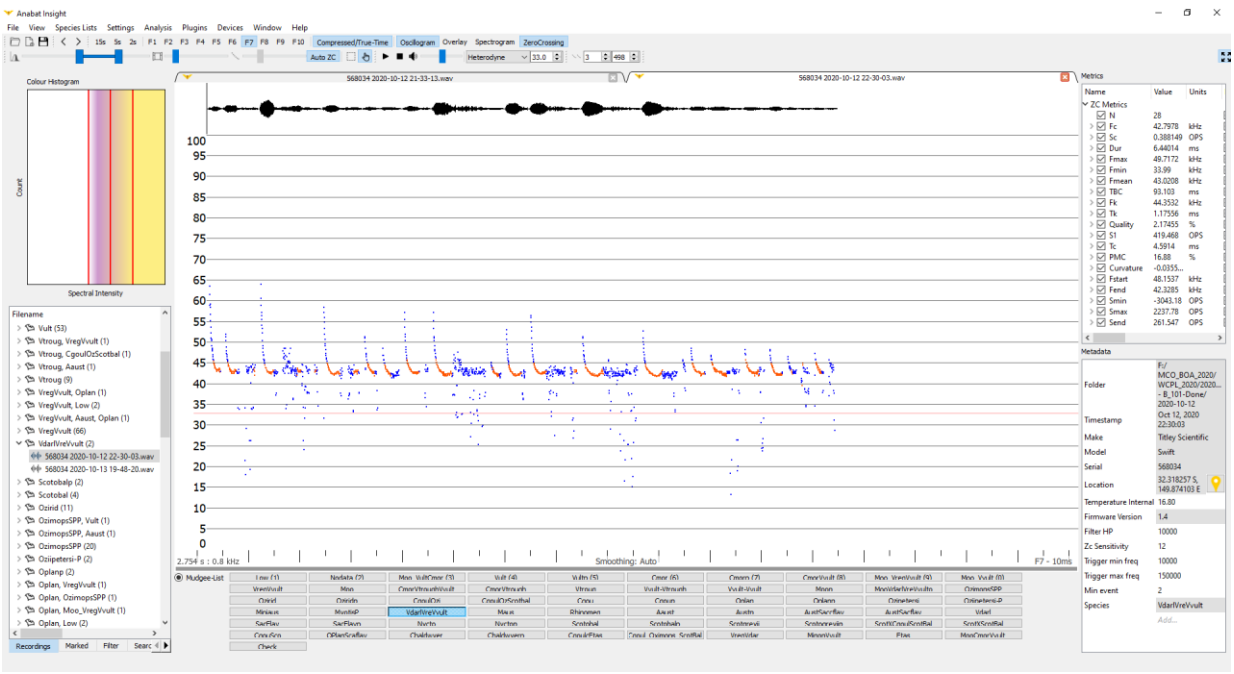

Figure 11 Potential call profile for Vespadelus darlingtoni (Large Forest Bat), Vespadelus regulus (Southern Forest Bat) or Vespadelus vulturnus (Little Forest Bat) recorded at ECA-B101 at 2230 (10:30 p.m.) on 12 October 2020.

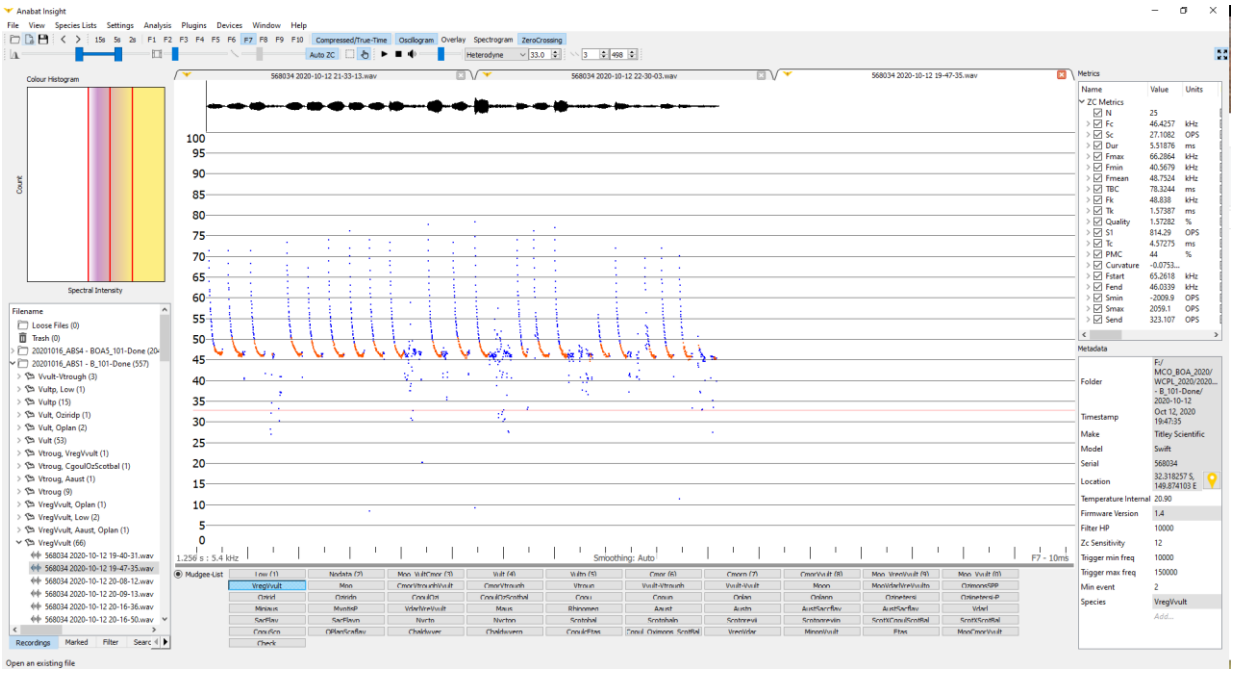

Figure 12 Potential call profile for Vespadelus regulus (Southern Forest Bat) or Vespadelus vulturnus (Little Forest Bat) recorded at ECA-B101 at 1947 (19:47 p.m.) on 12 October 2020.

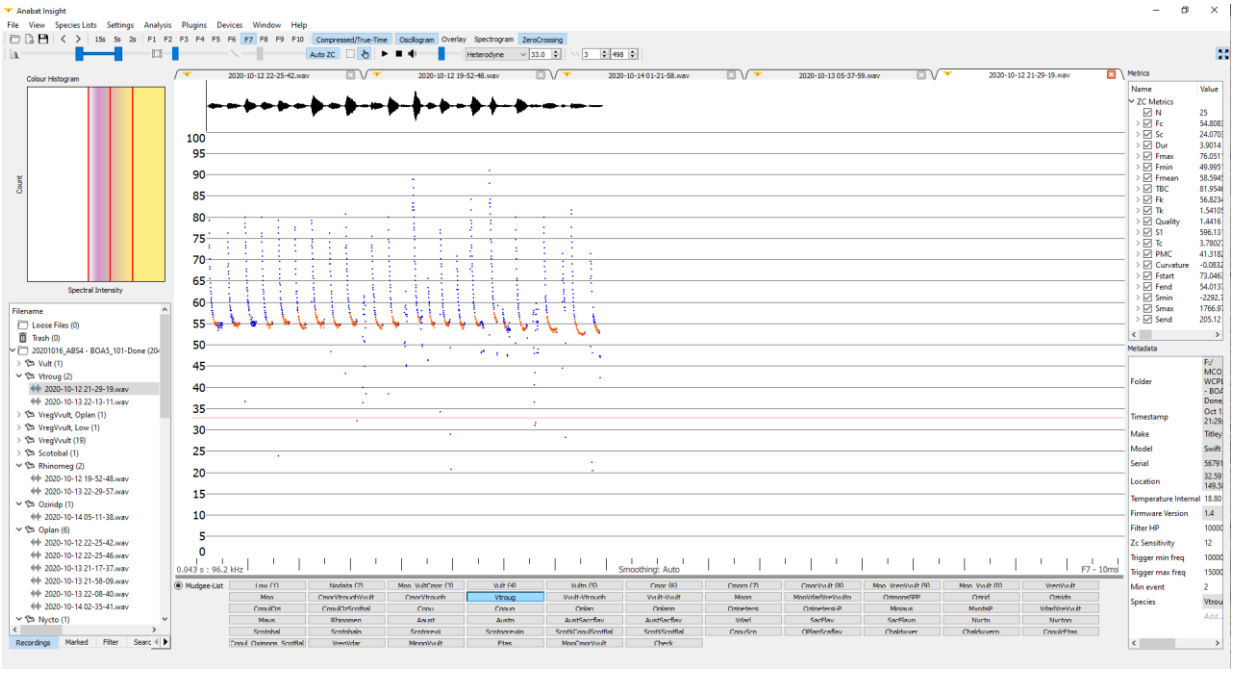

Figure 13 Call profile for Vespadelus troughtoni (Eastern Cave Bat) recorded BOA5-101 at 2129 (9:29 p.m.) on 12 October 2020.

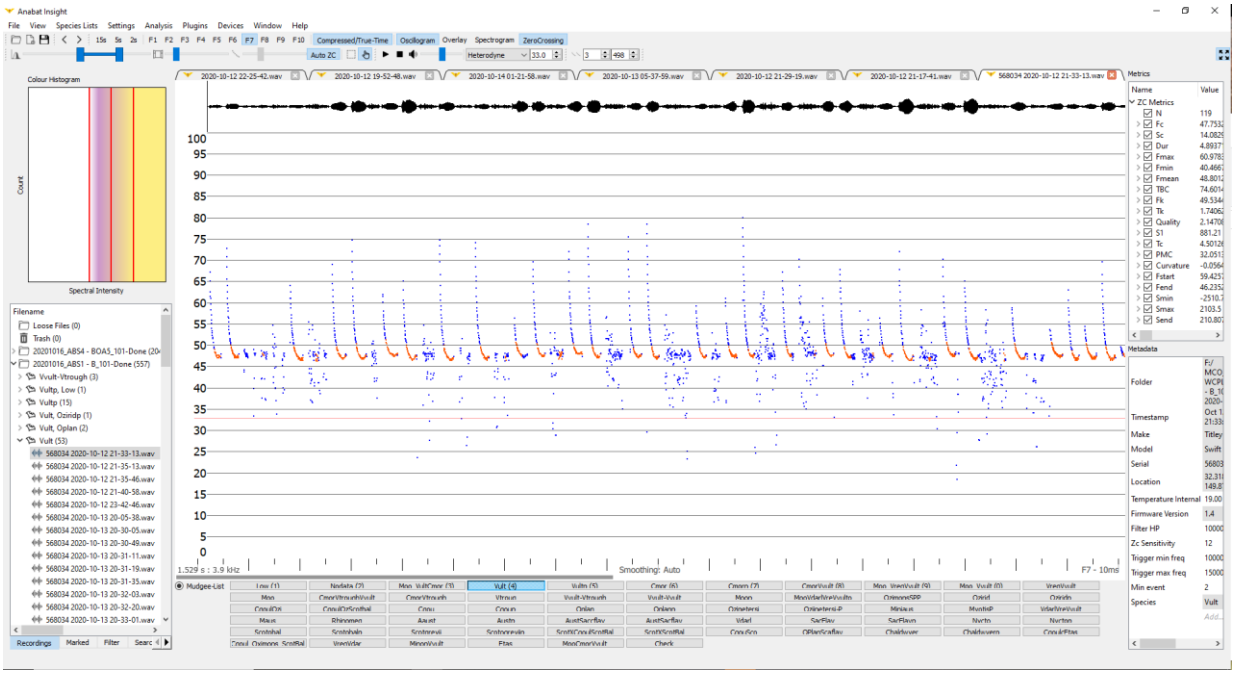

Figure 14 Call profile for Vespadelus vulturnus (Little Forest Bat) recorded at ECAB-101 at 2133 (9:33 p.m.) on 12 October 2020.

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Appendix D - BioMetric Performance and Completion Criteria

Performance and Completion Criteria were approved by DPIE on 23 April 2019. This table is incorporated into the BMP, which is pending approval by DPIE. These performance and completion criteria are applicable to Rehabilitation Areas monitoring sites.

BioMetric Performance & Completion Criteria

Attribute (OEH, 2017)	BVT	Native Plant Species Richness (No. species)		Native Over Storey Cover MIN-MAX (%)[7]		Native Mid – Storey Cover MIN-MAX (%)		Native Ground Cover Grass MIN-MAX (%)		Native Ground Cover Shrubs MIN-MAX (%)		Native Ground Cover Other MIN-MAX (%)		Number of Trees with Hollows	Total Length Fallen Logs (m)	
BVT Benchmark (OEH, 2017)	HU547	23		10-45		5-60		5-45		2-10		5-35		2	50	
	HU732	35		10-50		2-10		10-60		2-10		5-30		1.5	25	
	HU697	25		20-50		10-60		5-15		5-10		5-15		0.8	46	
	HU824	25		20-50		10-60		5-15		5-10		5-15		0.8	66	
	HU825	35		25-40		11-50		5-45		5-30		5-20		3	73	
Completion Criteria Allowable Future Attribute Score Increases Relative to Benchmark (After OEH, 2014b, 2015)		**1**		**1**		**1**		**1**		**1**		**1**		**0**	**0.5**	
		>50%		**>25<200%**		**>25<200%**		**>25<200%**		**>25<200%**		**>25<200%**		**N/A**	**>25%**	
WCPL Criteria	**BVT**	**Comp.**	**Perf.**	**Comp.**	**Perf.**	**Comp.**	**Perf.**	**Comp.**	**Perf.**	**Comp.**	**Perf.**	**Comp.**	**Perf.**		**Comp.**	**Perf.**
	HU547	11.5	6	2.5-90	1-90	1.25-100	1-100	1.25-90	1-90	0.5-20	0-10	1.25-70	0.5-70		12.5	6
	HU732	17.5	9	2.5-100	1-100	0.5-20	0-20	2.5-100	1-100	0.5-20	0-10	1.25-60	0.5-60	NIL	6.25	3
	HU697	12.5	6	5-100	3-100	2.5-100	1-100	1.25-30	1-60	1.25-20	1-10	1.25-30	0.5-60		11.5	6
	HU824	12.5	6	5-100	3-100	2.5-100	1-100	1.25-30	1-60	1.25-20	1-10	1.25-30	0.5-60		16.5	8
	HU825	17.5	9	6.25-80	3-80	2.75-100	1-100	1.25-90	1-90	1.25-60	1-30	1.25-40	0.5-80		18.25	9

Attribute (OEH, 2017)	Exotic Plant Cover (% of total cover)		Regeneration[7] (% of over-storey species that are naturally regenerating)		Overall SVS (OEH, 2015) (average of plots in vegetation zone)	
Completion Criteria Allowable Future Attribute Score Increases Relative to Benchmark (After OEH, 2014b, 2015)	**1**		**0.5**			
	<45%		**25%**		**16.93**	
WCPL Criteria	**Comp.**	**Perf.**	**Comp.**	**Perf.**	**Comp.**	**Perf.**
All relevant BVTs	<45%	<90%	To be determined based on number of OS species	No regeneration	17	7

[7] Relevant Regent Honeyeater habitat criteria
Comp. = Completion Criteria
Perf. = Performance Criteria at 10 years after landform establishment

Wilpinjong Coal – Biodiversity Management Plan

Appendix E - Interim Performance Targets / Benchmark Values

The following Interim Performance Targets and Benchmark Values are shown in the previous BMP (WCPL 2017). These IPTs will be superseded once the new BVT reference sites are established and accepted by DPIE, and the BMP is approved. These are currently applicable to BOAs, ECAs, Regeneration Areas and reference sites.

Table G - 1: Vegetation class benchmark condition state (WCPL 2017)

Vegetation Class	Site Attribute									
	NSR (count)	NOC	NMS	NGCG	NGCS	NGCO	EC	NTH (count)	OR	FL (m)
Western Slopes Dry Sclerophyll Forests	≥32	15 - 40	10 - 55	3 - 10	5 - 15	5 - 25	<5%	≥3	1	≥70
Western Slopes Grassy Woodlands	<35	6 - 25	14 - 50	3 - 35	3 - 25	5 - 1 - 40	<5%	≥2	1	<66

Table G - 2: Interim Performance Targets for Western Slopes Dry Sclerophyll Forests

Management Period	Interim Performance Target (SVS)	Site Attributes (% cover)									
		NSR (count)	NOC	NMS	NGCG	NGCS	NGCO	EC	NTH (count)	OR	FL (m)
Low Condition Vegetation											
Year 0 (Baseline)	6	<8	0	0	1	0	0	60	0	0	0
Years 1-5	34	12	0	3-10	1-2	1-5	1-3	60	0	1	10
Benchmark	>78	≥32	15-40	10-55	3-10	5-15	5-25	<5	≥3	1	≥70
Moderate to Good Condition Vegetation											
Year 0 (Baseline)	34	12	0	10	<3	<5	<4	60	0	1	10
Years 1-5	45	16	0	10-55	3-10	5-15	5-25	40	0	1	10
Benchmark	>78	≥32	15-40	10-55	3-10	5-15	5-25	<5	≥3	1	≥70
High Condition Vegetation											
Year 0 (Baseline)	70	18-32	15-40	10-55	3 -10	5-15	5-25	≤5	0	1	≥70
Years 1-20	70	18-32	15-40	10-55	3 -10	5-15	5-25	≤5	0	1	≥70
Benchmark	>78	≥32	15-40	10-55	3 -10	5-15	5-25	≤5	≥3	1	≥70

Table G - 3: Interim Performance Targets for Western Slopes Grassy Woodlands

Management period	Interim Performance Target (SVS)	Site Attributes (% cover)									
		NSR (count)	NOC	NMS	NGCG	NGCS	NGCO	EC	NTH (count)	OR	FL (m)
Low Condition Vegetation											
Year 0 (Baseline)	7	<9	0	0	5	0	0	60	0	0	0
Years 1-5	34	12	0	<4	60+	<2	<2	60	0	1	10
Benchmark	>78	≥23	10-45	5-60	5-45	2-10	5-35	<5	≥2	1	≥50
Moderate to Good Condition Vegetation											
Year 0 (Baseline)	34	12	0	≤3	60+	<2	<2	60	0	1	10
Years 1-5	45	12	0	5-60	45-60	<2	<2	40	0	1	10
Benchmark	>78	≥23	10-45	5-60	5-45	2-10	5-35	<5	≥2	1	≥50
High Condition Vegetation											
Year 0 (Baseline)	70	20-22	10-45	5-60	5-45	2-10	5-35	≤20	0	1	≥50
Years 1-20	70	20-23	10-45	5-60	5-45	2-10	5-35	≤20	0	1	≥50
Benchmark	>78	≥23	10-45	5-60	5-45	2-10	5-35	<5	≥2	1	≥50

Appendix F - Flora Species List

Family	Scientific Name	Native / Exotic
Acanthaceae	*Brunoniella australis*	Native
Alliaceae	*Allium triquetrum*	Exotic
Amaranthaceae	*Alternanthera nana*	Native
Anthericaceae	*Dichopogon fimbriatus*	Native
Anthericaceae	*Dichopogon strictus*	Native
Anthericaceae	*Laxmannia gracilis*	Native
Anthericaceae	*Thysanotus patersonii*	Native
Apiaceae	*Cyclospermum leptophyllum*	Exotic
Apiaceae	*Daucus glochidiatus*	Native
Apiaceae	*Hydrocotyle laxiflora*	Native
Asphodelaceae	*Bulbine bulbosa*	Native
Aspleniaceae	*Asplenium sp.*	Native
Asteraceae	*Arctotheca calendula*	Exotic
Asteraceae	*Asteraceae sp.*	Native/exotic
Asteraceae	*Calotis cuneifolia*	Native
Asteraceae	*Calotis lappulacea*	Native
Asteraceae	*Carthamus lanatus*	Exotic
Asteraceae	*Cassinia cunninghami*	Native
Asteraceae	*Cassinia laevis*	Native
Asteraceae	*Cassinia quinquefaria*	Native
Asteraceae	*Cassinia sifton*	Native
Asteraceae	*Centaurea sp.*	Exotic
Asteraceae	*Chondrilla juncea*	Exotic
Asteraceae	*Chrysocephalum apiculatum*	Native
Asteraceae	*Chrysocephalum sp.*	Native
Asteraceae	*Cirsium vulgare*	Exotic
Asteraceae	*Conyza bonariensis*	Exotic
Asteraceae	*Conyza sp.*	Exotic
Asteraceae	*Cotula australis*	Native
Asteraceae	*Cymbonotus lawsonianus*	Native
Asteraceae	*Euchiton sp.*	Native
Asteraceae	*Euchiton sphaericus*	Native
Asteraceae	*Facelis retusa*	Exotic
Asteraceae	*Gamochaeta calviceps*	Exotic

Family	Scientific Name	Native / Exotic
Asteraceae	*Gamochaeta sp.*	Exotic
Asteraceae	*Hypochaeris radicata*	Exotic
Asteraceae	*Lactuca saligna*	Exotic
Asteraceae	*Lagenophora stipitata*	Native
Asteraceae	*Olearia elliptica*	Native
Asteraceae	*Podolepis neglecta*	Native
Asteraceae	*Podolepis sp.*	Native
Asteraceae	*Pseudognaphalium luteo-album*	Native
Asteraceae	*Schkuhria pinnata*	Exotic
Asteraceae	*Senecio quadridentatus*	Native
Asteraceae	*Senecio sp.*	Native/exotic
Asteraceae	*Sigesbeckia orientalis*	Native
Asteraceae	*Silybum marianum*	Exotic
Asteraceae	*Solenogyne bellioides*	Native
Asteraceae	*Solenogyne sp.*	Native
Asteraceae	*Sonchus oleraceus*	Exotic
Asteraceae	*Sonchus sp.*	Exotic
Asteraceae	*Stuartina muelleri*	Native
Asteraceae	*Taraxacum officinale*	Native/exotic
Asteraceae	*Tolpis barbata*	Exotic
Asteraceae	*Triptilodiscus pygmaeus*	Native
Asteraceae	*Vittadinia cuneata*	Native
Asteraceae	*Vittadinia gracilis*	Native
Asteraceae	*Vittadinia muelleri*	Native
Asteraceae	*Vittadinia sp.*	Native
Asteraceae	*Xanthium spinosum*	Exotic
Boraginaceae	*Cynoglossum australe*	Native
Boraginaceae	*Echium plantagineum*	Exotic
Boraginaceae	*Echium vulgare*	Exotic
Boraginaceae	*Heliotropium amplexicaule*	Exotic
Brassicaceae	*Lepidium africanum*	Exotic
Brassicaceae	*Lepidium bonariense*	Exotic
Brassicaceae	*Lepidium sp.*	Native/exotic
Brassicaceae	*Sisymbrium officinale*	Exotic
Brassicaceae	*Sisymbrium sp.*	Exotic
Cactaceae	*Opuntia sp.*	Exotic

Family	Scientific Name	Native / Exotic
Cactaceae	*Opuntia stricta*	Exotic
Campanulaceae	*Wahlenbergia communis*	Native
Campanulaceae	*Wahlenbergia gracilis*	Native
Campanulaceae	*Wahlenbergia graniticola*	Native
Campanulaceae	*Wahlenbergia sp.*	Native
Caryophyllaceae	*Arenaria leptoclados*	Exotic
Caryophyllaceae	*Cerastium glomeratum*	Exotic
Caryophyllaceae	*Paronychia brasiliana*	Exotic
Caryophyllaceae	*Petrorhagia nanteuilii*	Exotic
Caryophyllaceae	*Petrorhagia dubia*	Exotic
Caryophyllaceae	*Silene gallica*	Exotic
Caryophyllaceae	*Stellaria media*	Exotic
Caryophyllaceae	*Stellaria pungens*	Native
Casuarinaceae	*Allocasuarina gymnanthera*	Native
Chenopodiaceae	*Chenopodium album*	Exotic
Chenopodiaceae	*Chenopodium sp.*	Native/exotic
Chenopodiaceae	*Dysphania pumilio*	Native
Chenopodiaceae	*Einadia hastata*	Native
Chenopodiaceae	*Einadia nutans*	Native
Chenopodiaceae	*Einadia trigonos*	Native
Chenopodiaceae	*Salsola australis*	Native
Clusiaceae	*Hypericum gramineum*	Native
Clusiaceae	*Hypericum perforatum*	Exotic
Colchicaceae	*Wurmbea dioica*	Native
Colchicaceae	*Wurmbea sp.*	Native
Convolvulaceae	*Convolvulus erubescens*	Exotic
Convolvulaceae	*Dichondra repens*	Native
Convolvulaceae	*Dichondra sp.*	Native
Crassulaceae	*Crassula sieberiana*	Native
Crassulaceae	*Crassula sp.*	Native/exotic
Cucurbitaceae	*Cucumis myriocarpus subsp. leptodermis*	Exotic
Cupressaceae	*Callitris endlicheri*	Native
Cyperaceae	*Carex appressa*	Native
Cyperaceae	*Carex inversa*	Native
Cyperaceae	*Cyperus gracilis*	Native
Cyperaceae	*Cyperus sp.*	Native

Family	Scientific Name	Native / Exotic
Cyperaceae	*Fimbristylis dichotoma*	Native
Cyperaceae	*Gahnia aspera*	Native
Cyperaceae	*Gahnia sieberiana*	Native
Cyperaceae	*Lepidosperma laterale*	Native
Cyperaceae	*Schoenus apogon*	Native
Dilleniaceae	*Hibbertia circumdans*	Native
Dilleniaceae	*Hibbertia obtusifolia*	Native
Dilleniaceae	*Hibbertia riparia*	Native
Dilleniaceae	*Hibbertia sp.*	Native
Droseraceae	*Drosera hookeri*	Native
Droseraceae	*Drosera peltata*	Native
Droseraceae	*Drosera sp.*	Native
Epacridaceae	*Acrotriche rigida*	Native
Epacridaceae	*Melichrus erubescens*	Native
Ericaceae	*Astroloma humifusum*	Native
Ericaceae	*Leucopogon muticus*	Native
Ericaceae	*Lissanthe strigosa*	Native
Euphorbiaceae	*Euphorbia drummondii*	Native
Euphorbiaceae	*Euphorbia sp.*	Native/exotic
Fabaceae	*Acacia decora*	Native
Fabaceae	*Acacia doratoxylon*	Native
Fabaceae	*Acacia genistifolia*	Native
Fabaceae	*Acacia gladiiformis*	Native
Fabaceae	*Acacia implexa*	Native
Fabaceae	*Acacia ixiophylla*	Native
Fabaceae	*Acacia leucolobia*	Native
Fabaceae	*Acacia linearifolia*	Native
Fabaceae	*Acacia penninervis*	Native
Fabaceae	*Acacia sp.*	Native
Fabaceae	*Acacia spectabilis*	Native
Fabaceae	*Acacia triptera*	Native
Fabaceae	*Acacia verniciflua*	Native
Fabaceae	*Aotus sp.*	Native
Fabaceae	*Aotus subglauca*	Native
Fabaceae	*Bossiaea buxifolia*	Native
Fabaceae	*Bossiaea sp.*	Native

Family	Scientific Name	Native / Exotic
Fabaceae	*Daviesia genistifolia*	Native
Fabaceae	*Daviesia sp.*	Native/exotic
Fabaceae	*Daviesia ulicifolia*	Native
Fabaceae	*Desmodium brachypodum*	Native
Fabaceae	*Desmodium rhytidophyllum*	Native
Fabaceae	*Desmodium varians*	Native
Fabaceae	*Glycine clandestina*	Native
Fabaceae	*Glycine tabacina*	Native
Fabaceae	*Hardenbergia violacea*	Native
Fabaceae	*Indigofera adesmiifolia*	Native
Fabaceae	*Medicago minima*	Exotic
Fabaceae	*Medicago polymorpha*	Exotic
Fabaceae	*Medicago sp.*	Exotic
Fabaceae	*Melilotus indicus*	Exotic
Fabaceae	*Ornithopus compressus*	Exotic
Fabaceae	*Podolobium ilicifolium*	Native/exotic
Fabaceae	*Pultenaea sp.*	Native/exotic
Fabaceae	*Swainsona galegifolia*	Native
Fabaceae	*Swainsona sp.*	Native
Fabaceae	*Templetonia stenophylla*	Native
Fabaceae	*Trifolium angustifolium*	Exotic
Fabaceae	*Trifolium arvense*	Exotic
Fabaceae	*Trifolium campestre*	Exotic
Fabaceae	*Trifolium glomeratum*	Exotic
Fabaceae	*Trifolium repens*	Exotic
Fabaceae	*Trifolium sp.*	Exotic
Fabaceae	*Trifolium subterraneum*	Exotic
Fabaceae	*Trifolium vesiculosum*	Exotic
Fabaceae	*Zornia dyctiocarpa*	Native
Gentianaceae	*Centaurium sp.*	Exotic
Geraniaceae	*Erodium botrys*	Exotic
Geraniaceae	*Erodium cicutarium*	Exotic
Geraniaceae	*Erodium crinitum*	Native
Geraniaceae	*Geranium molle*	Exotic
Geraniaceae	*Geranium solanderi*	Native
Goodeniaceae	*Goodenia hederacea*	Native

Family	Scientific Name	Native / Exotic
Goodeniaceae	*Goodenia ovata*	Native
Goodeniaceae	*Goodenia sp.*	Native
Haloragaceae	*Gonocarpus tetragynus*	Native
Haloragaceae	*Haloragis heterophylla*	Native
Haloragaceae	*Haloragis sp.*	Native
Hormiaceae	*Dianella cearula var. cearula*	Native
Hormiaceae	*Dianella revoluta*	Native
Hypoxidaceae	*Hypoxis glabella*	Native
Iridaceae	*Romulea rosea*	Exotic
Iridaceae	*Sisyrinchium rosulatum*	Exotic
Iridaceae	*Sisyrinchium sp.*	Exotic
Juncaceae	*Juncus sp.*	Native
Lamiaceae	*Ajuga australis*	Native
Lamiaceae	*Marrubium vulgare*	Native
Lamiaceae	*Mentha satureioides*	Native
Lamiaceae	*Salvia verbenaca*	Native
Lauraceae	*Cassytha pubescens*	Native
Linaceae	*Linum sp.*	Native/exotic
Linaceae	*Linum trigynum*	Exotic
Lomandraceae	*Lomandra confertifolia*	Native
Lomandraceae	*Lomandra filiformis*	Native
Lomandraceae	*Lomandra glauca*	Native
Lomandraceae	*Lomandra multiflora*	Native
Loranthaceae	*Amyema miquelii*	Native
Lythraceae	*Lythrum hyssopifolia*	Native
Malvaceae	*Brachychiton populneus*	Native
Malvaceae	*Lasiopetalum sp.*	Native
Malvaceae	*Malva parviflora*	Exotic
Malvaceae	*Modiola caroliniana*	Exotic
Malvaceae	*Sida corrugata*	Native
Malvaceae	*Sida rhombifolia*	Exotic
Malvaceae	*Sida sp.*	Native/exotic
Myrtaceae	*Angophora floribunda*	Native
Myrtaceae	*Eucalyptus albens*	Native
Myrtaceae	*Eucalyptus blakelyi*	Native
Myrtaceae	*Eucalyptus conica*	Native

Family	Scientific Name	Native / Exotic
Myrtaceae	*Eucalyptus crebra*	Native
Myrtaceae	*Eucalyptus melliodora*	Native
Myrtaceae	*Eucalyptus moluccana*	Native
Myrtaceae	*Eucalyptus punctata*	Native
Myrtaceae	*Eucalyptus sideroxylon*	Native
Myrtaceae	*Eucalyptus sp.*	Native
Myrtaceae	*Eucalyptus sparsifolia*	Native
Myrtaceae	*Melaleuca nodosa*	Native
Myrtaceae	*Melaleuca thymifolia*	Native
Myrtaceae	*Sannantha cunninghamii*	Native
Oleaceae	*Notelaea sp.*	Native
Onagraceae	*Oenothera indecora*	Exotic
Orchidaceae	*Caladenia fuscata*	Native
Orchidaceae	*Caladenia sp.*	Native
Orchidaceae	*Calandrinia eremaea*	Native
Orchidaceae	*Diuris goonooensis*	Native
Orchidaceae	*Microtis parviflora*	Native
Orchidaceae	*Microtis sp.*	Native
Orchidaceae	*Prasophyllum petilum*	Native
Orchidaceae	*Pterostylis bicolor*	Native
Orchidaceae	*Pterostylis mutica*	Native
Orchidaceae	*Pterostylis sp.*	Native
Orobanchaceae	*Parentucellia latifolia*	Exotic
Orobanchaceae	*Parentucellia sp.*	Exotic
Oxalidaceae	*Oxalis perennans*	Native
Oxalidaceae	*Oxalis sp.*	Native
Phyllanthaceae	*Poranthera microphylla*	Native
Phytolaccaceae	*Phytolacca octandra*	Exotic
Pittosporaceae	*Bursaria spinosa*	Native
Plantaginaceae	*Plantago debilis*	Native
Plantaginaceae	*Plantago lanceolata*	Exotica
Plantaginaceae	*Plantago sp.*	Native
Plantaginaceae	*Plantago varia*	Native
Plantaginaceae	*Veronica arvensis*	Exotic
Poaceae	*Aira sp.*	Exotic
Poaceae	*Aristida ramosa*	Native

Family	Scientific Name	Native / Exotic
Poaceae	*Aristida vagans*	Native
Poaceae	*Arundinella nepalensis*	Native
Poaceae	*Austrostipa scabra*	Native
Poaceae	*Austrostipa verticillata*	Native
Poaceae	*Avena sativa*	Exotic
Poaceae	*Bothriochloa macra*	Native
Poaceae	*Briza minor*	Exotic
Poaceae	*Bromus hordeaceus*	Exotic
Poaceae	*Cenchrus sp.*	Exotic
Poaceae	*Chloris gayana*	Exotic
Poaceae	*Chloris truncata*	Native
Poaceae	*Chloris ventricosa*	Native
Poaceae	*Cleistochloa rigida*	Native
Poaceae	*Cymbopogon refractus*	Native
Poaceae	*Cynodon dactylon*	Native
Poaceae	*Digitaria breviglumis*	Native
Poaceae	*Digitaria brownii*	Native
Poaceae	*Digitaria diffusa*	Native
Poaceae	*Digitaria eriantha*	Exotic
Poaceae	*Digitaria parviflora*	Native
Poaceae	*Digitaria sp.*	Native
Poaceae	*Echinopogon ovatus*	Native
Poaceae	*Eleusine tristachya*	Native
Poaceae	*Enneapogon nigricans*	Native/exotic
Poaceae	*Entolasia stricta*	Native
Poaceae	*Eragrostis brownii*	Native
Poaceae	*Eragrostis cilianensis*	Exotic
Poaceae	*Eragrostis curvula*	Exotic
Poaceae	*Eragrostis leptostachya*	Native
Poaceae	*Hordeum vulgare*	Exotic
Poaceae	*Lolium multiflorum*	Exotic
Poaceae	*Lolium sp.*	Exotic
Poaceae	*Microlaena stipoides*	Native
Poaceae	*Panicum effusum*	Native
Poaceae	*Paspalidium sp.*	Native
Poaceae	*Paspalum dilatatum*	Exotic

Family	Scientific Name	Native / Exotic
Poaceae	*Paspalum sp.*	Native/exotic
Poaceae	*Phalaris aquatica*	Exotic
Poaceae	*Poa sp.*	Exotic
Poaceae	*Rytidosperma caespitosum*	Native
Poaceae	*Rytidosperma pallidum*	Native
Poaceae	*Rytidosperma sp.*	Native
Poaceae	*Setaria pumila*	Exotic
Poaceae	*Setaria sp.*	Exotic
Poaceae	*Sporobolus creber*	Native
Poaceae	*Sporobolus sp.*	Native
Poaceae	*Vulpia bromoides*	Exotic
Poaceae	*Vulpia sp.*	Exotic
Polygonaceae	*Rumex brownii*	Native
Polygonaceae	*Rumex sp.*	Native
Portulacaceae	*Portulaca oleracea*	Native
Portulacaceae	*Portulaca sp.*	Native/exotic
Primulaceae	*Lysimachia arvensis*	Exotic
Proteaceae	*Persoonia linearis*	Native
Pteridaceae	*Cheilanthes distans*	Native
Pteridaceae	*Cheilanthes sieberi*	Native
Ranunculaceae	*Clematis aristata*	Native
Ranunculaceae	*Clematis glycinoides*	Native
Ranunculaceae	*Ranunculus sp.*	Native/exotic
Rosaceae	*Acaena ovina*	Native
Rubiaceae	*Asperula conferta*	Native
Rubiaceae	*Opercularia diphylla*	Native
Rubiaceae	*Opercularia hispida*	Native/exotic
Rubiaceae	*Pomax umbellata*	Native
Rubioideae	*Galium sp.*	Native
Rutaceae	*Phyllanthus hirtellus*	Native
Rutaceae	*Phyllanthus occidentalis*	Native
Rutaceae	*Phyllanthus sp.*	Native/exotic
Santalaceae	*Exocarpos strictus*	Native
Sapindaceae	*Dodonaea viscosa*	Native
Scrophulariaceae	*Eremophila debilis*	Native
Scrophulariaceae	*Verbascum thapsus*	Exotic

Family	Scientific Name	Native / Exotic
Scrophulariaceae	*Verbascum virgatum*	Exotic
Scrophulariaceae	*Veronica plebeia*	Native
Solanaceae	*Solanum aviculare*	Native
Solanaceae	*Solanum brownii*	Native
Solanaceae	*Solanum campanulatum*	Native
Solanaceae	*Solanum cinereum*	Native
Solanaceae	*Solanum nigrum*	Exotic
Solanaceae	*Solanum prinophyllum*	Native
Solanaceae	*Solanum sp.*	Native
Stackhousiaceae	*Stackhousia monogyna*	Native
Stackhousiaceae	*Stackhousia sp.*	Native
Stackhousiaceae	*Stackhousia viminea*	Native
Thymelaeaceae	*Pimelea sp.*	Native
Verbenaceae	*Verbena bonariensis*	Exotic
Verbenaceae	*Verbena sp.*	Native/exotic
Xanthorrhoeaceae	*Xanthorrhoea johnsonii*	Native
Zamiaceae	*Macrozamia secunda*	Native

Appendix G Fauna species list (Summer, Winter and Spring 2020)

Species name	Common name	BC Act	EPBC Act
Birds			
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		
Acanthiza lineata	Striated Thornbill		
Acanthiza nana	Yellow Thornbill		
Acanthiza pusilla	Brown Thornbill		
Acanthiza reguloides	Buff-rumped Thornbill		
Acanthorhynchus tenuirostris	Eastern Spinebill		
Acrocephalus australis	Australian Reed Warbler		
Aegotheles cristatus	Australian Owlet-nightjar		
Alisterus scapularis	Australian King-Parrot		
Anas superciliosa	Pacific Black Duck		
Anthochaera carunculata	Red Wattlebird		
Anthus novaeseelandiae	Australasian Pipit		
Artamus cyanopterus	Dusky Woodswallow	V	
Artamus superciliosus	White-browed Woodswallow		
Cacatua galerita	Sulphur-crested Cockatoo		
Cacomantis flabelliformis	Fan-tailed Cuckoo		
Cacomantis pallidus	Pallid Cuckoo		
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo		
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	
Ceyx azureus	Azure Kingfisher		
Chalcites osculans	Black-eared Cuckoo		
Chenonetta jubata	Australian Wood Duck		
Chrysococcyx lucidus	Shining Bronze-Cuckoo		
Cincloramphus mathewsi	Rufous Songlark		
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	
Colluricincla harmonica	Grey Shrike-thrush		
Coracina novaehollandiae	Black-faced Cuckoo-shrike		
Coracina tenuirostris	Cicadabird		
Corcorax melanorhamphos	White-winged Chough		
Cormobates leucophaea	White-throated Treecreeper		
Corvus coronoides	Australian Raven		
Coturnix ypsilophora	Brown Quail		

Species name	Common name	BC Act	EPBC Act
Cracticus nigrogularis	Pied Butcherbird		
Cracticus tibicen	Australian Magpie		
Cracticus torquatus	Grey Butcherbird		
Dacelo novaeguineae	Laughing Kookaburra		
Daphoenositta chrysoptera	Varied Sittella	V	
Dicaeum hirundinaceum	Mistletoebird		
Dromaius novaehollandiae	Emu		
Egretta novaehollandiae	White-faced Heron		
Elseyornis melanops	Black-fronted Dotterel		
Eolophus roseicapillus	Galah		
Eopsaltria australis	Eastern Yellow Robin		
Falco cenchroides	Nankeen Kestrel		
Falco peregrinus	Peregrine Falcon		
Falcunculus frontatus	Crested Shrike-tit		
Geopelia placida	Peaceful Dove		
Gerygone albogularis	White-throated Gerygone		
Gerygone fusca	Western Gerygone		
Glossopsitta concinna	Musk Lorikeet		
Glossopsitta pusilla	Little Lorikeet	V	
Grallina cyanoleuca	Magpie-lark		
Haliastur sphenurus	Whistling Kite		
Hirundo neoxena	Welcome Swallow		
Lalage tricolor	White-winged Triller		
Leucosarcia melanoleuca	Wonga Pigeon		
Lichenostomus chrysops	Yellow-faced Honeyeater		
Lichenostomus fuscus	Fuscous Honeyeater		
Lichenostomus leucotis	White-eared Honeyeater		
Lichenostomus melanops	Yellow-tufted Honeyeater		
Lichenostomus penicillatus	White-plumed Honeyeater		
Macropygia phasianella	Brown Cuckoo-dove		
Malurus cyaneus	Superb Fairy-wren		
Manorina melanocephala	Noisy Miner		
Melanodryas cucullata	Hooded Robin	V	
Melithreptus brevirostris	Brown-headed Honeyeater		
Melithreptus gularis gularis	Black-chinned Honeyeater	V	
Melithreptus lunatus	White-naped Honeyeater		

Species name	Common name	BC Act	EPBC Act
Merops ornatus	Rainbow Bee-eater		
Microeca fascinans	Jacky Winter		
Myiagra inquieta	Restless Flycatcher		
Neochmia temporalis	Red-browed Finch		
Neophema pulchella	Turquoise Parrot	V	
Ocyphaps lophotes	Crested Pigeon		
Origma solitaria	Rockwarbler		
Oriolus sagittatus	Olive-backed Oriole		
Pachycephala pectoralis	Golden Whistler		
Pachycephala rufiventris	Rufous Whistler		
Pardalotus punctatus	Spotted Pardalote		
Pardalotus striata	Striated Pardalote		
Petrochelidon aerial	Fairy Martin		
Petrochelidon nigricans	Tree Martin		
Phaps chalcoptera	Common Bronzewing		
Philemon citreogularis	Little friarbird		
Philemon corniculatus	Noisy Friarbird		
Phylidonyris niger	White-cheeked honeyeater		
Phylidonyris novaehollandiae	New Holland honeyeater		
Platycercus elegans	Crimson Rosella		
Platycercus eximius	Eastern Rosella		
Plectorhyncha lanceolata	Striped Honeyeater		
Podargus strigoides	Tawny Frogmouth		
Pomatostomus superciliosus	White-browed Babbler		
Psephotus haematonotus	Red-rumped Parrot		
Psophodes olivaceus	Eastern Whipbird		
Ptilonorhynchus violaceus	Satin Bowerbird		
Pyrrholaemus sagittatus	Speckled Warbler	V	
Rhipidura albiscapa	Grey Fantail		
Rhipidura leucophrys	Willy Wagtail		
Sericornis frontalis	White-browed Scrubwren		
Smicrornis brevirostris	Weebill		
Stagonopleura guttata	Diamond Firetail	V	
Strepera graculina	Pied Currawong		
Sturnus vulgaris	Common Starling		
Taeniopgia guttata	Zebra Finch		

Species name	Common name	BC Act	EPBC Act
Taeniopygia bichenovii	Double-barred Finch		
Threskiornis spinicollis	Straw-necked Ibis		
Todiramphus macleayii	Forest Kingfisher		
Todiramphus sanctus	Sacred Kingfisher		
Vanellus miles	Masked Lapwing		
Zosterops lateralis	Silvereye		
Amphibian			
Litoria caerulea	Green Tree Frog		
Reptiles			
Carlia tetradactyla	Southern Rainbow Skink		
Demansia psammophis	Yellow-faced Whipsnake		
Diplodactylus vittatus	Eastern Stone Gecko		
Diporiphora nobbi	Nobbi Dragon		
Furina diadema	Red-naped Snake		
Liopholis whitii	White's Skink		
Morethia boulengeri	Boulenger's Snake-eyed Skink		
Pogona barbata	Bearded Dragon		
Varanus varius	Lace Monitor		
Mammal			
Mus Musculus	House Mouse		
Mammal - Microbat			
Austronomus australis	White-Striped Free-tailed Bat		
Chalinolobus dwyeri	Large-eared Pied Bat	V	V
Chalinolobus gouldii	Gould's Wattled Bat		
Chalinolobus morio	Chocolate Wattled Bat		
Miniopterus orianae oceanensis	Large Bentwing Bat	V	
Nyctophilus sp.	Long-eared Bat		
Ozimops sp.	Free-tailed Bat		
Rhinolophus megaphyllus	Eastern Horseshoe Bat		
Scotorepens balstoni	Inland Broad-nosed Bat		
Vespadelus troughtoni	Eastern Cave Bat	V	
Vespadelus vulturnus	Little Forest Bat		

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Wilpinjong Coal 2020 Channel Stability Monitoring

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Abbreviations

Abbreviation	Description
ARI	Average Recurrence Interval
BEHI	Bank Erosion Hazard Index
CSM	Channel Stability Monitoring
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EY	Exceedances per Year
ML	Mining Lease
IFD	Intensity-Frequency-Duration
WCPL	Wilpinjong Coal Pty Ltd

Summary of key findings

Channel stability monitoring (CSM) was completed by Eco Logical Australia (ELA) on behalf of Wilpinjong Coal Pty Ltd (WCPL) from 30 November to 2 December 2020. The CSM program aims to provide qualitative measures of channel stability along Wilpinjong and Cumbo Creeks. Monitoring was undertaken across a total of 59 permanent monitoring locations – 49 on Wilpinjong Creek and 10 on Cumbo Creek. Consistent with previous monitoring, methods included surveying the designated reach of each monitoring site (approximately 100 m) and completing the Bank Erosion Hazard Index (BEHI) assessment, along with visual and photographic comparative assessments with data from previous years.

CSM results in 2020 were largely consistent with previous years, reflecting continued stability of the target creeks. For Wilpinjong Creek, BEHI ratings remained unchanged at 47 sites and declined at two sites, whilst for Cumbo Creek, ratings remained unchanged at all 10 sites. Site comparisons showed little observable change in the overall morphology of the channels. All sites showed a clear increase in both in-stream and bank vegetation ground cover, as well as in water levels and stream flow.

The 2020 CSM program was undertaken following well-above average rainfall in the preceding 6 and 12 month period, with multiple significant rainfall events occurring, which have the potential to cause erosion. An Intensity-Frequency-Duration (IFD) table was generated for the Wilpinjong catchment using the Bureau of Meteorology (BoM) 2016 Rainfall IFD Data system and detailed rainfall data from the WCPL Meteorological Station. Whilst no rainfall events exceeded the 1 in 5 year rainfall event generally accepted as likely to cause erosive scouring, there were several large rainfall events which caused erosion at localised sites where previous erosion was evident.

Identified historical erosion points were monitored in 2020 with sites E2, E4 and E11 experiencing minor active erosion in 2020. Overall, erosion points appear mostly consistent with previous years but require ongoing monitoring. Revegetation of the creek bank adjacent to E6, E7, E8 and E9 utilising native riparian woodland species was completed in 2019 with additional revegetation and remediation works recommended.

The results of 2020 CSM support conclusions made in previous monitoring and assessments, that ongoing mining operations are not causing stability issues within the target creek systems. Both Wilpinjong and Cumbo Creeks are typical of ephemeral creek systems in agricultural landscapes of the surrounding region, with channel stability issues within these creeks reflecting historical disturbances and land use practices, rather than contemporary mining operations.

1. Introduction

1.1 Background

Eco Logical Australia (ELA) was engaged by Wilpinjong Coal Pty Ltd (WCPL) to undertake annual channel stability monitoring (CSM) along Wilpinjong and Cumbo Creeks. CSM is required to satisfy Schedule 3, Condition 32 of WCPL's Project Approval (05-0021), and the CSM criteria detailed in Appendix 2 of the Wilpinjong Water Management Plan (WCPL 2018).

1.2 Regional overview

The Wilpinjong Coal Mine (WCM) is located in the Mid-Western Regional Council Local Government Area, approximately 45 km north-east of Mudgee. The mine is owned and operated by WCPL, a wholly owned subsidiary of Peabody Energy Australia.

The WCM is located at the headwaters of the Goulburn River which is a major tributary of the Hunter River catchment. Wilpinjong Creek is the main drainage channel within the WCM. It is an intermittent creek with a narrow floodplain that has a history of cattle grazing. The northern edge of the floodplain is bordered by the sandstone escarpments of the Goulburn River National Park (NP). Wilpinjong Creek has three coal mines in its catchment, Moolarben, Ulan and Wilpinjong, with the latter positioned furthest downstream. WCPL discharges treated mine water into Wilpinjong Creek, treated by reverse osmosis, at a licensed discharge point (EPL24) directly adjacent to WCM.

Cumbo Creek flows north through land managed by WCPL, passing between Pit 3, Pit 2, Pit 7 and Pit 4, before joining Wilpinjong Creek north of the eastern pit area. Wilpinjong Creek continues to flow east, for approximately 4.5 km downstream where it joins Wollar Creek, which continues another 13 km through the Goulburn River NP before entering the Goulburn River.

1.3 Previous channel stability assessments

A baseline channel stability assessment of Wilpinjong and Cumbo Creeks was undertaken in 2005 as part of the Environmental Impact Statement (EIS) for the Wilpinjong Coal Project (WCPL 2005) to characterise the existing condition of the Wilpinjong and Cumbo creek stream channels prior to mining. The Wilpinjong Creek survey included 49 sites and extended 12.5 km from the upstream gauging station to the confluence with Wollar Creek to the east. The Cumbo Creek survey included 10 sites and extended 3 km from the southern boundary of the Mining Lease (ML) 1573 north to the confluence with Wilpinjong Creek.

The baseline surveys concluded both Wilpinjong and Cumbo Creeks have been affected by pre-mining land management practices dominated by sheep and cattle grazing. These land management practices involved the clearing of riparian vegetation on both creeks to maximise grazing areas and stock access to drinking water. The clearing of this vegetation is assumed to have contributed significantly to bank instability. Disturbance from burrowing animals, both native (e.g. *Vombatus ursinus* (Common Wombat)) and introduced (e.g. *Oryctolagus cuniculus* (European Rabbit)), is also likely to have contributed to this instability.

Subsequent annual CSM has been undertaken in 2011, and 2014-2019, to assess the ongoing stability of the Wilpinjong and Cumbo Creeks during operational mining. Barnson (2017) developed a proforma to

assist in the assessment of creek stability at each survey location and to enable comparisons to be made between annual survey periods. Annual CSM reports have concluded that overall riparian health is poor, with erosion and bank stability issues present, typical of historically cleared agricultural catchments. Consistent site stability ratings in recent years is associated with prolonged drought conditions, resulting in minimal stream flow and reduced vegetation cover. Data collected by annual CSM to date has indicated that mining activities are not contributing to further channel stability issues in Wilpinjong and Cumbo Creeks.

1.4 Objectives

This report details the findings from the 2020 CSM program and provides a comparison of the regeneration progress of both Wilpinjong and Cumbo Creeks against previous monitoring conducted since 2011.

The CSM program aims to provide qualitative measures of stream bed and bank erosion and channel instability along Wilpinjong and Cumbo Creeks.

The key objectives of the 2020 CSM program are to:

- Evaluate erosional or depositional features of the creek banks
- Record the details of permanent monitoring sites with written descriptions and photographs
- Assess the stability of Wilpinjong and Cumbo Creeks using a rapid assessment methodology
- Compare visual channel stability at each of the permanent monitoring sites against previous monitoring records.

2. Methodology

2.1 Field survey – channel stability monitoring and comparative assessment

The field survey was conducted by ELA ecologists Elise Keane and Amanda Sales between 30 November and 2 December 2020.

A total of 59 permanent monitoring locations were surveyed (49 on Wilpinjong Creek and 10 on Cumbo Creek - **Figure 1**). Consistent with previous monitoring, surveys involved surveying the designated reach of each site (approximately 100 m) and completing the Bank Erosion Hazard Index (BEHI) assessment. BEHI assessment involves scoring a site on eight quantitative categories outlined below and in **Appendix A.**

The eight BEHI indicators of channel stability that were used to evaluate erosion at each site include:

- Bank Height (m)
- Bank Angle (°)
- Percentage of Bank Height with a Bank Angle Greater than 80°
- Evidence of Mass Wasting (% of Bank)
- Unconsolidated Material (% of Bank)
- Streambank Protection (% f Streambank covered in plant roots, vegetation, logs, branches, rocks, etc.)
- Established Beneficial Riparian Woody – Vegetation Cover
- Stream Curvature Descriptor.

The BEHI indicators produce an activity rating that classifies each location from 'Highly Unstable', indicating the drainage line is experiencing severe ongoing erosion, to 'Highly Stable', indicating the drainage line is highly stable in function and form. This rating system enables any deterioration or improvement in bank stability to be detected over time. The classification system is detailed below in **Table 1**.

Table 1: BEHI score ranges for each rating class

Rating	BEHI Score
Highly Stable	0-25
Moderately Stable	26-35
Stable	36-45
Unstable	46-55
Moderately Unstable	56-65
Highly Unstable	66-85

Field notes and photographs were taken to allow qualitative assessment through comparisons between monitoring periods. This process included written site descriptions using the previous monitoring report (ELA 2020) to make comparisons *in situ*, as well as taking upstream and downstream photographs at

each of the permanent monitoring sites. Site descriptions are provided in **Section 3** and copies of site photos are provided in **Appendix B**. Comparisons of the 2020 monitoring site (2011-2019) photographs has been made by referring to previous reports prepared by Barnson (2017) and ELA (2018, 2019 and 2020).

Previously established erosion points along Wilpinjong Creek were also assessed (**Figure 2**). These are in areas with moderate to severe erosion and are monitored to determine the presence and extent of on-going erosion. Management issues and threatened species are recorded opportunistically throughout the surveys, to highlight areas where management intervention is needed.

2.2 Rainfall and Flood Analysis

During the 2020 monitoring period there were several rainfall events that could potentially influence erosion in the target creeks. Flow data indicates there was an increase in water volume moving through the system during 2020, in comparison to the previous three years, which were characterised by lower than average rainfall and drought conditions (**Figure 3**, **Figure 4** and **Figure 5**).

The intensity and amount of rainfall can result in flooding and this influences erosion by way of scouring, slumping and surface destabilisation within rural creeks. The amount and rate of erosion is influenced by vegetation cover, topography, climatic factors and soil characteristics, along with the amount of rainfall and precipitation intensity.

An Intensity-Frequency-Duration (IFD) table was generated for the Wilpinjong catchment, using the Bureau of Meteorology (BoM) 2016 Rainfall IFD Data system. The process of determining IFD is known as frequency analysis and is an important part of hydrological design procedures. The IFD table was compared against the Wilpinjong rainfall data. Rainfall data for the 2020 monitoring period was collected from the WCPL Meteorological Station, Sentinex 34. Data was provided in 15 minute and hourly increments, as well as daily totals. This data was examined against the IFD table to determine the Average Recurrence Interval (ARI) or rarity of rainfall events over the 12-month period, to determine if any rainfall events would impact creek stability or result in erosion.

Figure 1: 2020 Channel stability monitoring locations along Cumbo and Wilpinjong Creek

Figure 2: Significant erosion locations along Wilpinjong Creek

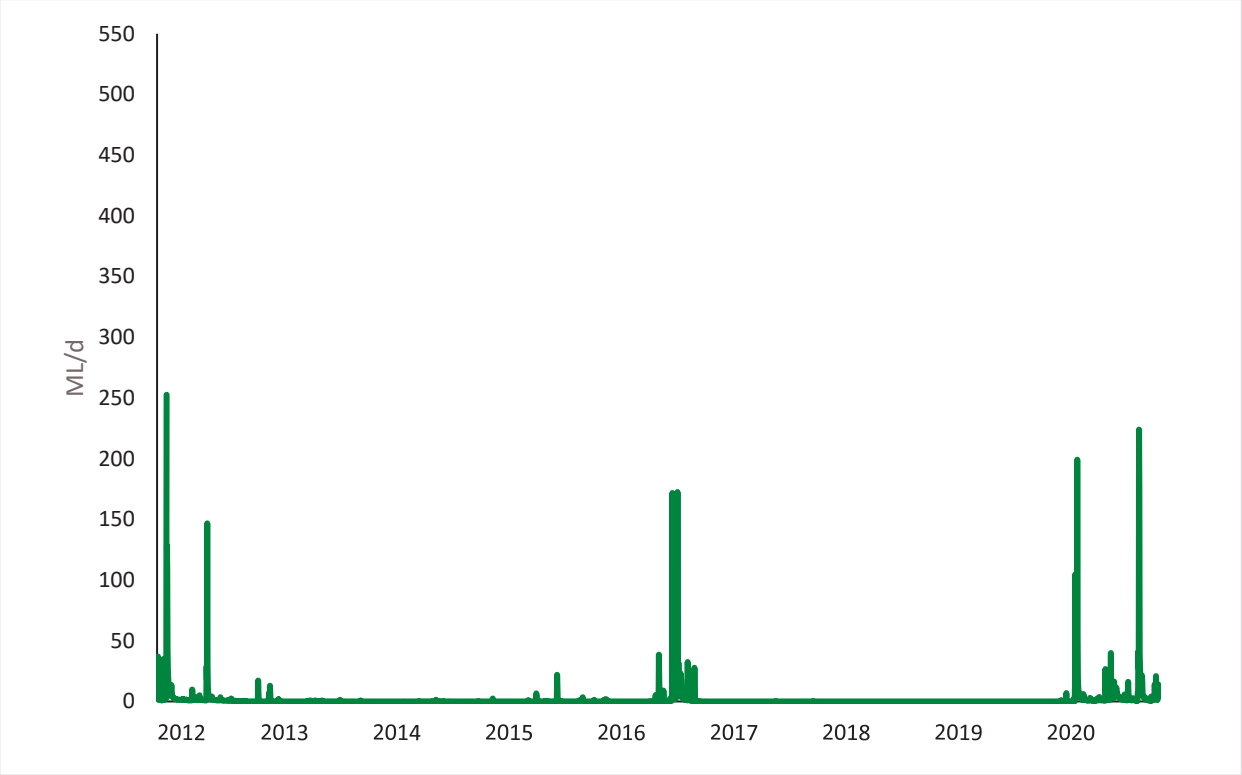

Figure 3: Wilpinjong Creek stream flow upstream of the WCPL mine discharge point EPL 24

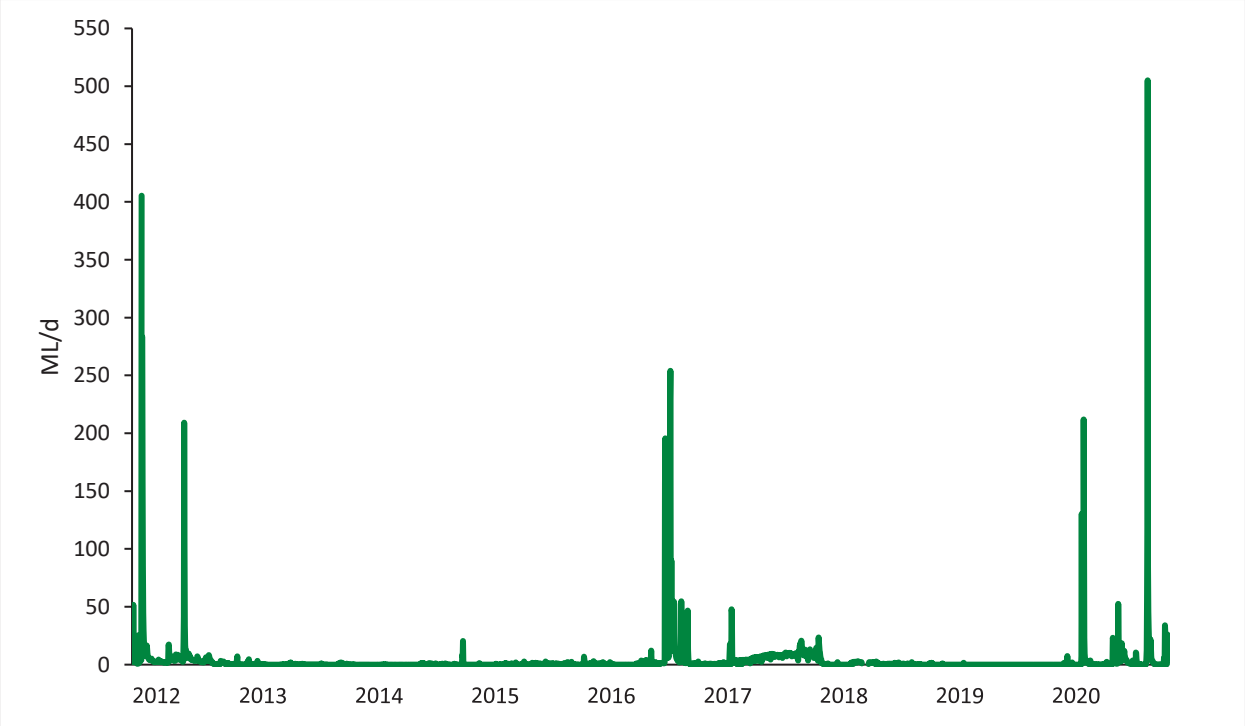

Figure 4: Wilpinjong Creek stream flow downstream of the WCPL mine discharge point EPL 24

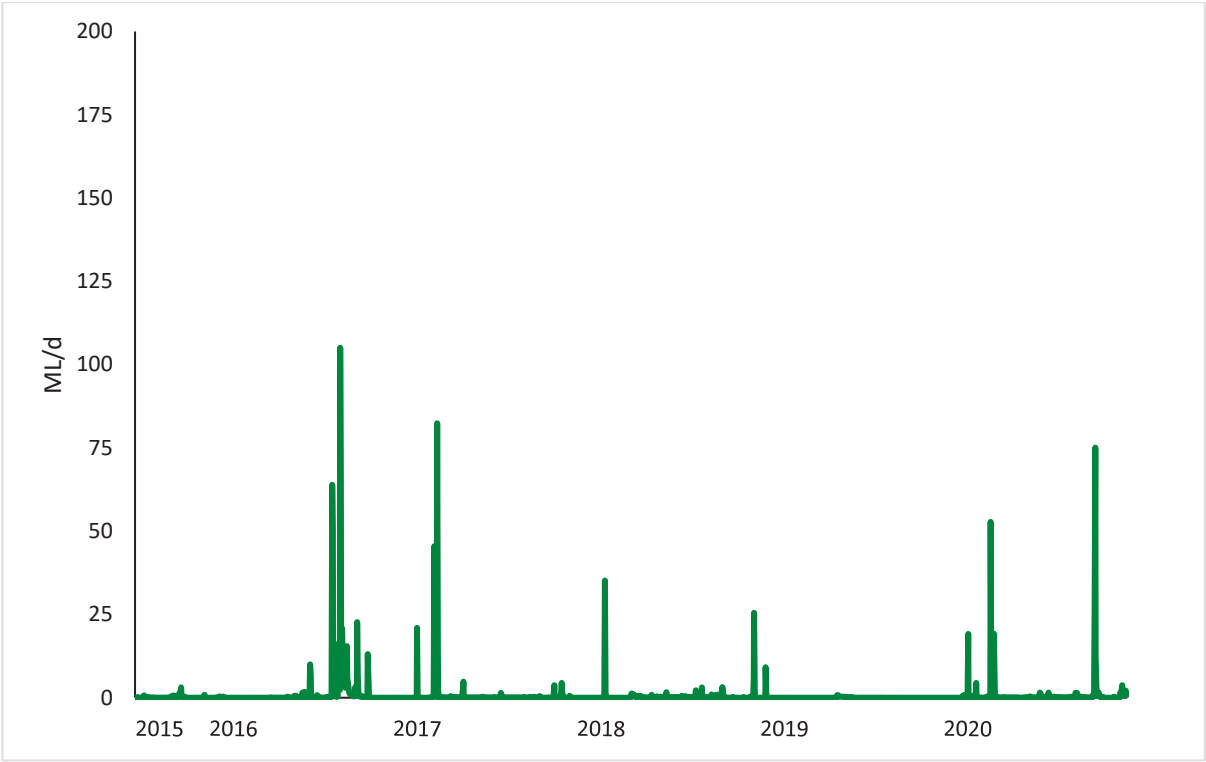

Figure 5: Cumbo Creek stream flow downstream of WCPL mine discharge point EPL 24

3. Results

3.1 Channel Stability Monitoring

The results of the BEHI assessments completed at sites along Wilpinjong Creek are presented below in **Table 2**, with results from Cumbo Creek sites presented in **Table 3**. Site descriptions and comparison notes can be found in **Table 4**.

Table 2: BEHI data for Wilpinjong Creek

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator								Total	Rating
				1	2	3	4	5	6	7	8		
WCk1	L	4	10	5	2	5	0	2.5	2.5	7.5	5	29.5	Mod Stable
WCk2	R	3.5	9	5	2	5	0	2.5	2.5	10	0	27	Mod Stable
WCk3	L	3	12	5	2	2.5	5	7.5	10	12.5	5	49.5	Unstable
WCk4	L	3.5	7	5	4	7.5	7.5	7.5	10	12.5	0	54	Unstable
WCk5	L	3	7	5	2	2.5	2.5	2.5	2.5	7.5	0	24.5	Highly Stable
WCk6	L	3	6	2.5	2	2.5	2.5	2.5	2.5	7.5	2.5	24.5	Highly Stable
WCk7	L	2.5	6	2.5	2	2.5	2.5	2.5	2.5	7.5	0	22	Highly Stable
WCk8	L	5	12	7.5	2	0	0	0	0	15	2.5	27	Mod Stable
WCk9	R	2	9	2.5	2	7.5	5	2.5	7.5	15	2.5	44.5	Stable
WCk10	R	1.5	15	2.5	0	0	0	0	0	15	2.5	20	Highly Stable
WCk11	R	1.5	18	0	0	0	0	2.5	2.5	10	2.5	17.5	Highly Stable
WCk12	R	2	12	2.5	2	0	0	5	7.5	12.5	5	34.5	Mod Stable
WCk13	L	4	8	5	4	0	0	0	0	10	5	24	Highly Stable
WCk14	L	1.8	7	2.5	2	0	0	2.5	2.5	12.5	0	22	Highly Stable
WCk15	L	1.8	6	2.5	2	2.5	2.5	2.5	2.5	10	2.5	27	Mod Stable
WCk16	L	2	7	2.5	2	5	0	0	0	7.5	0	17	Highly Stable
WCk17	R	1.8	4	2.5	2	0	0	2.5	0	15	2.5	24.5	Highly Stable
WCk18	R	2.5	5	2.5	2	5	2.5	0	2.5	15	2.5	32	Mod Stable
WCk19	L	2	4	2.5	2	5	0	2.5	7.5	15	0	34.5	Mod Stable
WCk20	L	1.8	5	2.5	2	2.5	5	2.5	7.5	12.5	0	34.5	Mod Stable
WCk21	R	1.3	5	0	2	2.5	2.5	0	2.5	15	2.5	27	Mod Stable
WCk22	R	1.6	8	2.5	2	0	5	5	10	12.5	2.5	39.5	Stable
WCk23	R	2.5	12	2.5	2	0	2.5	7.5	12.5	15	5	47	Unstable
WCk24	R	1.7	10	2.5	0	2.5	7.5	10	12.5	15	2.5	52.5	Unstable
WCk25	L	1.7	7	2.5	2	2.5	7.5	5	10	15	2.5	47	Unstable
WCk26	L	3.5	10	5	2	7.5	5	5	7.5	15	2.5	49.5	Unstable

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator								Total	Rating
				1	2	3	4	5	6	7	8		
WCk27	R	2.8	5	2.5	6	7.5	5	7.5	10	15	2.5	56	Mod Unstable
WCk28	L	2.5	5	2.5	2	5	5	5	7.5	12.5	2.5	42	Stable
WCk29	L	3.6	8	5	2	5	5	5	7.5	15	2.5	47	Unstable
WCk30	R	2.8	12	2.5	2	0	0	0	0	12.5	2.5	19.5	Highly Stable
WCk31	R	3	6	2.5	4	5	5	7.5	7.5	15	2.5	49	Unstable
WCk32	R	3.2	7	5	4	7.5	5	5	7.5	15	2.5	51.5	Mod Unstable
WCk33	L	3.2	6	5	4	7.5	5	5	7.5	10	5	49	Unstable
WCk34	R	2.4	6	2.5	4	5	5	2.5	5	15	5	44	Stable
WCk35	R	2.2	13	2.5	2	0	5	5	7.5	15	2.5	39.5	Stable
WCk36	R	2	15	2.5	2	0	2.5	2.5	2.5	15	2.5	29.5	Mod Stable
WCk37	R	2	10	2.5	2	2.5	5	7.5	10	15	2.5	47	Unstable
WCk38	L	3.1	6	5	2	2.5	2.5	2.5	2.5	10	5	32	Mod Stable
WCk39	L	3.2	7	5	4	2.5	5	5	7.5	15	2.5	46.5	Unstable
WCk40	R	3.2	14	5	2	0	7.5	10	12.5	15	0	52	Unstable
WCk41	R	2.8	8	2.5	2	2.5	2.5	0	2.5	15	0	27	Mod Stable
WCk42	R	3.8	6	5	4	7.5	5	10	10	12.5	2.5	56.5	Mod Unstable
WCk43	L	3.1	5	5	4	7.5	2.5	2.5	7.5	15	2.5	46.5	Unstable
WCk44	R	1.7	3	2.5	2	2.5	2.5	5	2.5	15	2.5	34.5	Mod Stable
WCk45	L	3.2	7	5	2	2.5	2.5	2.5	2.5	7.5	5	29.5	Mod Stable
WCk46	R	2.2	5	2.5	4	5	2.5	2.5	2.5	10	2.5	31.5	Mod Stable
WCk47	R	2.2	6	2.5	2	2.5	5	2.5	7.5	12.5	0	34.5	Mod Stable
WCk48	L	2.7	8	2.5	2	2.5	2.5	2.5	2.5	12.5	2.5	29.5	Mod Stable
WCk49	L	3.8	10	5	4	2.5	5	5	7.5	12.5	2.5	44	Stable

Table 3: BEHI for Cumbo Creek

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator								Total	Rating
				1	2	3	4	5	6	7	8		
CCk1	R	1.8	10	2.5	0	0	0	0	0	15	0	17.5	Highly Stable
CCk2	R	1.3	8	0	2	2.5	5	5	7.5	15	5	42	Stable
CCk3	L	0.4	2	0	0	0	0	0	0	15	2.5	17.5	Highly Stable
CCk4	R	1	13	0	0	0	0	0	0	15	2.5	17.5	Highly Stable
CCk5	R	1	8	0	0	0	0	2.5	2.5	15	2.5	22.5	Highly Stable
CCk6	R	1.8	10	2.5	2	0	2.5	0	2.5	15	2.5	27	Mod Stable
CCk7	R	0.5	2	0	2	2.5	0	0	0	15	2.5	22	Highly Stable
CCk8	L	2	15	2.5	0	0	0	0	0	15	2.5	20	Highly Stable
CCk9	L	0.7	2	0	2	2.5	0	0	0	15	2.5	22	Highly Stable
CCk10	L	0.7	4	0	2	2.5	0	0	0	15	2.5	22	Highly Stable

One weed species, *Rubus fruticosus* (Blackberry), which is classified as a regional priority weed under the Central Tablelands Regional Strategic Weed Management Plan 2017 – 2022 (Local Land Services 2017), was identified at two sites along Wilpinjong Creek (**Table 4** and **Figure 6**). Additionally, there was a high abundance of *Carthamus lanatus* (Saffron Thistle) observed across the monitoring sites. This weed has grown prolifically across the surrounding region in response to above average rainfall throughout 2020, particularly in cleared areas, such as those adjacent to Wilpinjong and Cumbo Creeks.

Table 4: Monitoring site descriptions - Wilpinjong Creek and Cumbo Creek

Site	Upstream	Downstream
WCk1	• Running water in creek • Increased groundcover on bank • Vegetation in channel • Localised erosion along stock tracks	• Evidence of grazing by stock including cattle hoof prints • Some bare soil patches • Running and pooling water • Increase of vegetation in channel and on banks
WCk2	• Increase in vegetation in channel and on bank • Running water/pooling in creek • Minimal localised erosion, mainly from stock presence	• Good vegetation cover on banks and in channel • Running and pooling water • Evidence of stock presence
WCk3	• Increase in vegetation cover on bank and in channel • Slow flow of water and ponding in creek • Evidence of cattle in channel, with scats and tracks present • Localised erosion along stock tracks	• Increase in vegetation on banks and in channel • Minimal erosion from stock • Woody debris on LHS • LHS erosion looks to be stable post rainfall events
WCk4	• Slow flow of water and ponding in creek • Some active erosion in past year. Left bank unstable, significant bank collapse and undercutting, not currently active • Vegetation present on both banks and in channel	• LHS erosion active in past year • Vegetation on banks and in channel • Woody debris on LHS and some on RHS at fence line • Stock presence evident • Fence broken by high flow and debris
WCk5	• *Phragmites australis* (Common reed) present in channel • LHB erosion active • Vegetation on bank and in channel • Slow flow of water and pooling • Some bare soil from erosion cut out • Eucalypt regeneration in channel bed	• Good vegetation on banks and in channel with *Phragmites australis* present • Some unconsolidated material present from erosion and flow events in past year
WCk6	• Fallen trees in channel bed • Eucalypt regeneration in channel • *Gahnia aspera* (Rough Saw-sedge) and shrubs growing on left bank • Woody debris from rainfall event • Good vegetation on banks and in channel • *Phragmites australis* present	• Good vegetation on bank and channel • Woody debris from flow events present • Pooling water, some very low flow in stream

Site	Upstream	Downstream
WCk7	• *Phragmites australis* present • Pooling water • Vegetation on banks and in channel • *Rubus fruticosus* present	• Fallen eucalypt tree • Minor woody debris on RHS • Vegetation present on bank and in channel
WCk8	• Vegetation cover on banks and in channel • *Phragmites australis* present • Some woody debris	• Banks stable • Good vegetation cover on banks and in channel with *Phragmites australis* present • Some woody debris present from flow events • Ponding and slow flowing water in stream
WCk9	• Vegetation in channel and on banks • Some bare ground on RHB • Erosion stable • *Phragmites australis* present • Some debris washed up by water flow	• Step banks on RHS but appears stable post rainfall events • *Phragmites australis* present in channel • Some woody debris • Pooling and ponding water in channel
WCk10	• Vegetation on banks and in channel • Ponding of water • *Phragmites australis* present	• Stable banks • Some bare soil on RHS at steep section • *Phragmites australis* present and vegetation cover on banks • Slow flow and ponding in channel
WCk11	• Wombat activity on bench on right bank • Vegetation in stream and on bank • Ponding and very slow flow of water • Some woody debris and fallen Eucalypt saplings	• Good macrophyte cover and vegetation cover in channel and on banks • Some woody debris present • Ponding water in channel
WCk12	• Sediment present from upstream erosion • Vegetation cover on banks • *Phragmites australis* present in channel • Ponding water • Some woody debris washed up by water flow	• Ponding water, no flow in channel • Sediment and unconsolidated material present from flow events • *Phragmites australis* present in channel and good vegetation cover on banks
WCk13	• Good vegetation cover on banks and in channel • Debris on banks • Low flow of water and ponding • *Phragmites australis* present	• Undercutting on left bank downstream of reach, active in the past year • Some bare soil on RHS bank. Vegetation cover good otherwise • LWD on RHS bank

Site	Upstream	Downstream
WCk14	• Ponding water, very low to no flow of water • *Phragmites australis* on banks and in channel with high vegetation cover • Minor debris at base of tree	• Vegetation cover good on banks and some present in channel • Low to no flow of water with some ponding areas minor debris on banks from flow events
WCk15	• Vegetation on banks and in stream • LWD on LHS of bank • Ponding, with no water flow • *Phragmites australis* present • Some sediment at base of channel	• Vegetation cover on banks and in channel, *Phragmites australis* present • Debris on fence from flow events • Some sediment from erosion upstream • LWD on LHS and RHS banks
WCk16	• No water flow, ponding of water in channel • Good vegetation cover on banks and some in channel • Some debris from high water flow events • *Phragmites australis* present	• LWD on RHS • *Phragmites australis* present in channel and on bank edges • God vegetation cover • No flow in channel
WCk17	• Highly vegetated, with *Phragmites australis* in channel and on bank	• Dense vegetation of *Phragmites australis* in channel, preventing access in addition to wet conditions
WCk18	• Good ground cover • *Phragmites australis* in channel • Ponding of water in channel • Wombat burrows in both banks	• Erosion active on RHS bank in past year but appears stable • Debris on banks from flow events • *Phragmites australis* in channel and good vegetation cover on banks
WCk19	• High vegetation cover of grasses/rushes in channel and banks • Ponding water with no water flow • Minor debris	• *Phragmites australis* in channel and good vegetation cover on banks • Bare patches present on RHS • Ponding water in stream • Some LWD
WCk20	• Increased vegetation on bank and in channel • Active erosion on LHB in past year • *Phragmites australis* present in channel	• Channel and banks well vegetated with *Phragmites australis* and *Lomandra* spp. • Increase in vegetation cover from previous year • Minor lateral erosion on both banks occurring in past year • Some regeneration on LHS bank
WCk21	• Very high vegetation cover on banks and *Phragmites australis* in channel • No water flow but wet conditions • Debris and leaf litter build up in channel	• Good vegetation cover on banks and in channel • LHS erosion active in past year • No flow but wet conditions in channel

Site	Upstream	Downstream
WCk22	• Good vegetation cover in channel and on left bank • *Phragmites australis* present • No riparian tree cover on LHB with only small riparian zone on RHB	• Erosion evident on RHS bank, active in the past year • Good vegetation cover on banks and in channel with *Phragmites australis* present • RHS some bare soil patches • No riparian tree cover
WCk23	• Good vegetation cover in channel with *Phragmites australis* present • Good vegetation cover on banks, with some regeneration • Erosion has occurred on LHB in past year • Erosion on top of both banks, leading to exposed patches	• Good vegetation cover in channel *Phragmites australis* present • Increase I bank vegetation cover but still some bare soil patches present, particularly the RHS • Wet conditions in channel
WCk24	• Good cover of *Lomandra* spp. On left bank • Bare exposed patches on RHB • Some woody debris • Good vegetation cover in channel bed, with *Phragmites australis* present	• Erosion on RHS bank active in the past year • Good vegetation cover on LHS bank with some regeneration present • *Phragmites australis* in channel
WCk25	• Erosion on right bank has been active in past year • Bank vegetation is dominated by *Carthamus lanatus* • Good vegetation cover with *Phragmites australis* present in channel • Good ground cover and banks • Some erosion on LHB	• *Phragmites australis* in channel • Significant bare soil patches with notching erosion occurring in the past year • Good vegetation cover on upper banks • LWD on RHS bank
WCk26	• Good vegetation cover in stream and on banks • *Phragmites australis* in channel	• Active erosion in past year on both sides of the channel • *Phragmites australis* in channel with good vegetation cover on upper banks
WCk27	• Good vegetation in channel, with *Phragmites australis* present • Active erosion on right bank in past year • Good vegetation cover on banks	• *Phragmites australis* in channel with good coverage • Good vegetation cover on banks with some bare patches of soil with active erosion in the past year
WCk28	• LWD on LHS bank • Good vegetation cover in banks and in channel • Bare sections present on left bank • Regeneration at top of left bank	• Good vegetation cover in channel with *Phragmites australis* present • Vegetation cover on banks increased from previous year • Sections of LHS bank are steep with active erosion occurring in the past year • Some areas of bare soil (minor) on left and right banks
WCk29	• Increase in vegetation cover • *Phragmites australis* in channel and on bank	• Increase of vegetation in channel and on banks • *Phragmites australis* in channel

Site	Upstream	Downstream
		• *Carthamus lanatus* dominate banks • Active erosion in the past year • *Rubus fruticosus* still present in channel
WCk30	• Good cover of *Phragmites australis* in channel with good vegetation cover on banks • Water ponding with little to no flow • Wombat burrows on RHB • Good general regeneration on both banks	• No change to gully forming on the RHS bank downstream end of reach • Good cover of *Phragmites australis* in channel • Increase in vegetation cover on banks • Minor change to eroded section on LHS with bare soil patches • Water ponding in stream, no flow
WCk31	• Minor erosion in past year, fairly stable • *Phragmites australis* in channel • Increase in vegetation on banks • Channel wet with minor flow and ponding	• *Phragmites australis* in channel and extending to banks • Debris from flow events present • Good vegetation cover on banks • Minor erosion and exposed root systems on RHS bank
WCk32	• Good cover of *Phragmites australis* in channel and vegetation cover on banks • Left bank showing signs of erosion, with minor increase in vegetation on mid to upper bank • Right bank very steep erosion leading to exposed roots. Erosion has been active in the past year, currently stable	• Right bank erosion active in past year but appears to the stable • Left bank vegetation cover increased from previous year • RHS bank dominated by *Carthamus lanatus*
WCk33	• Increase vegetation on bank and in stream with *Phragmites australis* present • Some minor erosion on LHS and woody debris present • Tree cover present on left bank with some regeneration and ground cover	• LHS bank showing signs of active erosion in past year • Sediment and unconsolidated material in base of channel • Exposed root systems and bare patches of soil on LHS mid bank section, good vegetation cover on upper banks • Tree cover moderate • *Phragmites australis* present in channel
WCk34	• In channel vegetation cover remains high with *Phragmites australis* dense in stream • Good vegetation on banks with minimal areas of bare ground • Minor erosion evident in past year	• Right bank is steep with minor erosion occurring in the past year • Some bare soil on RHS banks • Left bank showing increase in vegetation cover • Good cover of *Phragmites australis* in channel • Ponding water in stream, no flow

Site	Upstream	Downstream
	• Right bank stable but some wombat burrows and animal track present	
WCk35	• In stream vegetation remains high and extends onto the banks with *Phragmites australis* present • *Carthamus lanatus* present on RHS bank • RHS ban bare patches present with active erosion in the past year indicated by receding bank edge.	• Increase in vegetation cover on RHS, dominated by *Carthamus lanatus* • Some debris present in channel from flow events • Regeneration downstream of reach on left bank • Good cover of *Phragmites australis* in channel
WCk36	• *Phragmites australis* present in channel and good vegetation cover on banks • Minor erosion on the LHS bank and minor riling on RHS • Some bare patches on both sides of the bank	• Slumping on RHS bank showing signs of activity in the past year but appears stable • Some undercutting evident and exposed bare soil downstream on LHS • Increase in vegetation cover in stream and on banks • Little riparian tree cover and *Carthamus lanatus* dominate vegetation cover
WCk37	• Increase in vegetation both in stream and on banks with *Phragmites australis* present • *Carthamus lanatus* present on RHS bank with some bare soil and active erosion in the past year • LHS bank remains well vegetated (grazed) with some minor lateral erosion	• Bare soil patches present on RHS bank and some evidence of active erosion in past year • Debris present on RHS • LWD present on LHS bank • Vegetation cover increase in past year, *Carthamus lanatus* dominating RHS bank • Good cover of *Phragmites australis* in channel
WCk38	• Increase in vegetation on banks and in channel with Rush species present • Ponding water, no flow at time of monitoring • Debris on LHS bank with minor erosion in the past year	• Scarce cover of *Phragmites australis* on LHS bank • Rush spp. present in channel • Good vegetation cover on both banks with some minor debris on both sides
WCk39	• Increase in vegetation cover on banks and in stream • Grasses and rush species present • Minor LHS bank erosion in the past year. Appears to be stable however bare soil is present • Ponding of water, no flow	• Increase in vegetation cover on banks and in channel • Erosion on left bank showing evidence of minor active erosion in past year • Upper left bank steep but currently vegetated and stable

Site	Upstream	Downstream
WCk40	• Increase in vegetation cover on banks and in channel • Grass and rush species present in channel with ponding water • LHS bank stable but some active lateral erosion occurring in the past year	• Increase in vegetation on banks and in stream with rush and grass spp. present • Debris present from rainfall events • RHS bank bare patches of soil present
WCk41	• Good vegetation cover on banks, RHS small amount of bare soil present and exposed tree roots • Sediment build-up on LHS from erosion upstream • Slow flowing water with grass and rush species present in channel	• Creek bed and left bank well vegetated and stable • LWD on LHS bank • RHS bank erosion consistent with last year post rainfall events, stable • Slow flow of water in stream
WCk42	• Increased vegetation in channel and on banks • *Carthamus lanatus* present in upper banks • Debris present from flow events with sediment from upstream on RHS bank erosion appears stable • LWD on LHS bank	• Increase of vegetation in channel and on banks • Undercutting stable and root system exposure consistent with last year post flow events
WCk43	• Increase in vegetation cover in channel • Good vegetation cover on bank, however *Carthamus lanatus* present • Vegetation on banks appears to be stabilising post grazing • Erosion present but stable on LHS bank	• Slow flow of water in stream • Increase and good vegetation cover in channel with LWD and woody debris past rainfall event • Good vegetation cover on banks, however dominated by *Carthamus lanatus* • LHS bank steep with exposed root systems, appears stable post flow events
WCk44	• Increase in overall vegetation cover, *Carthamus lanatus* dominating the upper banks • Stock activity evident • LHS appears stable RHS exposed root systems appears consistent with previous year post flow events.	• Increase of vegetation cover in channel and on banks • *Carthamus lanatus* dominate upper banks • Some bare soil on LHS and erosion appears stable • Water pooling in stream, no flow
WCk45	• Increase stream vegetation cover • LWD and debris present in channel and on LHS bank • LHS bank stable with vegetation present	• Significant vegetation cover on banks and an increase of vegetation cover in channel • Pooling water with slow flow in stream • LWD and debris on LHS bank

Site	Upstream	Downstream
		• Evidence of stock presence including hoof prints
WCk46	• Increase in vegetation cover in streams and on banks • LWD present on RHS bank • Banks stable on both sides	• Significant vegetation cover in channel and on banks • Ponding water in stream with very slow flow • Evidence of stock presence • LHS bank exposed root systems appears stable post flow events • RHS bank has minor exposed steep sections and appears stable
WCk47	• Increase of macrophytes in stream • Debris on LHS bank and in channel • Banks steep but stable with some erosion near fence post that has also broken in past year	• Increase of macrophyte habitat in channel • Increase of groundcover on left and right banks • Ponding water in stream with slow flow • Debris present in channel from flow events • Erosion from stock presence appears stabilised by vegetation
WCk48	• Increase in vegetation in channel with macrophyte habitat present • Good vegetation cover on banks • Left bank steep but stable after active erosion in the past year	• Vegetation cover increased in channel with macrophyte habitat present • Good vegetation cover on banks • Debris and LWD on RHS bank • Stock presence and subsequent erosion appears stable on RHS
WCk49	• Increase in vegetation cover on banks and in channel • Washout in centre with some minor undercutting • RHS lateral erosion • LHS appears more stable with some minor lateral erosion • Sediment and unconsolidated material present	• Increase in vegetation on banks • LHS steep but currently stable • RHS showing signs of lateral erosion • Sediment and unconsolidated material build-up on channel bed • LWD and small debris present on LHS bank • Slow flow of water through stream
CCk1	• Increase in vegetation in channel • Increase of vegetation on banks, *Carthamus lanatus* dominate with some regeneration	• Increase in vegetation on bank and in stream • *Carthamus lanatus* dominate bank vegetation
CCk2	• Increased vegetation in channel and on banks	• Good vegetation cover and stable channel in and left bank

Site	Upstream	Downstream
	• *Carthamus lanatus* dominate banks • Active erosion in past year but appears consistent with previous year and stable	• Some bare soil and bed rock exposure on right bank but stable • *Carthamus lanatus* dominating vegetation cover on banks • Stagnant pooled water
CCk3	• Increase of vegetation in channel • Good vegetation cover on banks • Debris from flow events present • Ponding stagnate water and mud	• Increase of macrophyte vegetation in channel • Vegetation cover increased on banks but dominated by *Carthamus lanatus* • No riparian tree cover
CCk4	• Good groundcover in channel and on banks • *Carthamus lanatus* present with some grasses • Some stagnant water present	• Site remains stable • Some stagnant water • Good and stable vegetation cover with *Carthamus lanatus* present
CCk5	• Channel remains vegetated with an increase in density • Groundcover on banks has increased, grasses with *Carthamus lanatus* present • Some bare ground on upper right bank due to animal tracks	• Increase in vegetation in channel and on banks • Debris present from flow events • *Carthamus lanatus* dominate upper banks
CCk6	• Area well vegetated with an increase from previous year with grass and rush species • Exposed root systems consistent with last year, appears stable post flow events. No lateral erosion • *Carthamus lanatus* present on upper banks	• Increase in vegetation in channel and on left and right banks • RHS bank showing signs of active erosion in past year but appears stable
CCk7	• Increase in groundcover • *Carthamus lanatus* present • Banks remain stable	• Increase of groundcover in channel • Vegetation cover on banks increased however dominated by *Carthamus lanatus* • Minor erosion on left bank appears stable post rainfall events
CCk8	• Regrowth of vegetation in channel with *Phragmites australis* present • Vegetation on banks comprised of grass species with *Carthamus lanatus* present	• Increase of vegetation in channel, *Phragmites australis* present • Good vegetation cover on left and right banks

Site	Upstream	Downstream
CCk9	• Increase in vegetation cover, mostly *Carthamus lanatus* with some grass species and *Rumex* spp.	• Increase in vegetation cover on banks and in stream • *Carthamus lanatus* dominating bank • Minor lateral erosion appears stable
CC10	• Increase in vegetation cover, rush and grass species, with *Carthamus lanatus* present • Some minor erosion in the past year with bank height increase	• Increase in vegetation cover, grass spp. with *Carthamus lanatus* dominating • Evidence of active lateral erosion on LHS bank • *Rumex sp*. present in channel

Figure 6: Location of listed weeds along Wilpinjong Creek

3.2 Rainfall and Flood Analysis

The total catchment area of Wilpinjong Creek upstream of the project area (from the upstream gauging station) was calculated to be 81 km², with the downstream catchment calculated to be 175 km². The Cumbo Creek catchment area (upstream of the confluence with Wilpinjong Creek) was calculated to be 70 km² (Barnson 2017). Both creeks are ephemeral in nature, with flow through the system limited only after prolonged and/or intense rainfall events. Information relating to the velocities of flow versus scouring potential of soils within in each creek is somewhat limited. It is generally accepted that well vegetated creek banks and beds will not scour during minor storm events (i.e. events below 1 in 5 year rainfall events). No such event was recorded during 2020, however, multiple significant rainfall events were recorded throughout the year and are detailed in the following section.

IFD tables and graphs were produced via the BoM 2016 Rainfall IFD Data system for:

- Frequent and Infrequent events – the annual exceedance probability (AEP) provided as a percentage (**Table 5** and **Figure 7**)
- Very frequent events – with the number of times an event is likely to occur or be exceeded within any given year (**Table 6** and **Figure 8**)

Table 5: Rainfall depths (mm) for durations and Annual Exceedance Probabilities (AEP) for frequent and infrequent events

	Annual Exceedance Probability (AEP)						
Duration	**63.20%**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**
15 min	12.2	13.5	17.8	20.8	23.9	28.2	31.7
30 min	16.3	18	23.7	27.8	31.9	37.6	42.1
45 min	18.6	20.6	27.1	31.7	36.4	42.7	47.6
1 hour	20.3	22.5	29.6	34.5	39.5	46.2	51.4
1.5 hour	22.8	25.2	33.1	38.6	44.1	51.4	57
2 hour	24.7	27.3	35.8	41.7	47.6	55.4	61.4
3 hour	27.6	30.6	40.1	46.7	53.3	62	68.8
4.5 hour	31.1	34.5	45.3	52.8	60.3	70.4	78.3
6 hour	34	37.7	49.7	58	66.2	77.6	86.7
9 hour	38.7	43	56.9	66.7	76.4	90.4	102
12 hour	42.5	47.4	63	74	85.1	101	115
18 hour	48.7	54.3	72.8	86	99.5	120	137
24 hour	53.4	59.7	80.5	95.6	111	135	155

SOURCE: BOM DESIGN RAINFALL DATA SYSTEM (2016) AVAILABLE AT: http://www.bom.gov.au/water/designRainfalls/revised-ifd/

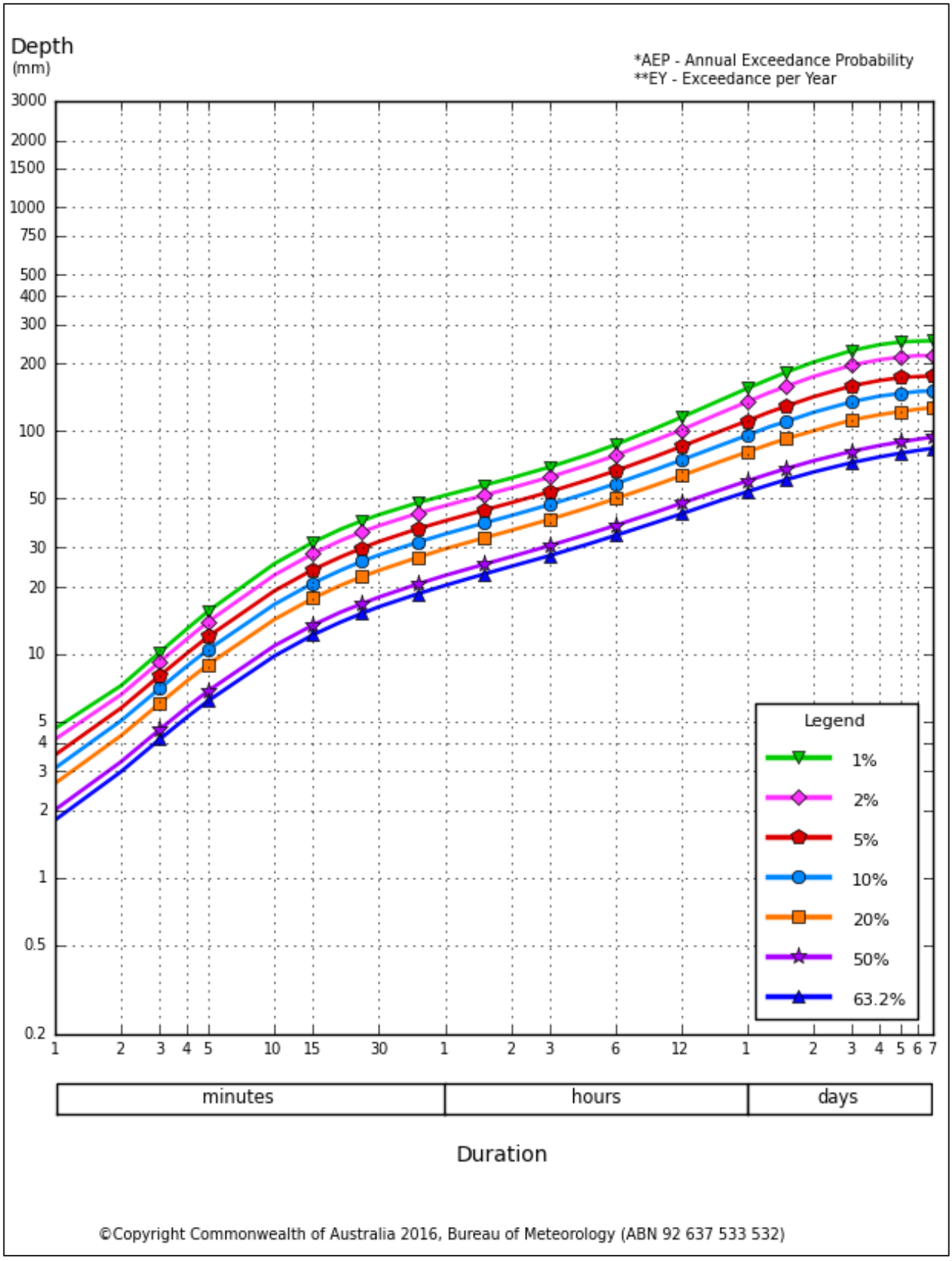

Figure 7: Rainfall depth for durations and Annual Exceedance Probabilities (AEP) for frequent and infrequent events

Table 6: Rainfall depth (mm) for durations and Exceedance per Year (EY) for very frequent events

	Exceedance per Year (EY)							
Duration	**12EY**	**6EY**	**4EY**	**3EY**	**2EY**	**1EY**	**0.5EY**	**0.2EY**
15 min	4.59	5.43	6.92	7.98	9.51	12.2	15	18.1
30 min	6.43	7.53	9.45	10.8	12.8	16.3	20	24.2
45 min	7.62	8.85	11	12.5	14.7	18.6	22.9	27.7
1 hour	8.51	9.84	12.1	13.8	16.2	20.3	25	30.1
1.5 hour	9.85	11.3	13.8	15.6	18.2	22.8	28	33.8
2 hour	10.9	12.4	15.1	17	19.8	24.7	30.3	36.5
3 hour	12.4	14.1	17.1	19.2	22.3	27.6	34	40.9
4.5 hour	14.1	16	19.4	21.8	25.2	31.1	38.3	46.2
6 hour	15.3	17.5	21.2	23.8	27.5	34	41.9	50.7
9 hour	17.3	19.8	24	27.1	31.3	38.7	47.8	58.1
12 hour	18.8	21.5	26.3	29.6	34.4	42.5	52.6	64.2
18 hour	21.1	24.2	29.7	33.6	39.1	48.7	60.3	74.2
24 hour	22.8	26.2	32.3	36.6	42.8	53.4	66.3	82.1

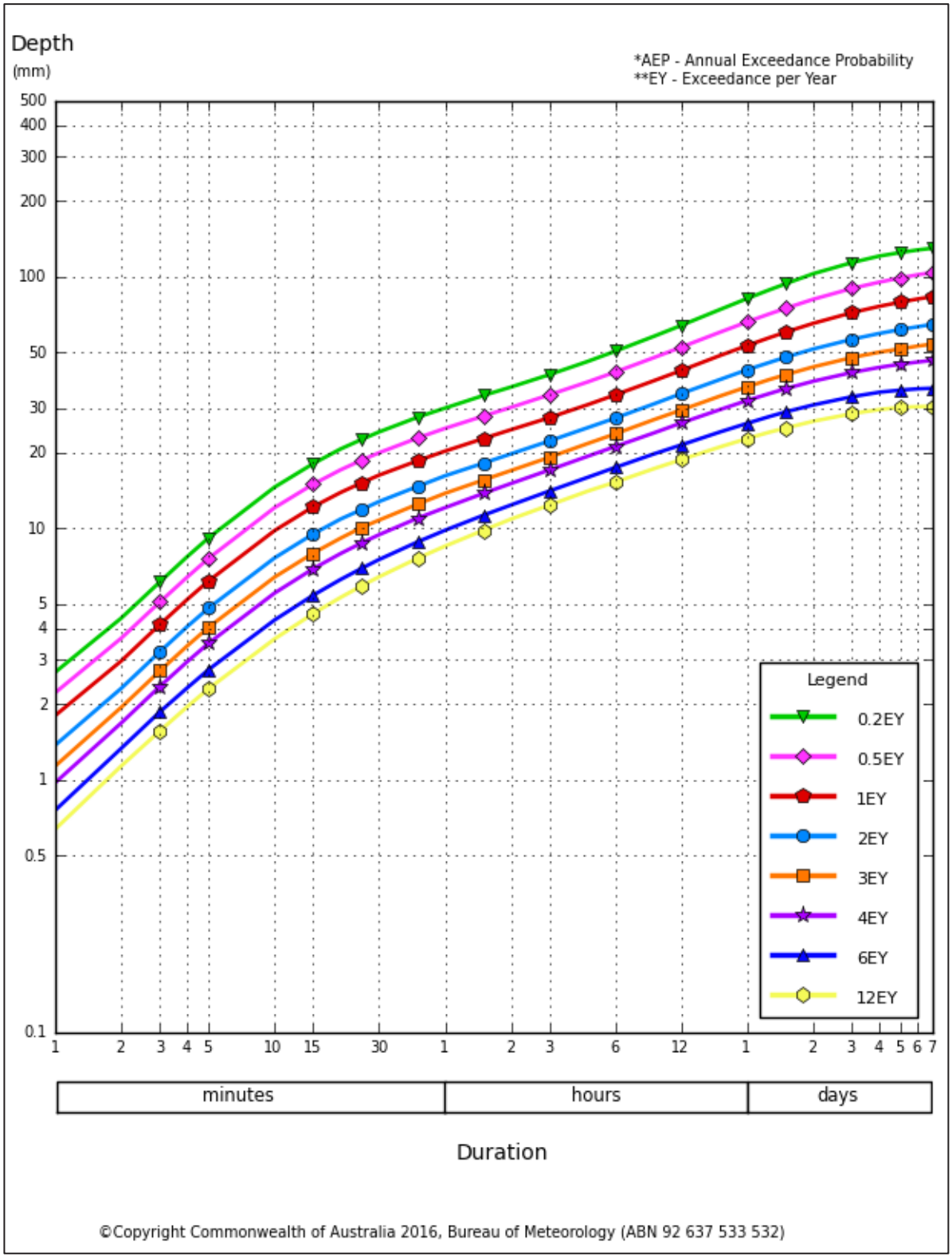

Figure 8: Rainfall depth for durations and Exceedance per Year (EY) for very frequent events

The total rainfall for the reporting period of 1 January to 31 December 2020 was calculated to be 915.8 mm, with 116 days of recorded rainfall. This annual total is far greater than the previous three years, which recorded 531.4 mm, 482.2 mm and 265.6 mm for 2017, 2018 and 2019 respectively. Total rainfall for the 2020 period is also above the historical mean for the region (594.1 mm as per Bureau of Meteorology) indicating the 2020 period was far wetter than preceding years and the long-term average. Monthly rainfall data, provided by WCPL, is presented in **Appendix C.**

In review of the available 15-minute rainfall data for 2020 against the durations and AEP, one event exceeded the 50% AEP (one in two-year rainfall event). This event recorded 14.4 mm of rain between 12:45 – 13:00 on 18 December 2020.

In review of the hourly rainfall data for 2020 against the durations and AEP, the following two exceedances were recorded:

- 28 October 2020: One 50% AEP was recorded with 26.6mm recorded between 17:45- 18:45.
- 18 December 2020: One 63.20% AEP (annual storm event) was recorded with 28.2mm recorded between 12:15 - 13:15.

In review of daily rainfall data for 2020, one 63.2% AEP was recorded on 28 October 2020 with 55.6 mm over a 24-hour period.

Analysis of Exceedance per Year (EY) for very frequent events in respect to 15-minute rainfall durations, shows that 13 rainfall events were recorded above the 12 exceedances per year (greater than 4.59 mm). Recorded events were in the expected ranges of exceedance, of these events there was:

- Four 12EY events
- Three 6EY events
- Two 4EY events
- One 3EY event
- Two 2 EY events
- One 1EY event.

On inspection of the calculated hourly rainfall data for 2020, there were 14 rainfall events recorded that fell above the 12 exceedance events per year (greater than 8.51 mm). Of these events there was:

- Three 12EY events
- Four 6EY events
- Three 3EY events
- Two 2EY events
- Two 0.5EY events.

The two 0.5EY events correspond to a 1 in 2-year storm event. These events occurred on the 28 October and 18 December 2020 and recorded 26.6 mm and 28.2 mm of precipitation respectfully, within a one-hour period.

Analysis of EY for daily duration noted 13 rainfall events that fell above the 12 exceedance events per year. These were all within the expected exceedances for a 12 month period and included:

- Two 12EY events
- Four 6EY events
- Two 4EY events
- Two 3EY events
- Two 2EY events
- One 1EY event.

Of the daily duration exceedance events listed above, three of these events occurred during successive days and equate to an expected exceedance of 48 hour rainfall duration equal to two exceedances per year (2EY event). The three rainfall events were as follows:

- 3-4 April 2020 = 54.8 mm
- 28-29 October 2020 = 55.8 mm
- 17-18 December 2020 = 54.2 mm.

Velocity of Wilpinjong and Cumbo Creek (see **Figure 3**, **Figure 4** & **Figure 5**) after these significant rainfall events, as provided by WCPL, are outlined in **Table 7.**

Table 7: Recorded stream flow post significant rainfall events

Date	Upstream Cumbo Creek	Upstream Wilpinjong Creek	Downstream Wilpinjong Creek
	ML/d		
4 April	52.74	104.71	130.42
28 October	29.32	223.97	118.21
29 October	75.08	174.23	505.09
18 December	1.59	14.12	0.54

During analysis an anomaly was noted for the 18 December rainfall event for the flow rate of Wilpinjong Creek, downstream of the EPL 24 discharge location. Flow during this event was significantly lower than expected, considering the quantity of rainfall and the previous flow rates recorded for similar events. After consultation with WCPL it was determined that the flow meter was potentially obstructed by the increase in sediment within the system. Alternatively, the rainfall recorded may have been a localised event and not resulted in significant input into the target creek systems. Localised storm events and their influence on stream flow is likely responsible for the variable flow recorded at the downstream gauging station in comparison to the upstream levels in **Table 7**.

While rainfall events experienced through the 2020 period did not exceed a one in two year rainfall event, the consistency of rain over the 12 month period had the potential to contribute to local erosion and scouring in the target creeks. Durations of 15-min, hourly and daily levels were all recorded above the expected exceedances predicted in a 12-month period. Additionally, two of these events exceeded a one in two year storm event in quick succession, with three events also above the expected exceedance of 48 hr total rainfall.

4. Discussion and Recommendations

Of the 49 sites surveyed along Wilpinjong Creek, 33 sites recorded scores in the stable range, whilst 16 sites recorded scores in the unstable range (**Table 2**). The lowest scoring sites (all Moderately Unstable) were WCk27 and WCk42 and were typified by mass sediment wasting and less than 50% streambank protection and riparian woodland.

The western section of Wilpinjong Creek (incorporating WCk1 to WCk8) contains good areas of natural regeneration, with overall moderate to good riparian woodland vegetation and habitat present. Within 2020, there was an increase in stream vegetation cover at most sites, particularly an increase in *Phragmites australis*, following dieback in 2019.

The middle section of Wilpinjong Creek (incorporating sites WCk18 to WCk44) is characterised by cleared adjacent paddocks and narrow, scattered riparian woodland (where present). Widespread historic clearing in this section of the creek has a pronounced influence on the channel stability scores, with unstable BEHI scores recorded for *Established Beneficial Riparian Woody Vegetation Cover*, as well as unstable scores for *Streambank Protection* at some sites. The eastern section of Wilpinjong Creek (incorporating sites WCk45 to WCk49) is characterised by a relatively steep and narrow valley, which has resulted in a straight channel with an overall high bank height.

Of the ten sites surveyed along Cumbo Creek, all were in the Stable range (**Table 3**). The reach of Cumbo Creek is characterised by a shallow meandering channel with low stable banks. The adjacent paddocks have been historically cleared with only very sparse riparian vegetation woodland remaining. Despite the lack of woody riparian vegetation, the creek remains in a stable condition.

4.1 Multi-year comparisons

Following on from the baseline channel stability assessment of Wilpinjong and Cumbo Creeks undertaken in 2005 as part of the WCPL EIS (WCPL 2005), annual monitoring has been undertaken during 2011, and 2014-2020. Annual monitoring since 2011 shows that the channel stability has remained relatively constant, both upstream and downstream of WCM. The following sections compare 2020 results to the results of previous monitoring results detailed above.

4.1.1 Site stability scores

Site channel stability data in the form of BEHI scores are available from 2016 – 2019 for direct comparison. Site stability ratings (based on BEHI scores) for Wilpinjong Creek sites are presented in **Table 8**, with Cumbo Creek ratings presented in **Table 9**. Differences in ratings were only noted as 'Improved' or 'Declined' where a trend was observed over two consecutive years. If no differences were observed over three consecutive years (inclusive of 2020), the ratings were determined to be unchanged, indicating a consistent stability rating for that site. For Wilpinjong Creek, ratings remained unchanged at 47 sites and declined at two sites. For Cumbo Creek, ratings remained unchanged at all sites.

These mostly consistent results from 2016 to 2020 reflect the overall stable nature of both creeks. Declines observed in stability ratings were minimal, with both sites only dropping one stability category

level, e.g. Highly Stable to Moderately Stable (WCk12). There were 19 sites along Wilpinjong Creek that recorded an increased stability rating between 2019 and 2020, largely due to vegetation cover increases.

Table 8: Wilpinjong Creek site stability scores 2016 - 2020 comparison

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	2020 Rating	Difference
WCk1	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk2	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk3	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk4	Highly Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unstable	Unchanged
WCk5	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Highly Stable	Unchanged
WCk6	Stable	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk7	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk8	Stable	Stable	Stable	Unstable	Moderately Stable	Unchanged
WCk9	Unstable	Stable	Stable	Unstable	Stable	Unchanged
WCk10	Highly Stable	Highly Stable	Moderately Stable	Stable	Highly Stable	Unchanged
WCk11	Moderately Stable	Highly Stable	Highly Stable	Moderately Stable	Highly Stable	Unchanged
WCk12	Moderately Stable	Highly Stable	Highly Stable	Moderately Stable	Moderately Stable	Declined
WCk13	Stable	Moderately Stable	Stable	Stable	Highly Stable	Unchanged
WCk14	Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk15	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk16	Highly Stable	Moderately Stable	Moderately Stable	Stable	Highly Stable	Unchanged
WCk17	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Highly Stable	Unchanged
WCk18	Stable	Stable	Stable	Stable	Moderately Stable	Unchanged
WCk19	Unstable	Stable	Stable	Stable	Moderately Stable	Unchanged
WCk20	Unstable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk21	Unstable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	2020 Rating	Difference
WCk22	Moderately Unstable	Stable	Stable	Stable	Stable	Unchanged
WCk23	Moderately Unstable	Stable	Stable	Stable	Unstable	Unchanged
WCk24	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk25	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk26	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk27	Stable	Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unchanged
WCk28	Unstable	Stable	Stable	Stable	Stable	Unchanged
WCk29	Unstable	Stable	Stable	Unstable	Unstable	Declined
WCk30	Stable	Moderately Stable	Highly Stable	Moderately Stable	Highly Stable	Unchanged
WCk31	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk32	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unchanged
WCk33	Moderately Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk34	Unstable	Unstable	Unstable	Unstable	Stable	Unchanged
WCk35	Stable	Moderately Stable	Stable	Stable	Stable	Unchanged
WCk36	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk37	Stable	Stable	Stable	Stable	Unstable	Unchanged
WCk38	Stable	Stable	Stable	Stable	Moderately Stable	Unchanged
WCk39	Stable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk40	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk41	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk42	Highly Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unchanged
WCk43	Not surveyed	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk44	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk45	Stable	Stable	Stable	Stable	Moderately Stable	Unchanged
WCk46	Stable	Moderately Stable	Moderately Stable	Stable	Moderately Stable	Unchanged
WCk47	Stable	Moderately Stable	Stable	Stable	Moderately Stable	Unchanged

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	2020 Rating	Difference
WCk48	Stable	Stable	Stable	Stable	Moderately Stable	Unchanged
WCk49	Stable	Stable	Stable	Unstable	Stable	Unchanged

Table 9: Cumbo Creek site stability scores 2016 - 2020 comparison

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	2020 Rating	Difference
CCK1	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK2	Moderately Stable	Stable	Stable	Stable	Stable	Unchanged
CCK3	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK4	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK5	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK6	Moderately Stable	Highly Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
CCK7	Not surveyed	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK8	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK9	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK10	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged

4.1.2 Photographic comparisons

Photographic comparisons of sites across 2017, 2018, 2019 and 2020 monitoring are included in **Appendix B**. Photos taken from 2011, 2014, 2015 and 2016 monitoring were also compared, however, digital copies were not available to be included in this report.

Comparisons indicate that there has been little observable change in the overall morphology of the stream. Notable differences that were apparent were in relation to vegetation cover with all sites showing a clear increase in vegetation cover, both in channel and on banks. Areas that underwent significant dieback of macrophyte cover in 2019 showed substantial regeneration of *Phragmites australis* in channels and extending onto adjacent banks.

Water levels were also notably higher compared to previous years, particularly within Wilpinjong Creek which was retaining water and flowing throughout the majority of its reach at the time of monitoring. Cumbo Creek, while not flowing at the time of monitoring, showed signs of minor active erosion in the past 12 months during heavy rainfall events. Vegetation increase was also notable in Cumbo Creek, however, was dominated by *Carthamus lanatus* and other exotic annual species.

Increases in vegetation cover and water levels visible in the site photos were observed both upstream and downstream of the WCPL water discharge location and are attributable to the above average rainfall experienced in the region over the past 12 months.

4.2 Erosion points

Table 10 provides photos of the significant erosion points along Wilpinjong and Cumbo Creeks (**see Figure 2**). These sites were identified as having moderate to severe historical erosion and the potential for continued erosion during times of downstream and lateral flow. Overall, erosion points were consistent with previous years with the majority of sites appearing stable or only demonstrating minor erosion. Site E2 contained rills which were forming on the exposed bare soil and site E4 showed further exposure of root systems and gully retreat. Site E11 also displayed an increase in undercutting of the bank edge.

Table 10 **Table 10: Significant erosion points and suggested remediation works**

Erosion point	Image	Notes / suggested works
E1 (768557, 6422438)		Appears stable post rainfall events with some minor erosion. Revegetation and check dams (**Section 4.3**).
E2 (768469, 6422527)		Rills forming on exposed bare soil. Revegetation and mulching (**Section 4.3**).

Erosion point	Image	Notes / suggested works
E3 (768558, 6422432)		Minor erosion and gully retreat evident. Revegetation and check dams (**Section 4.3**).
E4 (768614, 6422382)		Further exposure of root systems and erosion evident. Check dams (**Section 4.3**).

Erosion point	Image	Notes / suggested works
E6 (772166, 6420287)		Appears stable post rainfall events. Revegetation and check dams (**Section 4.3**).
E7 (772431, 6420352)		Minor undercutting evident, appears stable. Revegetation (**Section 4.3**).

Erosion point	Image	Notes / suggested works
E8 (773014, 6420339)		Appears stable post rainfall events. Continue to monitor rill
E9 (773397, 6420376)		Minor increase in undercutting. Revegetation (**Section 4.3**).

Erosion point	Image	Notes / suggested works
E10 (773772, 6420328)		Appears stable post rainfall events. Revegetation and mulching (**Section 4.3**).
E11 (771670, 6419956)		Increase in undercutting evident and rills forming. Revegetation and mulching (**Section 4.3**).

4.3 Revegetation and remediation

Revegetation works were completed in 2019 by WCPL on a 1.6 km section of Wilpinjong Creek, approximately between sites WCk27 and WCk25 (see **Figure 1**). Revegetation was undertaken on both sides of the creek using tubestock of local native species listed in **Table 11.**

Further revegetation work was completed in 2020 along approximately 1.9 km of Cumbo Creek and 1 km of Wilpinjong Creek using tubestock of species listed in **Table 11**. Revegetation condition assessments were carried out in September and October 2020 for Wilpinjong and Cumbo Creek. Wilpinjong Creek returned an average survival rate of 57% whilst Cumbo Creek had a survival rate of 88% (Skillset Land Works 2020). It was determined that good survival rates were influenced by the higher than average rainfall, although sections with lower tubestock survival rates may have been impacted by grazing pressure from native and exotic fauna. Revegetation monitoring is ongoing.

Additional revegetation work is recommended to target the erosion points E1 to E4, where erosion occurred during 2020 and the potential for further lateral erosion exists. With site E2 showing evidence of rilling, the application of mulch to the bank sides (including hydro-mulch) is recommended to assist stabilisation until vegetation establishes, along with the installation of coarse-rock, large-woody debris, coir logs and/or hay bale check dams to reduce water flow in designated erosion points. Sites E1, E3 and E4 all showed signs of erosion, from minor activity to gully retreat and further root exposure. Revegetation work to target the potential for further lateral erosion is recommended. In these areas, revegetation works should extend to a minimum distance equal to the height of the adjacent eroded bank, to reinforce the existing bank and provide space for the bank to partially erode whilst the vegetation becomes established (Abernathy and Rutherford 1999). Fencing works will also assist in excluding native and introduced fauna from revegetation and remediation areas.

Table 11: Native species used for Wilpinjong Creek and Cumbo Creek revegetation works

Scientific Name	Common Name
Native trees	
Angophora floribunda	Rough-barked Apple
Casuarina cunninghamiana	River Sheoak
Eucalyptus blakelyi	Blakely's Red Gum
Eucalyptus melliodora	Yellow Box
Native shrubs	
Acacia decora	Western Silver Wattle
Acacia floribunda	Gossamer Wattle
Acacia implexa	Hickory Wattle
Native ground cover	
Lomandra spp.	Mat-rush

4.4 Exclusion of livestock

Livestock (cattle) access to the riparian zone continues to impact on the overall stability and riparian health of Wilpinjong Creek. While the increase in vegetation in the surrounding area has reduced the impact of stock grazing there was evidence of stock presence observed within the eastern section of Wilpinjong Creek (incorporating sites WCk44 to WCk48), as well as the far-western section (incorporating sites WCk1 to WCk4) during 2020 monitoring. Excluding stock from the riparian zone in these areas is recommended to improve creek stability and health and assist natural regeneration.

5. Conclusion

The channel stability of both Wilpinjong and Cumbo Creeks is characteristic of ephemeral systems in agricultural landscapes, and consistent with other creeks in the surrounding region. Both creek systems exhibit characteristic channel stability issues associated with agricultural landscapes including:

- Historically cleared and degraded riparian vegetation and the presence of exotic species, including Regional Priority Weeds such as *Rubus fruticosus*.
- Lateral gully-erosion at several locations, as a result of increase runoff velocity occurring perpendicular to the creek line from adjacent cleared paddocks.
- Continued livestock access contributing to bank instability, reducing in-stream and riparian vegetation and hampering natural regeneration.
- Other introduced and native fauna (e.g. European Rabbit and Common Wombat) burrowing within the riparian zone.

The 2020 reporting period recorded rainfall levels that were above the historical average, however, even with a significant increase in water flowing through the system, the channel stability of Wilpinjong and Cumbo Creeks remained predominantly unchanged. Increased flow was observed both upstream and downstream of the WCM.

Erosion and bank stability issues within the Wilpinjong and Cumbo Creeks are the result of historic agricultural practices within the riparian zone, including widespread clearing and direct stock access to the bank and channel. There is no evidence that mining activities are adversely impacting the channel stability of the target creeks surrounding the WCM.

6. References

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Appendix A - BEHI Assessment Scoring

Indicator	Measure	Score
1. Bank Height (m)	0 - 1.5	0
	1.5-3	2.5
	3-4.5	5
	4.5-6	7.5
	6+	10
2. Bank Angle (°)	0-20	0
	21-60	2
	61-80	4
	81-90	6
	91-120	8
	> 120	10
3. Percentage of Bank Height with a Bank Angle Greater than 80°	0-10	0
	11 to 25	2.5
	26-50	5
	51-75	7.5
	76-100	10
4. Evidence of Mass Wasting (% of Bank)	0-10	0
	11 to 25	2.5
	26-50	5
	51-75	7.5
	76-100	10
5. Unconsolidated Material (% of Bank)	0-10	0
	11 to 25	2.5
	26-50	5
	51-75	7.5
	76-100	10
6. Streambank Protection (% of Streambank covered by plant roots, vegetation, logs, branches, rocks, etc.)	0-10	15
	11 to 25	12.5
	26-50	10
	51-70	7.5
	70-90	2.5
	90-100	0
7. Established Beneficial Riparian Woody – Vegetation Cover	0-10	15
	11 to 25	12.5

Indicator	Measure	Score
	26-50	10
	51-70	7.5
	70-90	2.5
	90-100	0
8. Stream Curvature Descriptor	Meander	5
	Shallow Curve	2.5
	Straight	0
Site Ratings (totals)	Highly Stable	0-25
	Mod Stable	26-35
	Stable	36-45
	Unstable	46-55
	Mod Unstable	56-65
	Highly Unstable	66-85

Appendix B – Site Photo Comparisons

Figure B - 1: WCk1 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 2: WCk2 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 3: WCk3 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 4: WCk4 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 5: WCk5 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 6: WCk6 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 7: WCk7 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 8: WCk8 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 9: WCk9 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 10: WCk10 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 11: WCk11 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 12: WCk12 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 13: WCk13 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

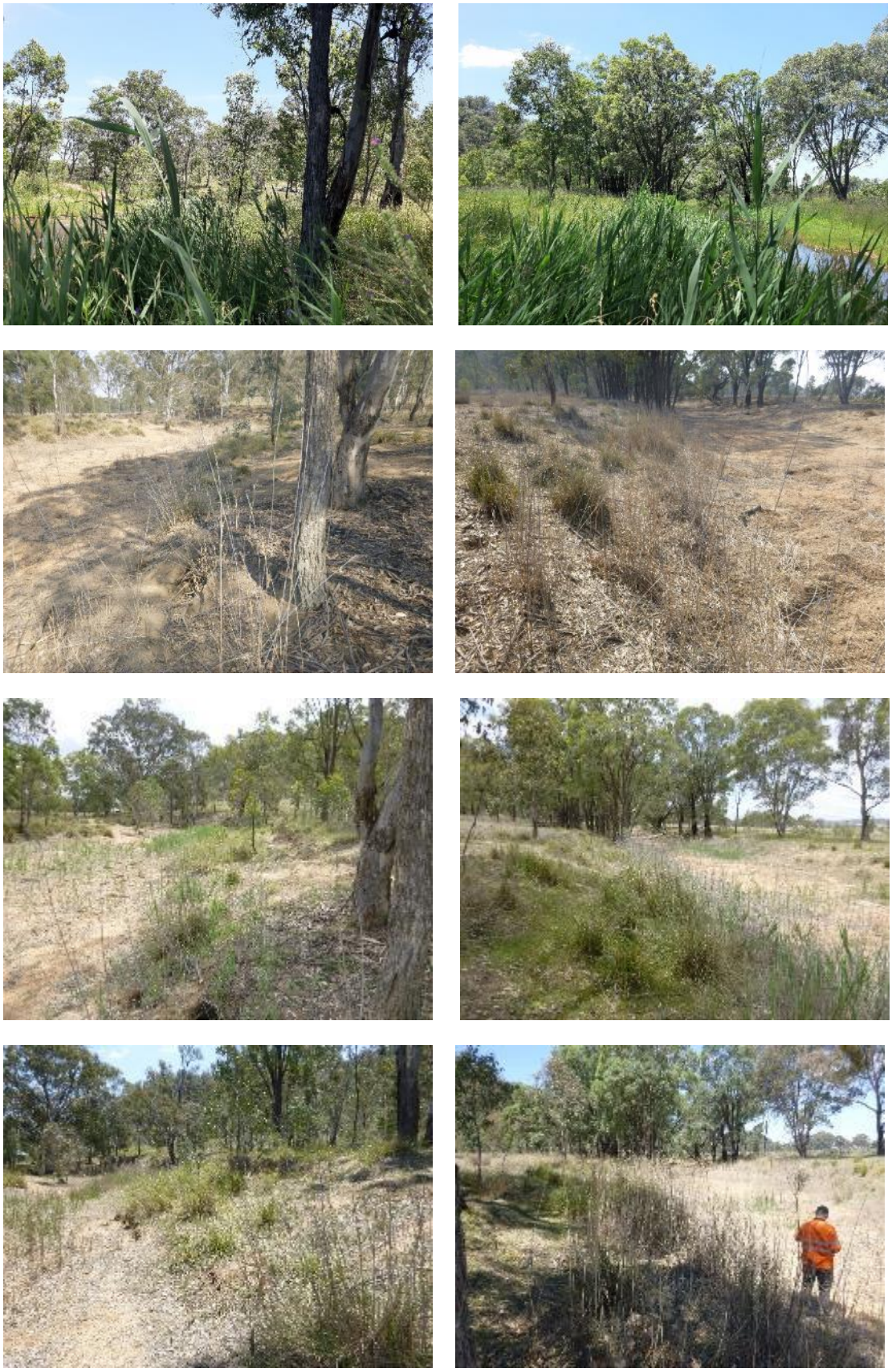

Figure B - 14: WCk14 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 15: WCk15 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 16: WCk16 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 17: WCk17 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream (Note: access to photo point not possible in 2020)

Figure B - 18: WCk18 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 19: WCk19 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 20: WCk20 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 21: WCk21 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 22: WCk22 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 23: WCk23 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 24: WCk24 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 25: WCk25 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 26: WCk26 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 27: WCk27 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 28: WCk28 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 29: WCk29 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 30: WCk30 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 31: WCk31 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

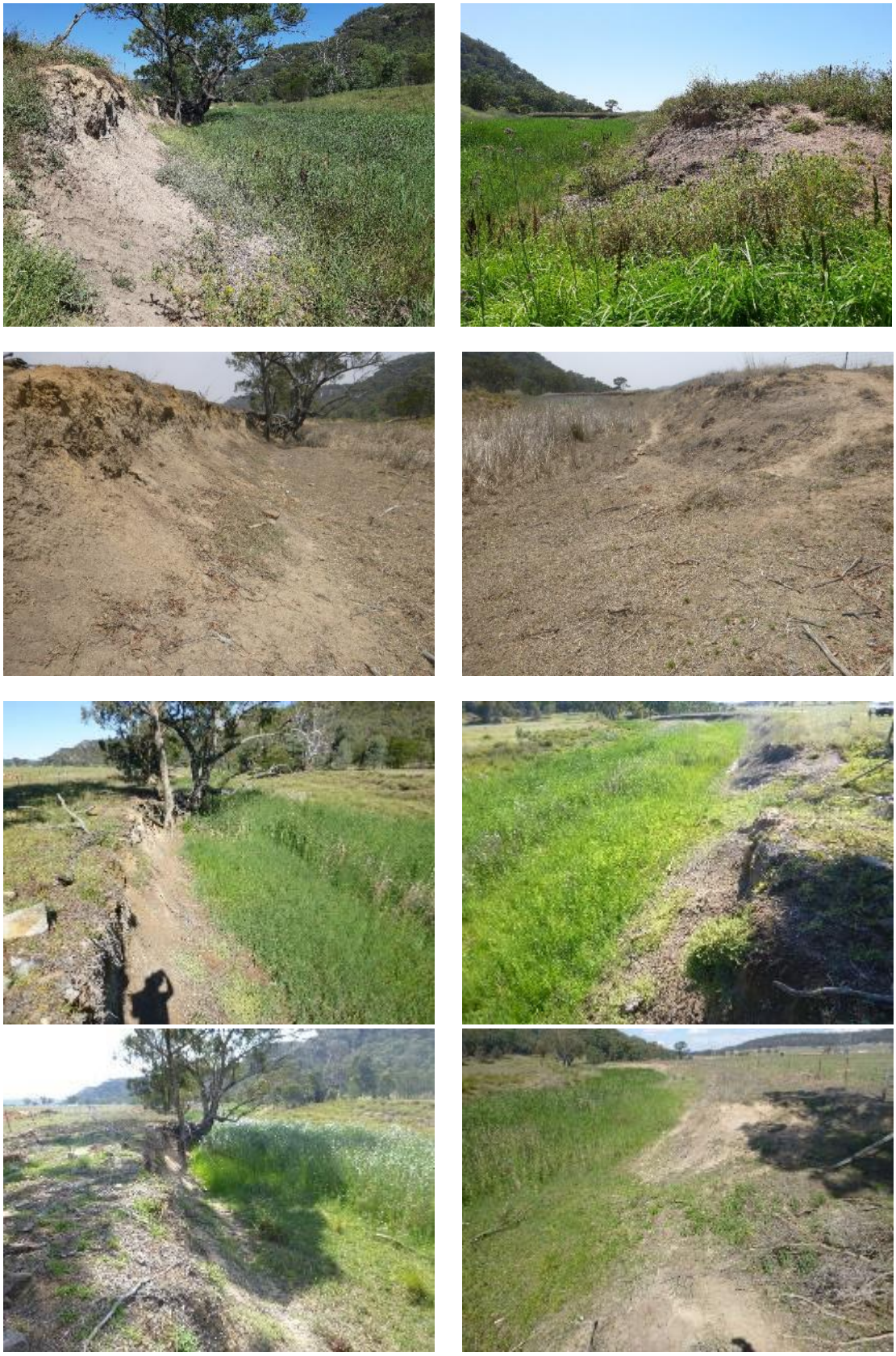

Figure B - 32: WCk32 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 33: WCk33 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 34: WCk34 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 35: WCk35 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 36: WCk36 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 37: WCk37 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 38: WCk38 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 39: WCk39 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 40: WCk40 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 41: WCk41 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 42: WCk42 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 43: WCk43 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 44: WCk44 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 45: WCk45 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 46: WCk46 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 47: WCk47 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 48: WCk48 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 49: WCk49 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 50: CCk1 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 51: CCk2 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 52: CCk3 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

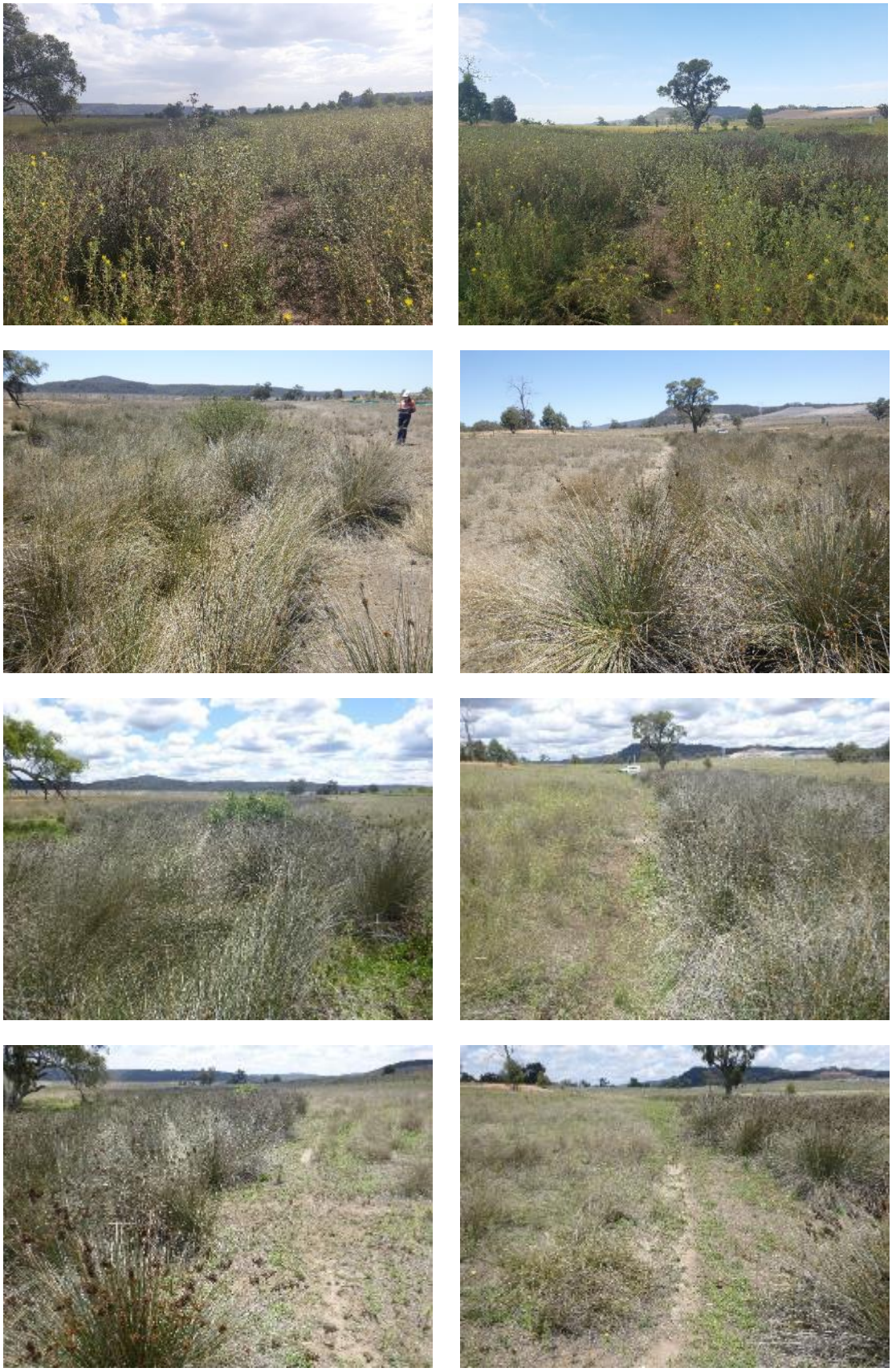

Figure B - 53: CCk4 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

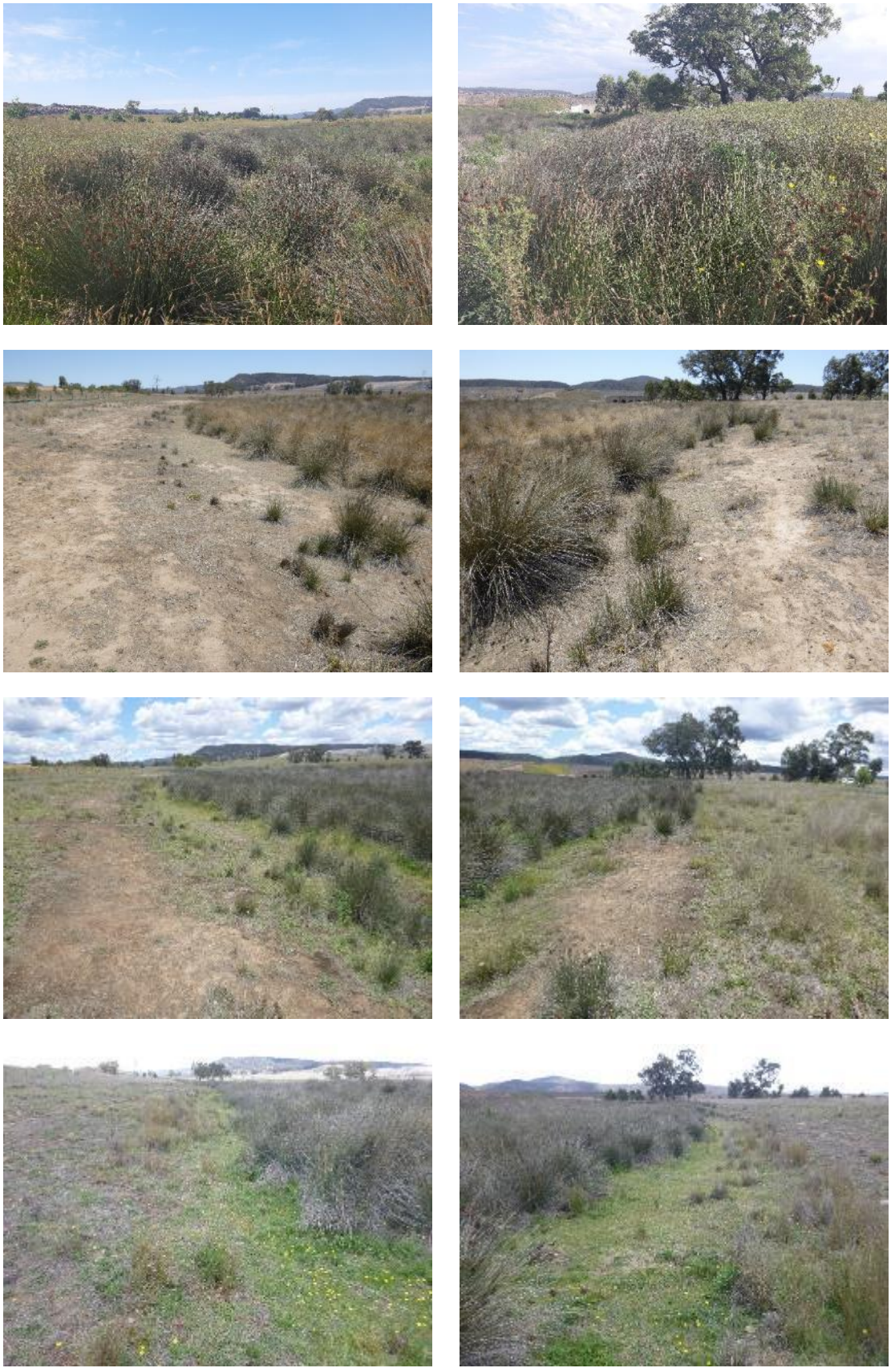

Figure B - 54: CCk5 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 55: CCk6 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 56: CCk7 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2018 upstream, 2019 upstream

Figure B - 57: CCk8 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 58: CCk9 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Figure B - 59: CCk10 site photos clockwise from top left: 2020 upstream, 2020 downstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream, 2019 upstream

Appendix C – Monthly Rainfall Data

Table C - 1: Monthly rainfall from 2014 - 2020 (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2014	15.6	60.0	112.6	62.8	13.8	29.8	28.6	28.8	14.6	15.4	24.4	126.7	533.1
2015	127.6	11.6	9.4	108.4	42.8	42.8	38.0	53.8	7.8	61.0	59.0	118.4	680.6
2016	152.1	7.2	23.5	14.8	66.8	104.2	101.1	40.9	198.7	86.6	51.9	90.6	938.4
2017	27.8	34.2	146	23	32.4	10.4	5.8	25.2	3	28.4	92.6	102.6	531.4
2018	24.4	77	24.6	42.2	12.4	21.6	1.2	43.8	39.6	56.8	47.4	91.2	482.2
2019	54.8	7.4	108.8	0	17.6	10.6	2.6	10.2	23	5.6	22	3	265.6
2020	27.2	127	92	117	16	23.4	70	36.4	77.2	150.6	17.4	161.6	915.8
Historical Mean	66.5	62.6	53.5	39.4	37.5	43.7	42.3	40.8	41.5	51.3	55.4	59.6	594.1

SOURCE: WCPL WEATHER STATION SENTINEX 34, AND BUREAU OF METEOROLOGY, 2020 (HISTORICAL AVERAGES) WOLLAR (BARRIGAN STREET) WEATHER STATION NUMBER: 62032

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Wilpinjong Coal 2020 Stream Health Monitoring Report

Wilpinjong Coal Pty Ltd

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Template 2.8.1

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Abbreviations

Abbreviation	Description
ANZECC	Australian and New Zealand Environment and Conservation Council
AUSRIVAS	Australian River Assessment System
DO	Dissolved oxygen
EC	Electrical conductivity
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EPL	Environment Protection Licence
LGA	Local Government Area
MWRC	Mid Western Regional Council
NP	National Park
RCE	Riparian, Channel and Environment
SHM	Stream Health Monitoring
SIGNAL2	Stream Invertebrate Grade Number Average Level
WCM	Wilpinjong Coal Mine
WCPL	Wilpinjong Coal Pty Ltd

Summary of key findings

Stream health monitoring was undertaken during spring 2020 within the Wilpinjong Coal Mine (WCM) surrounding catchments. A total of eleven (11) permanent sites were monitored along Wilpinjong, Wollar and Cumbo creeks, as well as two control sites located along Barigan Creek.

The aquatic habitat assessment recorded mid-range scores, typical of catchments in the region. Results were largely consistent with previous years, with minor differences attributable to changes in stream bed macrophyte and groundcover, as a result of fluctuating water levels and climatic conditions.

Water quality results were recorded across various parameters and consistent with previous years Parameters outside Australian and New Zealand Environmental and Conservation Council (ANZECC) guidelines across the majority of sites were dissolved oxygen (DO) and electrical conductivity (EC). Water quality results have been shown to fluctuate considerably across monitoring years, during times of variable stream flow levels and at sites both upstream and downstream of the WCM licensed discharge point. As such, these results indicate that natural factors rather than mining operations are key in determining water quality in the catchments surrounding the WCM.

Across all monitoring sites, a total of 20 macroinvertebrate Orders and 56 Families were recorded. Stream invertebrate grade number average level (SIGNAL2) scores increased in 2020, following declines recorded since 2016, in which habitat quality and availability also declined due to prolonged drought conditions. In line with previous years, SIGNAL2 scores were <4.0 for all but two sites, indicative of severely disturbed systems in which the sites are located. The temporal and spatial consistency of these macroinvertebrate results indicates that historical disturbances within the catchments surrounding the WCM and monitored as part of the SHM program, are the main factors responsible for current stream health conditions.

1. Introduction

1.1 Background

Wilpinjong Coal Pty Ltd (WCPL) are required to undertake annual stream health monitoring (SHM) to satisfy the updated requirement of Development Consent SSD 6764 Condition 29 & 30 (ii) (previously under Schedule 3, Condition 32 of WCPL's Project Approval (05-0021)) and the SHM criteria detailed in Appendix 2 of the Wilpinjong Water Management Plan (WCPL 2018). Eco Logical Australia (ELA) was engaged by WCPL to undertake SHM in the 2020 monitoring period.

1.2 Regional overview

The Wilpinjong Coal Mine (WCM) is located in the Mid-Western Regional Council Local Government Area, approximately 45 km north-east of Mudgee. The mine is owned and operated by WCPL, a wholly owned subsidiary of Peabody Energy Australia.

The WCM is located at the headwaters of the Goulburn River which is a major tributary of the Hunter River catchment. Wilpinjong Creek is the main drainage channel within the WCM. It is an intermittent creek with a narrow floodplain that has a history of cattle grazing. The northern edge of the floodplain is bordered by the sandstone escarpments of Goulburn River National Park (NP). Wilpinjong Creek has three coal mines in its catchment, Moolarben, Ulan, and Wilpinjong, with the latter positioned furthest downstream. WCPL discharges water, treated by reverse osmosis, into Wilpinjong Creek at Environment Protection Licence (EPL) point 24 (EPL 24) directly adjacent to WCM.

Barigan Creek flows north through agricultural land as a tributary to Wollar Creek, joining south of the town of Wollar. Cumbo Creek flows north through land managed by WCPL, passing between Pit 3 and Pit 4, before joining Wilpinjong Creek north of the eastern pit area. Wilpinjong Creek continues to flow east, for approximately 4.5 km downstream where it joins Wollar Creek, which continues another 13 km through the Goulburn River NP before entering the Goulburn River.

1.3 Previous aquatic ecology assessments

A baseline aquatic assessment was undertaken for the Wilpinjong Coal Project Environmental Impact Statement (EIS) (BIO-ANALYSIS 2005). The assessment found that aquatic habitats were in poor condition and generally reflected the degraded nature of their immediate catchments with poor water quality, degraded riparian vegetation with low diversity and abundance of macroinvertebrates.

Annual SHM was conducted in 2006, 2008 and 2009 (Roberts 2006; 2008; 2009), and from 2011 to 2013 (Landline Consulting 2011; 2012; 2013). During these periods, water quality was generally outside the Australian and New Zealand Environmental and Conservation Council (ANZECC) guidelines and pollution-tolerant macroinvertebrate families dominated the aquatic community. Monitoring results found no evidence of any adverse impacts on the aquatic environment resulting from mining operations.

BIO-ANALYSIS (2015) undertook an aquatic ecology assessment for the Wilpinjong Extension Project (WEP) which found that the aquatic environment remained in a highly degraded state. The assessment concluded that the proposed Project would have minimal direct impacts on aquatic ecology and potential impacts downstream of the Project would be minimised with a number of existing mitigation measures already implemented at WCM.

Annual SHM recommenced in 2016 (ELA 2017), following the approval of the updated Surface Water Management and Monitoring Plan (WCPL 2016). Monitoring results from the 2016 monitoring showed an overall improvement of water quality and stream invertebrate grade number average level (SIGNAL2) scores. Prolonged drought conditions during the 2017 - 2019 surveys resulted in reduced stream flow, with the majority of sites within the ephemeral creeks surrounding the WCM, unable to be surveyed. The sites which were able to be surveyed during this period, recorded an overall reduction in water quality and SIGNAL2 scores as stream flow and habitat availability continued to decline.

A review of the Stream Health Monitoring program was undertaken and recommendations provided (BIO-ANALYSIS 2018). Recommendations included the collection of three replicate macroinvertebrate samples at each stream health monitoring site, along with the discontinuation of select existing sites and establishment of additional new sites. Based on these recommendations, three sites along Wilpinjong Creek were discontinued. An additional site on Wollar Creek was established, downstream of the confluence of Wilpinjong and Wollar Creek and two sites were established on Barigan Creek, providing additional external control sites. These recommendations were implemented for the 2020 monitoring program.

1.4 Objectives

The ongoing SHM program for WCM is aimed to assist in determining the need for any maintenance and/or contingency measures. The objectives of annual SHM within Wilpinjong, Cumbo, Wollar and Barigan Creeks include:

- Survey of aquatic macroinvertebrate assemblages in spring if streamflow or ponded water is present and access to the creeks is safe, paired with in situ surface water quality sampling at each sampling site
- An assessment of environmental condition at each site based on a variety of ecological indices
- Comparisons of site indices against previous survey data to assess changes through time, and comparisons to trigger levels that would prompt further investigation.

2. Methodology

2.1 Survey overview

The 2020 SHM was undertaken by ELA ecologists Tom Kelly and Amanda Sales from 23 to 26 November 2020. A total of 13 permanent monitoring sites were surveyed, including two sites along Cumbo Creek and five sites along Wilpinjong Creek that had been previously monitored. Three sites along Wollar Creek were also assessed with an additional site established past the confluence of Wollar and Wilpinjong Creek as well as two additional control sites established on Barigan Creek (**Table 1**, **Figure 1**). All sites surveyed contained water suitable for sampling with the exception of site CC2 which was dry. This was the first time since 2013 that such a high proportion of sites were able to be monitored.

The monitoring site locations reflect a balance of sites both upstream and downstream of WCPL discharge point (EPL Point 24), as well as the various creeks (including external creeks) within the surrounding catchment. Photographs of each site are included at **Appendix A**.

Table 1: 2020 monitoring sites

Creek	Site	Upstream / Downstream*	Inundation Status	Easting	Northing
Wilpinjong Creek	WC1	Upstream	Wet	767680	6422970
	WC2	Upstream	Wet	768490	6422490
	WC6	Downstream	Wet	774580	6420860
	WC7	Downstream	Wet	775100	6421060
	WC8	Downstream	Wet	775860	6420820
Cumbo Creek	CC1	Upstream	Wet	772710	6418130
	CC2	Upstream	Dry	772980	6418950
Wollar Creek	WO1	Upstream	Wet	777940	6418170
	WO2	Upstream	Wet	777780	6418950
	WO3	Downstream	Wet	777790	6420100
	WO4	Downstream	Wet	778030	6420596
Barigan Creek	BC1	Upstream	Wet	778704	6409493
	BC2	Upstream	Wet	779830	6403765

*Indicates Upstream / Downstream of WCPL discharge point EPL Point 24)

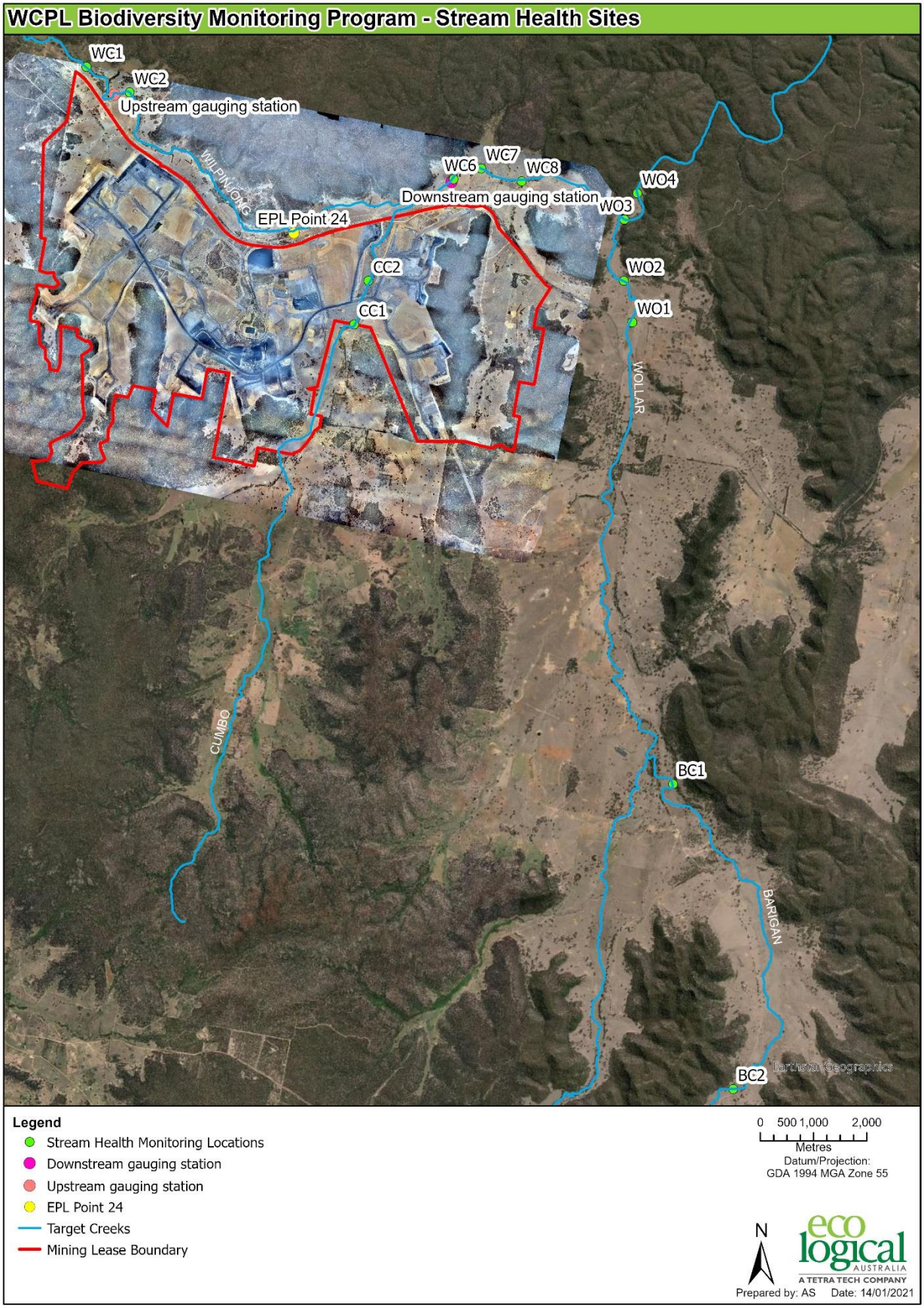

Figure 1: Monitoring sites along Wilpinjong, Cumbo, Wollar and Barigan Creeks

2.2 Survey methods

2.2.1 Aquatic habitat assessment

Aquatic habitat assessments were based on the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries 2013), which outlines the features important for fish habitat in freshwater, estuarine, and marine areas. Habitat assessments allow the significance of river reaches to be determined, regardless of whether target fish species are present permanently, or for brief periods of time.

Aquatic habitat variables (environmental data) were noted for each site, with observations made from the bank on the following characteristics:

- General signs of disturbance
- Habitat type
- Channel topography
- Current water level
- Bank and bed slope
- Degree of river shading
- Amount of detritus
- Macrophyte type and extent
- Riparian zone width
- Snags and large woody debris coverage
- Stream width and depth
- Surrounding land use
- Description of the natural substrate
- Extent of bank overhang
- Amount of trailing bank vegetation.

Riparian condition was assessed using a version of the Riparian, Channel and Environmental (RCE) inventory (Peterson 1992) that was modified for Australian conditions (Chessman *et al*. 1997). The modified RCE has 13 descriptors, each with a score from one (poor condition) to four (good condition).

Descriptors included width and condition of the riparian zone, surrounding land use, extent of bank erosion, stream width, water depth, occurrence of pools, riffles and runs, sub-stratum type, presence of snags and woody debris, in-stream and emergent macrophytes, algae, and barriers to fish passage. The total score for each site was derived by summing the score for each descriptor and calculating the result as a percentage of the highest possible score (up to 52).

Sites with a high RCE score indicate that the riparian zone is largely undisturbed, while those with a low score have undergone substantial modification. Based on the original classification established by Peterson (1992), site condition was rated as follows:

- Poor for RCE scores of 0-24%
- Fair for RCE scores of 25-43%
- Good for RCE scores of 44-62%

- Very Good for RCE scores of 63-81%
- Excellent for RCE scores of 82-100%.

RCE results from 2020 were compared with results from previous monitoring years dating to 2016, when RCE was introduced to the WCPL SHM program (**Section 4.1**).

2.2.2 Water quality

Complementing documented biological data, physicochemical parameters were measured at all sites where sufficient water was present, including:

- temperature
- dissolved oxygen (DO)
- electrical conductivity (EC)
- turbidity (NTU)
- pH.

Water quality results from 2020 were compared with previous year's results for DO, EC, turbidity and pH (**Section 4.2**). Results date back to 2006, however, not all parameters have results available for each year.

2.2.3 Macroinvertebrate communities

Where sufficient water was present, macroinvertebrate samples were collected at each site using the Australian Rivers Assessment System (AUSRIVAS) protocols (Turak *et al*. 2004). Three representative samples were collected at each stream health monitoring site. Samples were collected from 10 m of representative edge, pool and/or riffle habitats using a standard AUSRIVAS kick net with 250 µm mesh. The net was bounced along the bottom to disturb resting invertebrates, and then rapidly passed again through the water column to collect the disturbed taxa. Edge habitats were defined as adjacent to the creek bank in areas of little or no flow, including alcoves and backwaters, with abundant leaf litter, fine sediment deposits, macrophyte beds and overhanging bank vegetation (Turak *et al*. 2004).

Macroinvertebrate samples were live-sorted in the field for a minimum of 40 minutes. If new taxa were collected in the period from 30 to 40 minutes, picking continued for 10 minutes. If no new taxa were found after the additional 10 minutes, sorting stopped. The maximum sorting time was 60 minutes. All picked animals were preserved in 70% ethanol solution and transferred to the laboratory for identification. Specific care was taken to ensure cryptic, fast moving taxa were represented.

Macroinvertebrates were identified to family level, except for *Copepoda, Ostracoda, Cladocera*, *Oligochaeta, Platyhelminthes, Hirudinea, Collembola, Gastropoda* and *Ostracoda* which were identified to order.

The Stream Invertebrate Grade Number - Average Level (SIGNAL2) is a biotic index that allocates a value to each macroinvertebrate family based upon their sensitivity to pollution. A macroinvertebrate family with a value of ten indicates high sensitivity, while a value of one indicates low sensitivity (i.e. high pollution tolerance) (Chessman *et al*. 1997). The SIGNAL2 score for the entire site is calculated by

summing the SIGNAL2 grades for each family collected at that site and then dividing by the total number of families collected. SIGNAL2 scores are used to grade aquatic health into the following categories:

- SIGNAL2 Score > 6: Healthy Habitat
- SIGNAL2 Score 5-6: Mild Pollution
- SIGNAL2 Score 4-5: Moderate Pollution
- SIGNAL2 Score < 4: Severe Pollution.

Average SIGNAL2 scores for 2020 were compared with scores from previous years, dating back to 2006 (where available) (**Section 4.3**). SIGNAL2 scores from 2011 to 2013 (Landline Consulting 2011; 2012; 2013) were calculated using abundance weighting of macroinvertebrate taxa which resulted in slightly higher average SIGNAL2 scores for sites with relatively abundant macroinvertebrates. Whilst this method differs slightly from that undertaken in previous years, the results are largely consistent and valid for comparison.

2.3 Climate and flow data

During the four days of monitoring, the temperature was warm and consistent with historical averages, with minimal rainfall occurring across the monitoring period (Table 2). 2020 monitoring was undertaken following above average rainfall in the preceding two and twelve months, which followed on from a prolonged drought period extending back to 2017. Significant rainfall in October 2020 ensured the availability of adequate surface water for sampling (Table 3).

Table 2: Temperature and rainfall data for the Spring 2020 monitoring period

Date	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)
23 Nov 2020	16.5	26.1	3.6
24 Nov 2020	13.1	26.6	0.2
25 Nov 2020	15.3	27.7	0
26 Nov 2020	12.9	33.2	0

Source: WCPL Weather Station Sentinex 34

Table 3: Temperature and rainfall preceding survey

Month	2020			Historical means		
	Mean min. temp (°C)	Mean max. temp (°C)	Total Rainfall (mm)	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)
February	18.3	27.9	127.0	15.7	29.4	62.6
March	14.8	24.7	92.0	12.8	26.8	53.5
April	10.3	22.3	117.0	8.0	23.0	39.4
May	5.6	17.8	16.0	4.0	18.6	37.5
June	4.1	15.9	23.4	2.4	15.0	43.7
July	3.4	15.6	70.0	1.1	14.6	42.3
August	3.6	15.6	36.4	1.5	16.3	40.8
September	7.2	20.5	77.2	4.3	19.7	41.5

Month	2020			Historical means		
	Mean min. temp (°C)	Mean max. temp (°C)	Total Rainfall (mm)	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)
October	10.5	24.0	150.6	7.8	23.2	51.3
November	13.5	28.4	17.4	11.3	26.5	55.4

Source: 2020 data from the WCPL Weather Station Sentinex 34, historical data from the BoM weather stations at Mudgee Airport (temp) and Wollar (Barigan St) weather station (rainfall)

Flow levels in Wilpinjong Creek since 2012 have averaged 3.05 ML/day downstream and 1.41 ML/day upstream of the WCPL licensed discharge point. Flow decreased significantly at both gauging stations from early 2017 until February 2020, when above average rainfall was recorded (**Figure 3**).

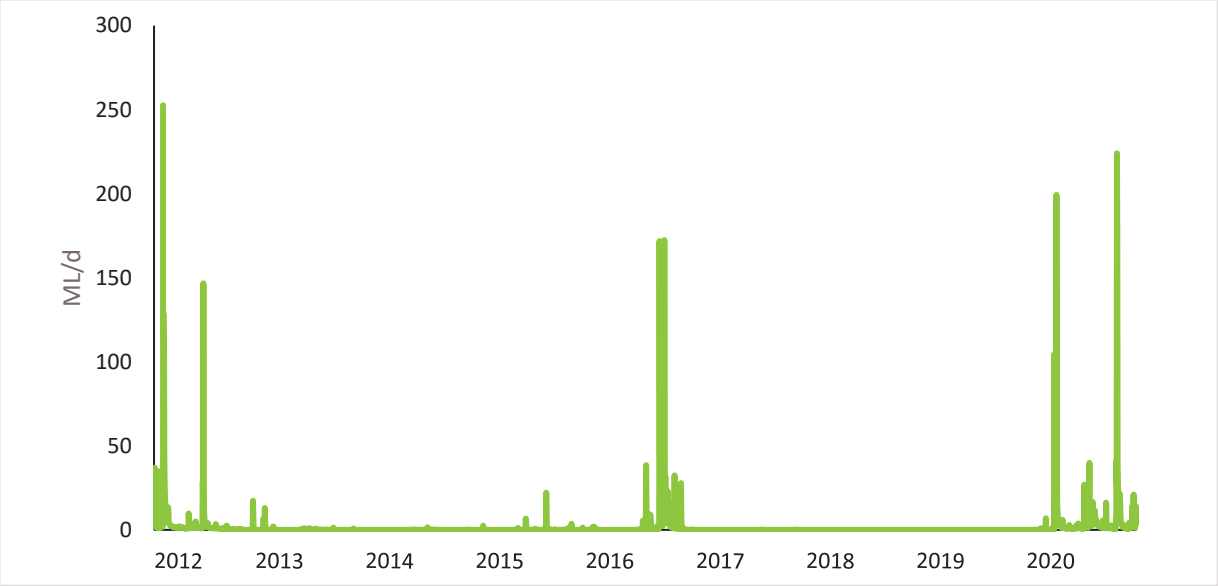

Figure 2: Stream flow upstream of the WCPL mine discharge point EPL 24

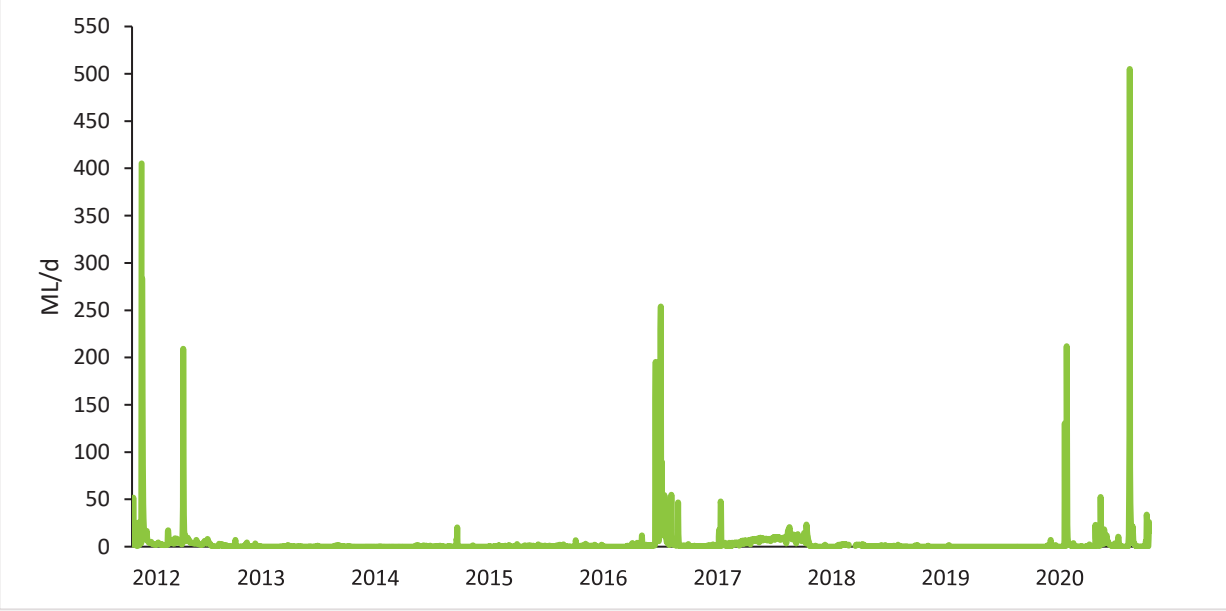

Figure 3: Stream flow downstream of the WCPL mine discharge point EPL 24

3. Results

3.1 Aquatic habitat assessment

Results of the habitat assessment, including water, substrate, vegetation, land use, and how these elements contribute to the RCE score are detailed below. A breakdown of how the 13 RCE parameters scored for each site is included in Table 4.

Table 4: Site results for the 13 RCE parameters

Descriptor	WC1	WC2	WC6	WC7	WC8	WO1	WO2	WO3	WO4	BC1	BC2	CC1	CC2
Land use pattern beyond immediate riparian zone	3	3	2	2	3	2	3	3	4	3	3	2	3
Width of riparian strip of woody vegetation	3	3	3	3	3	3	3	3	4	3	3	2	1
Completeness of riparian woody strip of vegetation	2	2	2	2	3	2	2	2	4	3	1	1	1
Vegetation of riparian zone within 10 m of channel	4	4	2	2	2	3	3	3	4	3	1	2	1
Stream bank	2	2	3	3	3	2	3	3	3	3	3	3	3
Bank undercutting	3	3	3	3	4	3	3	3	3	3	3	4	4
Channel form	2	3	3	3	3	3	3	3	3	3	3	2	3
Riffle/pool sequence	2	3	3	3	3	3	3	3	3	3	3	2	2
Retention devices in stream	1	1	1	2	2	4	4	3	3	2	2	1	1
Channel sediment accumulations	4	3	4	4	4	2	3	3	3	3	2	4	4
Stream bottom	1	2	2	3	1	3	1	2	2	2	2	2	1
Stream detritus	1	3	2	2	2	2	3	3	3	3	2	2	2
Aquatic vegetation	2	2	4	4	2	1	2	2	2	2	2	2	4
Total	**30**	**34**	**34**	**36**	**35**	**33**	**36**	**36**	**41**	**36**	**30**	**29**	**30**
Total %	**57.7**	**65.4**	**65.4**	**69.2**	**67.3**	**63.5**	**69.2**	**69.2**	**78.8**	**69.2**	**57.7**	**55.8**	**57.7**
Condition classification	**G**	**VG**	**VG**	**VG**	**VG**	**VG**	**VG**	**VG**	**VG**	**VG**	**G**	**G**	**G**

G = Good; VG = Very Good

Site WC1

This site is upstream of WCM and has a thin patch of riparian woodland on both banks, with cleared pasture in the floodplain beyond. The stream bank is approximately 20 m wide and rises 1.5 to 2m above the bed. There is an artificial dam present that has retained a substantial amount of debris from

runoff and stream flow. Since the previous monitoring period there was flood inundation at the site with visible changes in water level and vegetation cover. In comparison to the previous year, water was flowing through the system and while there was a reduction in the level of turbidity and plume there were sediment oils and anaerobic odours evident during visual inspection, indicating moderately poor water quality.

Riparian vegetation consisted of mature and juvenile *Angophora floribunda* (Rough-barked Apple) and *Eucalyptus blakelyi* (Blakely's Red Gum) trees. The dominant shrub species was *Cassinia sifton* (Sifton Bush). The vegetation present is predominantly comprised of native species. Contrasting to 2019, there were dense stands of *Phragmites australis* (Common Reed) situated within the creek bed.

This site scored an RCE score of 57.7%, consistent with 2019, indicating that the riparian and channel condition is rated as 'Good'.

Site WC2

WC2 had a moderate flow of water through the stream in 2020 in contrast to 2019, in which the site was dry. The northern bank of Wilpinjong Creek is severely eroded above a shelf of horizontal bedrock strata. The bank is approximately 20 m wide, with a height of 1.5 m. The site sits amongst cleared pasture, with a thin patch of riparian woodland on the southern bank.

The site had experienced inundation since the last visit and the changes seen were in relation to water levels and macrophyte growth in the channel. No sediment oils or odours were observed during inspection with only slight turbidity and some plume evident.

The dominant riparian vegetation included Rough-barked Apple and *Eucalyptus melliodora* (Yellow Box). All vegetation species within the site were native. There was 40% bare ground above the watermark on the left bank and 10% bare ground on the right bank, an improvement from the 2019 observations.

The site scored an RCE index of 65.4%, which places it in the 'Very Good' category, which is consistent with 2019.

Site WC6

Site WC6 has a small weir at the western (upstream) end of the reach. Downstream of the weir the stream flows across bedrock and compacted sand and silt. There is cleared mixed pasture along both sides of the creek, with mature trees on both upper banks. The width of riparian woodland increases downstream of the reach. The width of the bank is 15 m with a 1.5 m high bank.

The southern bank has some exposed rock ledges and a short rocky side arm. The dominant riparian vegetation is Blakely's Red Gum, Yellow Box, *Eucalyptus albens* (White Box) and *Lomandra confertifolia*. Stands of macrophytes that had previously died off did not increase in cover substantially, however, ground cover has increased overall at the site, including above the high watermark on both banks. A mixture of native and exotic forbs and grasses are present in the channel with 80% of ground cover comprised of native species.

Water levels have noticeably increased since 2019 with moderate flow observed, which allowed for riffle sampling to be conducted. No odours, water or sediment oils were observed, although some mobile sediment and plume was evident.

The site scored 65.4% in the RCE index, giving it a classification of 'Very Good'.

Site WC7

This site had a moderate flow through its reach at the time of monitoring. The creek bank at this site is 20 m wide and 2 m in height, creating an overall low slope. Both banks were well vegetated with scattered Blakely's Red Gum, Rough-barked Apple and Yellow Box trees and predominantly native ground cover. Ground cover within the stream is dense, with some evidence of stock presence (cattle pats and hoof prints). Bedrock forms much of the upstream portion of the stream bed, with minor woody debris present as in-stream retention devices. Bare ground above the watermark has reduced since 2019.

No water or sediment odours were present, however, some water oils were evident. Additionally, moderate turbidity and sediment plumes were also observed.

WC7 scored 69.2% for the RCE index, giving it a classification of 'Very Good'.

Site WC8

This site was experiencing moderate flow at the time of monitoring, with evidence of inundation above the current level also apparent. The creek bank is 1 m high and 15 m wide, creating an overall low slope, with sedimentary bedrock exposed on the southern bank. The land use on both sides of the creek is agricultural, with a thin strip of riparian woodland on the southern bank, while the northern bank immediately becomes pasture.

Woodland riparian vegetation on the southern bank includes scattered Blakely's Red Gum, Rough-barked Apple and White Box, with a sparse predominantly exotic, shrub species. Ground cover has increased since 2019 and is comprised of mixed native and exotic forbs and grasses. Macrophyte vegetation has also retuned since it had undergone significant dieback in 2019, and now form dense clumps within the channel. Native grasses and predominantly exotic forbs also form a low cover in the stream bank.

WC8 scored 67.3% for the RCE index, giving it a classification of 'Very Good'.

Site WO1

Site WO1 has a bank height of 2 m and bank width of 25 m, creating an overall low slope. The site is intersected by a concrete causeway on Araluen Road. The land use along both sides of the bank is cleared pasture, with the upstream reach currently accessed by cattle. During the time of survey, the site had a moderate flow of water through the reach. There was significantly more water present at this site compared to 2019, with evidence present of inundation above the current level during this time. There was no evidence of odours, oils or turbidity at the time of monitoring, there was some sediment plume observed.

During the time of sampling there was moderately dense stands of *Typha orientalis* (Cumbungi) and an increase in macrophyte vegetation with no evidence of stock present at the time of inspection. The ground cover on the banks consists of both native and exotic species with a significant decrease of bare ground above the watermark on both banks.

This site scored 63.5% for the RCE index, giving it a classification of 'Very Good'.

Site WO2

This site is located on Wollar Creek, where the bank is 20 m wide and 2 m high. At the downstream end of the reach, the creek passes under a concrete causeway on Mogo Road. There was an increase in the water level since last assessment with the creek undergoing inundation during 2020. There was a moderate flow of water through the reach during monitoring with no evidence of odours or oils, however, some plume and turbidity was observed.

Both banks are predominantly cleared, with only scattered woody riparian vegetation present. The ground cover is comprised of mixed native and exotic species with a significant increase in vegetation cover above the high water mark on both the left and right banks. Vegetation in stream consists of dense stands of Cumbungi and Common Reed.

WO2 scored 69.2% for the RCE index, giving it a classification of 'Very Good'.

Site WO3

This site is along Wollar Creek, approximately 100 m downstream of the confluence with Wilpinjong Creek. The site has a bank width of 20 m and bank height of 3 m. At the time of the survey there was a moderate flow of water through the system with a combination of pools, edges and riffle habitat sampled. Visual inspection observed no odours or oils present in the water or sediment with some turbidity and plume evident.

The land adjacent to both banks has been partially cleared but transitions into native remnant vegetation in the downstream section of the reach. There is a good canopy cover over the creek at this site, with overstory species Blakely's Red Gum, Rough-barked Apple and Yellow Box present. Stands of Cumbungi, that had previously undergone dieback in 2019, have since regrown.

WO3 scored 69.2% for the RCE index, giving it a classification of 'Very Good'.

Site WO4

This site was one of three sites that was established during the 2020 monitoring period. WO4 is located on Wollar Creek approximately 1.25km downstream of the confluence with Wilpinjong Creek. The site has a bank width of 6 m and a bank height of 4.5 m. There is good canopy cover over the creek with both banks comprising of native woodland adjacent to the channel. Overstorey species include Rough-barked Apple and Blakely's Red Gum with native shrubs and a mixture of, but predominately native, grasses and forbs. There is a small patch of cleared pasture on the left bank but no evidence of recent stock presence.

During stream assessment there was a mixture of edge, pool and riffle habitat that was sampled with water flow observed to be moderate at the time of inspection. Visual inspection identified some plume and turbidity at the site but no evidence of oils or odours in the water or sediments.

WO4 scored 78.8% for the RCE index, giving it a classification of 'Very Good'.

Site CC1

This site is located in Cumbo Creek which was retaining water at the time of sampling however no surface flow was observed. The bank width is 10 m and bank height is 1.8 m. The site is intersected by a concrete creek-crossing which in times of water, dams the upstream portion of the reach. 2019 was

the first year in which this site was completely dry since SHM began. However, 2020 saw the site undergo inundation during large rainfall events, which resulted in an increase in vegetation and water levels

The land use along both banks is comprised of pasture dominated by *Carthamus lanatus* (Saffron Thistle), with dense clumps of *Juncus* sp. present on both banks. The channel contained a dense stand of Cumbungi and other macrophyte vegetation. A single *Eucalyptus conica* (Fuzzy Box) is located immediately upstream of the site.

Sampling was conducted in pool and edge habitat, but no riffle was sampled. Visual inspection observed a slightly saline water odour but normal sediment odours. No turbidity, water or sediment oils were identified, however, there was some plume evident.

This site scored 55.8% for the RCE index, giving it a classification of 'Good'.

Site CC2

This site was dry at the time of sampling consistent with the ephemeral nature of the creek and previous monitoring. The bank width is 50 m and bank height is 0.5 m, with this section of Cumbo Creek forming a series of narrow channel on a low-energy broad floodplain. Woody riparian vegetation is extremely limited with only scattered Rough-barked Apple and Fuzzy Box trees present. The groundcover is dense, comprised of both native and exotic species including *Juncus* sp., *Carthamus lanatus* (Saffron Thistle) and *Paspalum dilatatum* (Paspalum). The density of ground cover within the channel and across the floodplain indicates that the site is predominantly dry across all seasons.

CC2 scored 57.7% for the RCE index, giving it a classification of 'Good'.

Site BC1

This site was established during 2020 monitoring. BC1 is located on Barigan Creek approximately 900 m upstream from the confluence with Wollar Creek. BC1 bank height is 5 m with a width of 7 m, creating a moderate-steep slope. Land use adjacent to the site is cleared grazing paddocks on the left bank with partially cleared areas with a small corridor of native woodland on the right bank with a moderate incline. Canopy cover is sparse with some trees providing some coverage over the site.

Riparian vegetation consisted of mature and juvenile Blakely's Red Gum and Yellow Box trees. Groundcover consisted of a mix of native and exotic forbs and grasses with good ground coverage on both banks. In channel vegetation consisted of dense stands of Cumbungi as well as Common Reed.

At the time of inspection there was a moderate flow of water through the system and edge and macrophyte habitat was sampled. No riffle habitat was present. Visual inspection identified some turbidity and plume but no water or sediment oils or odours were evident at time of assessment.

BC1 scored 69.2% for the RCE index, giving it a classification of 'Very Good'.

Site BC2

This site was established during 2020 monitoring. BC2 is located on Barigan Creek approximately 10 km from the confluence with Wollar creek. The site is intersected by a concrete causeway on Barigan Road and at the time of assessment had a moderate flow of water moving through the system. Bank height is 2 m with a width of 14 m.

The land use along both banks is cleared agricultural land, with in-stream vegetation comprised of a mix of native and exotic groundcover including *Juncus* sp., *Cyperus* spp. and *Paspalum dilatatum.* There is one Rough-barked Apple located downstream of the site providing only limited woody riparian vegetation.

At the time of monitoring, there was some turbidity and plume present, but no oils or odours were evident. A mixture of edge macrophyte and riffle habitat was sampled.

BC2 scored 57.7% for the RCE index, giving it a classification of 'Good'.

3.2 Water quality

The results of the water quality sampling for temperature, EC, DO, pH and Turbidity are detailed below in Table 5Error! Reference source not found.. As noted above, site CC2 was dry at the time of monitoring and as such, no sample was taken.

Water temperatures at the time of sampling ranged between 17.6°C and 34.1°C. The warmest water was recorded at site WC2, which was sampled in the afternoon, with relatively shallow water present at this site.

EC levels were high overall across all sites. The lowest EC measured was at WC8, located downstream of WCPL discharge site, with a reading of 273.6 and was the only site to come within the ANZECC guidelines. The highest value was recorded at CC1, located on site between Pit 3 and Pit 4, with a reading of 8321, substantially higher than all other monitoring sites.

DO ranged between 29.1% saturation at WO1 to 32.7% saturation at BC2. All sites sampled were well below the recommended ANZECC guideline range. The pH at sites ranged between 7.46 and 8.39, with sites WO3, WO4, BC1 and WC1 exceeding the ANZECC guidelines, yet still in a weakly alkaline range. Turbidity ranged from 2.8 at CC1, to 21.3 at WC1, with all sites within ANZECC guidelines. (Table 5).

Table 5: Physicochemical results

Variable	ANZECC Range	WC1	WC2	WC6	WC7	WC8	WO1	WO2	WO3	WO4	BC1	BC2	CC1
Temperature (°C)	N/A	21.4	34.1	27	23.7	22.5	18.9	20.6	24.8	28.8	17.6	26.8	20
Conductivity (µS/cm)	30-350	472.4	457.7	740	529	273.6	2967	2857	882	981	1225	374.5	8231
DO (% saturation)	90-110	29.9	30.4	32.0	30.1	30.4	29.1	30.9	32.6	31.6	32.6	32.7	31.5
DO (mg/L)	N/A	2.51	2.42	2.34	2.43	2.51	2.57	2.64	2.58	2.33	2.35	2.45	2.64
pH	6.5-8.0	8.39	7.95	7.91	7.78	7.46	7.91	7.80	8.15	8.02	8.25	7.87	7.61
Turbidity (NTU)	2-25	21.3	11.1	9	7.2	8.3	4.6	5.7	6.1	5.6	3.8	5	2.8

3.3 Macroinvertebrate communities

Macroinvertebrate results are presented in Table 6 and in **Appendix B**. A total of 20 macroinvertebrate Orders and 56 Families were recorded across all sites. Seven taxa were recorded across all 12 monitoring sites, including Chironomidae from the Order Diptera which was the most abundantly recorded taxa. Macroinvertebrate taxonomic richness during 2020 was highest at site BC2 (39 taxa) and lowest at site WC7 (20 taxa). At the time of sampling, these sites had a variety of available micro-habitat for macroinvertebrates, including macrophytes, woody debris and riffles.

Pollution sensitivity ratings for each family/order were used to calculate the average SIGNAL2 score for each site. Where families/orders have no assigned SIGNAL2 sensitivity rating, they were not included in the averages, however, are still represented in results for taxa richness. Average SIGNAL2 scores range from 2.6 (severely disturbed) at WC1 to 4.0 (moderately disturbed) at WO3 and WO4 (Table 6). Ten of the twelve sites had an average SIGNAL2 score of less than 4.0 and as such, are classified as severely disturbed, whilst the remaining two sites are classified as moderately disturbed.

Section 6.2 of the WCPL Surface Water Management and Monitoring Plan (WCPL 2018) outlines the following trigger condition for SHM:

- Minimum taxon richness: 15 taxa; and
- Minimum SIGNAL2 index: 3.0.

One site (WC1) recorded a SIGNAL2 score below the trigger threshold, however, this site recorded 22 taxa and as such, does not meet both trigger thresholds.

Table 6: SIGNAL2 scores for 2020 monitoring sites

Measure	WC1	WC2	WC6	WC7	WC8	WO1	WO2	WO3	WO4	BC1	BC2	CC1
Taxa richness	22	28	26	20	22	30	27	30	31	32	39	25
Average SIGNAL2 score	2.6	3.3	3.3	3.9	3.4	3.4	3.2	4.0	4.0	3.3	3.4	3
SIGNAL2 pollution condition	S	S	S	S	S	S	S	M	M	S	S	S

S = Severe, M = Moderate

4. Discussion

4.1 Aquatic habitat assessment

All sites received either 'Good' or 'Very Good' classification for their RCE indices. This puts them in the mid-range for riparian and channel habitat quality. Habitat conditions within Wilpinjong, Wollar and Cumbo Creek sites were largely consistent with those recorded in previous years, both upstream and downstream of the WCPL licensed discharge point (**Figure 4**). Temporal differences were largely restricted to changes in macrophyte and ground cover (*Stream bank*) and water levels (*Stream bottom* and *Stream detritus*) (**Table 4**). Overall, RCE results are consistent across the monitoring period (2016 – 2020).

Lack of in-stream retention devices (*Retention devices in stream*) such as logs, and boulders were common at many sites, with scores of one or two recorded for this attribute. This is typical of streams in agricultural landscapes as large debris have generally been removed, and woody riparian vegetation that would provide fallen branches and logs is limited. In-stream retention devices help slow the movement of flow, which in turn reduces the waters erosive power and contributes to of the local area. Retention devices are also important for the accumulation of coarse particulate organic matter, an important energy source for macroinvertebrate communities.

Similarly, the stream bed structure (*Stream bank*, *Stream bottom* and *Stream detritus*) also scored low overall, due to lack of vegetation cover and the presence of loose and mobile sediments along the stream bed at most sites. This is typical in a highly modified agricultural landscape where sites have reduced bank stability leading to increased erosion and sedimentation.

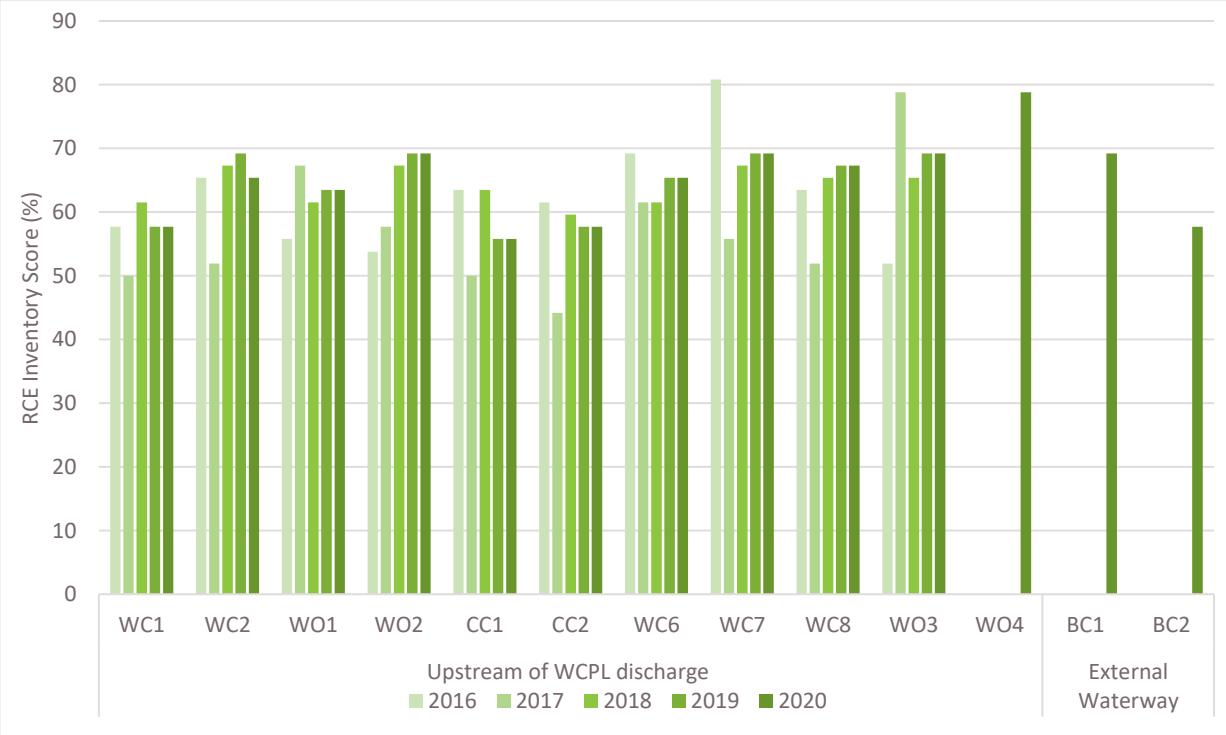

Figure 4: RCE scores across all sites and years

4.2 Water quality

Water temperature overall was warm (average temperature 25.5°C), consistent with the time of year of sampling and reflective of the generally shallow stream depth, along with minimal riparian shading. Given the above factors, the water temperature at each site is likely to fluctuate considerably. Increased water temperature decreases the ability to retain DO required to support aquatic organisms and is likely linked to the low DO concentrations recorded at each site. DO concentrations can further fluctuate due to a range of factors including organic and bacterial activity, water flow and circulation and time of day.

DO concentrations in 2020 were below the ANZECC guideline range across all sites and were amongst the lowest recorded since the commencement of monitoring. DO concentrations have fluctuated considerably across sites and years and are consistently outside of ANZECC guidelines (**Figure 5**). These results have been recorded both upstream and downstream of the WCPL discharge point, as well as the two control sites located along Barigan Creek. This suggests DO concentrations and fluctuations are a result of natural processes and are not linked to mining operations. To date there are no clear climatic, temporal or spatial patterns observable reading DO fluctuations.

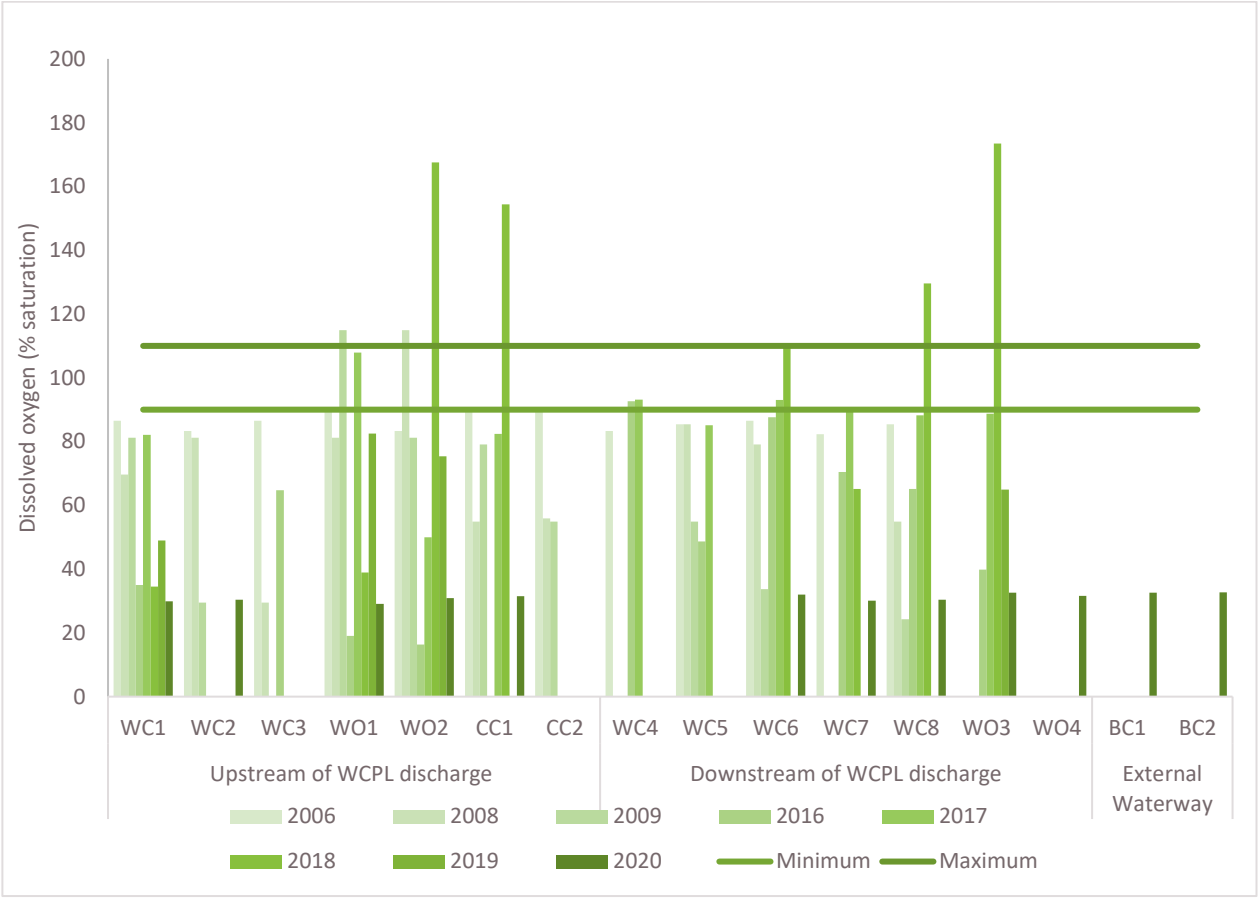

Figure 5: DO (% saturation) results across all sites and years

EC was above ANZECC guidelines at all but one site (WC8) surveyed in 2020, consistent with past monitoring years and the naturally saline groundwater in the region (BIO-ANALYSIS 2015). Whilst EC has varied considerably across all sites and all years, it has been consistently above ANZECC guidelines both upstream and downstream of the WCPL licensed discharge point (**Figure 6**).

EC concentrations recorded in 2020 again show a declining trend in EC scores at sites further downstream along Wilpinjong and Wollar Creeks. These results indicate that naturally saline groundwater becomes more diluted as it travels downstream and interacts with an increasing proportion of runoff. EC levels recorded at control sites BC1 and BC2 during 2020 were largely consistent with those recorded within Wilpinjong and Wollar Creeks and further indicate that natural variables rather than mining operations are responsible for overall high EC concentrations within the catchment.

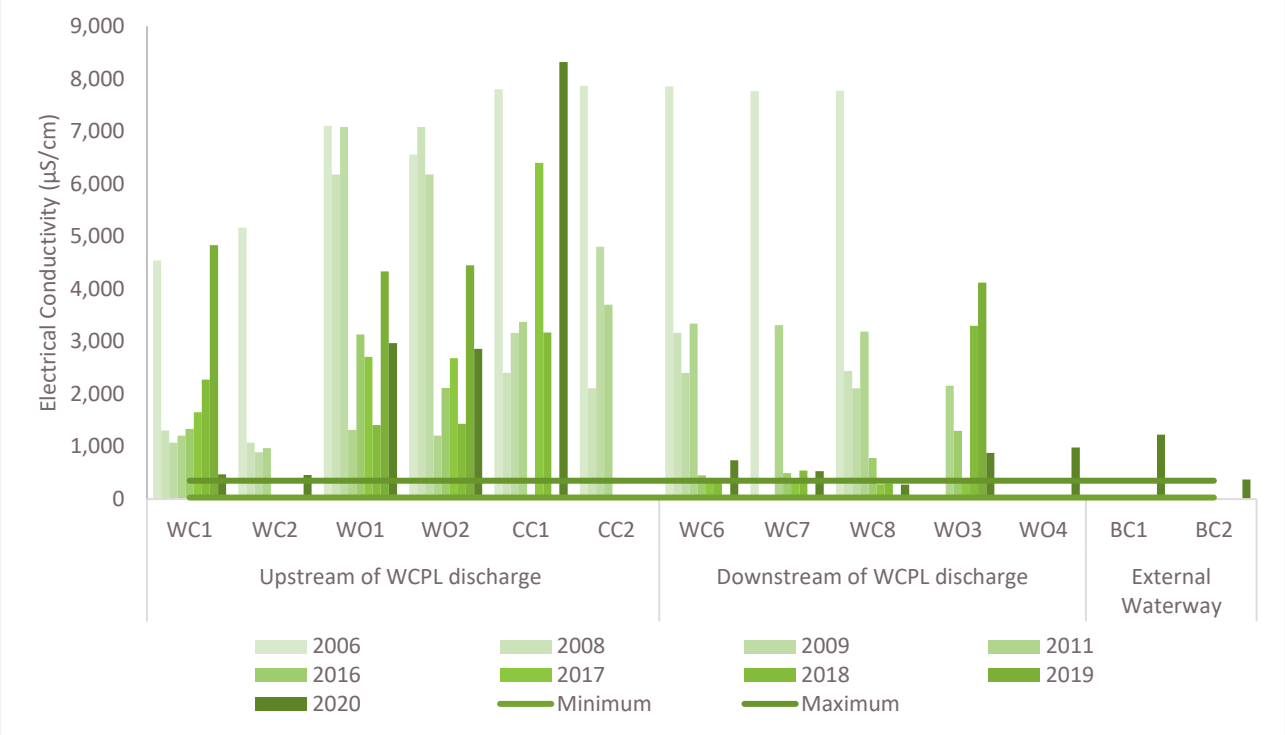

Figure 6: EC (µS/cm) results across all sites and years

Turbidity was within the ANZECC guidelines (2-25 NTU) for all sites in 2020 as seen below in **Figure 7**. Turbidity decreased at all sites surveyed that were also surveyed in 2019, as a result of increased flow and connection across the system in 2020, which is in contrast to the stagnant isolated pools surveyed in 2019. The pH results for all SHM sites monitored during 2020 were within or marginally outside of ANZECC guidelines. Across all sites and monitoring years, pH has remained highly consistent (**Figure 8**).

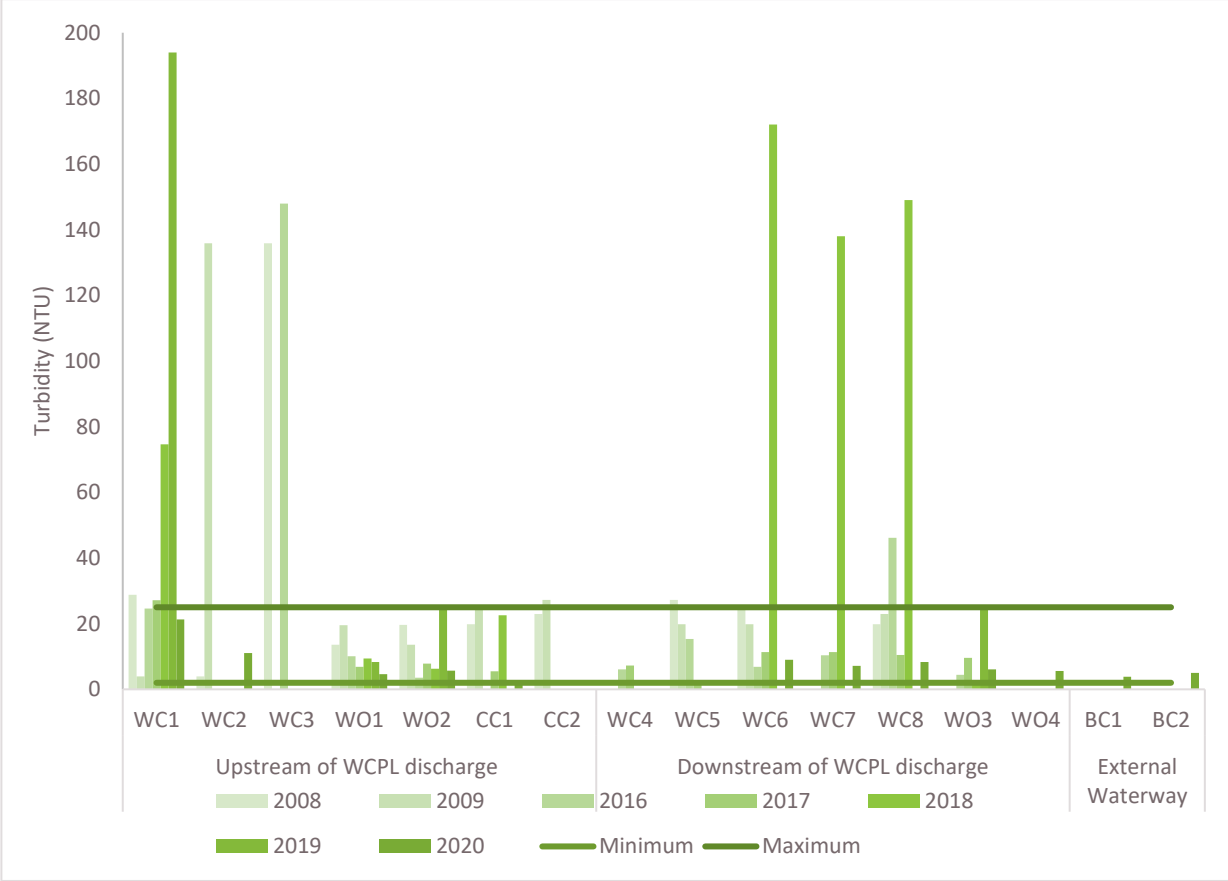

Figure 7: Turbidity (NTU) results across all sites and years

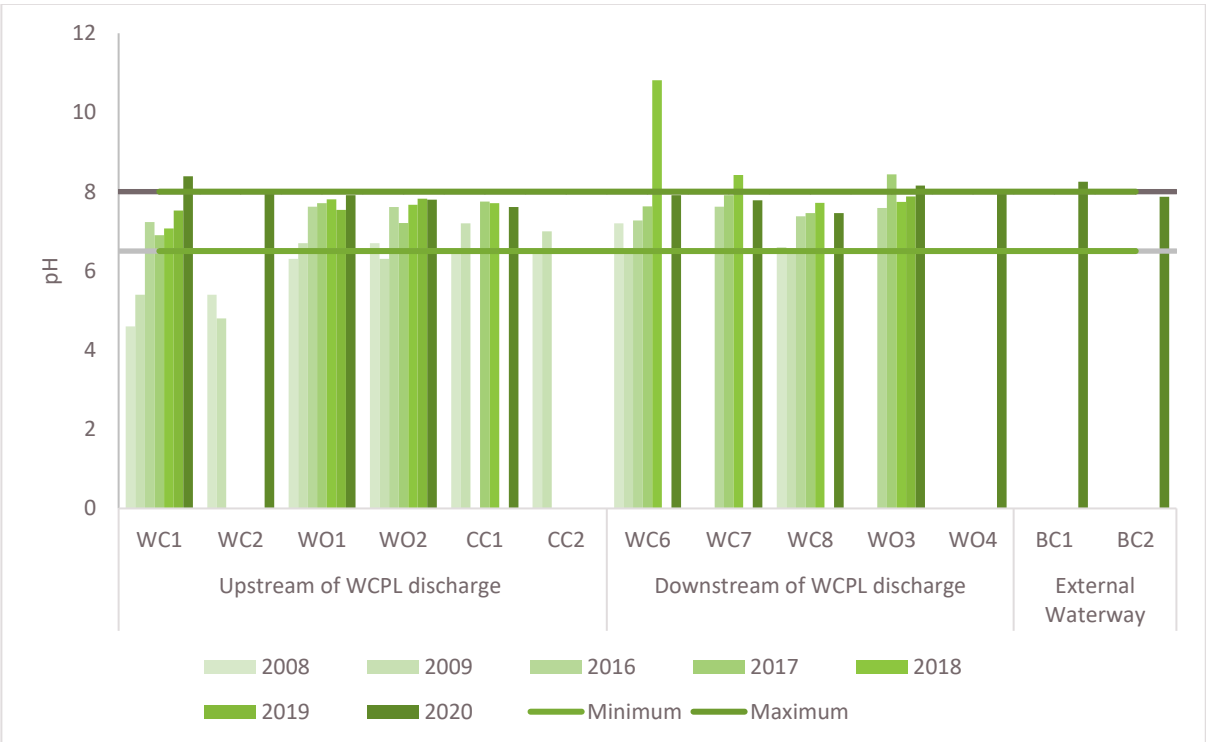

Figure 8: pH results across all sites and years

4.3 Macroinvertebrate communities

Across all monitoring years, the average SIGNAL2 score for each site (excluding sites established in 2020) is <4.0 with these scores indicative of severely disturbed systems. These scores have been consistently recorded during periods of variable surface water flow and availability and at sites both upstream and downstream of the WCM, including the two control sites located in the external Barigan Creek. Such results therefore reflect the overall disturbed nature of the catchment, largely attributable to historical agricultural and land use practices.

SIGNAL2 scores increased in 2020, halting the trend of declining scores recorded since 2016 with the reduction of habitat availability and condition due to drought conditions (**Figure 9**). These results demonstrate the influence that climatic conditions can have on macroinvertebrate results in the catchments surrounding the WCM.

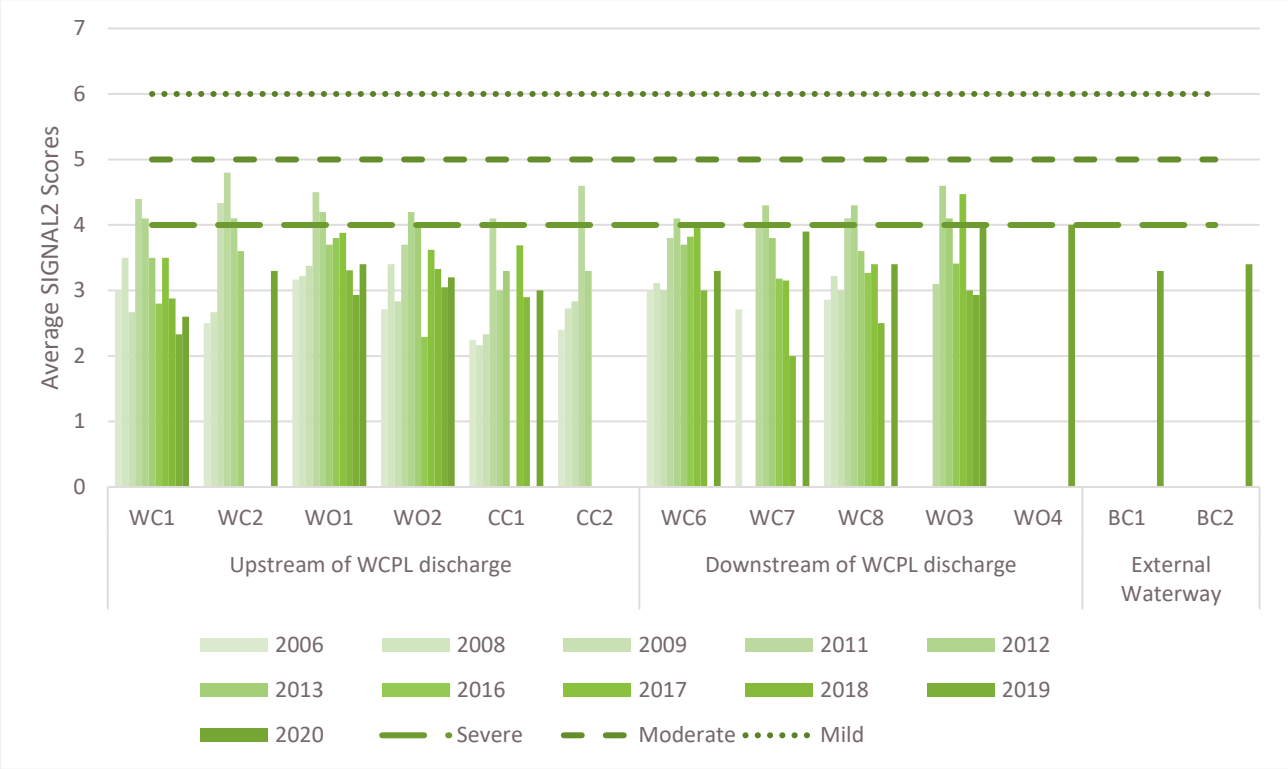

Figure 9: Average SIGNAL2 macroinvertebrate scores across all sites and years

5. Conclusions and recommendations

A total of eleven (11) permanent sites along Wilpinjong, Wollar and Cumbo Creeks underwent SHM in 2020, along with two (2) control sites at Barigan Creek. All sites except for CC2, were monitored for water quality and macroinvertebrates, which is the first time since 2013 that such a high proportion of sites were able to be monitored.

The habitat condition at all 13 sites were classified as either good or very good, which places the sites in the mid-range of aquatic habitat scores, typical of catchments in the surrounding region. Overall, aquatic habitat results have remained largely consistent across survey years, with differences primarily relating to changes in stream bed macrophyte and groundcover, as a result of fluctuating water levels in response to climatic conditions.

Water quality results continue to be outside of ANZECC guidelines across most sites for both DO and EC. Results for both parameters have fluctuated considerably across years and across varying stream flow levels, at sites both upstream and downstream of the WCPL licensed discharge point. As such, these results indicate that natural variables, rather than mining operations are the main factors which influence water quality in the sampled catchments.

A total of 20 macroinvertebrate Orders and 56 Families were recorded across all sites. SIGNAL2 scores increased in 2020, halting the decline in average scores recorded since 2016, in association with declining habitat quality and availability due to prolonged drought conditions. In line with previous years, SIGNAL2 scores were <4.0 for all but two sites, indicative of severely disturbed sites. The temporal and spatial consistency of these results indicates that historical disturbances within the catchments surrounding the WCM and monitored as part of the SHM program, are the main factors responsible for current stream health conditions.

Site WC7 was monitored in 2020, however, it will be discontinued from the SHM program as per previous recommendations, as this site is surplus to requirements for downstream monitoring (BIO-ANALYSIS 2018).

6. References

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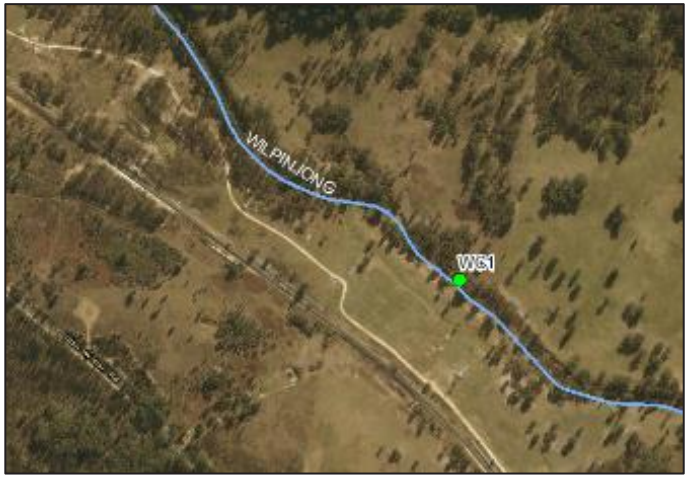
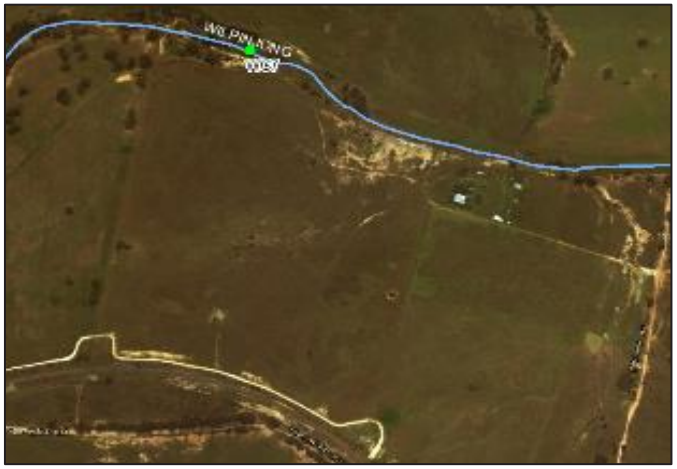
Appendix A Site Photos



Site WC1 (from left to right: site location, upstream, downstream (23/11/2020))

Site WC2 (from left to right: site location, upstream, downstream (23/11/2020))


Site WC6 (from left to right: site location, upstream, downstream (24/11/2020))




Site WC7 (from left to right: site location, upstream, downstream (23/11/2020))


Site WC8 (from left to right: site location, upstream, downstream (23/11/2020))


Site WO1 (from left to right: site location, upstream, downstream (25/11/2020))


Site WO2 (from left to right: site location, upstream, downstream (25/11/2020))


Site WO3 (from left to right: site location, upstream, downstream (25/11/2020))

Site WO4 (northern site - from left to right: site location, upstream, downstream (25/11/2020))

Site CC1 (from left to right: site location, upstream, downstream (24/11/2020))


Site CC2 (from left to left: site location, upstream, downstream (24/11/2020))


Site BC1 (from left to right: site location, upstream, downstream (26/11/2020))

Site BC2 (from left to right: site location, upstream, downstream (26/11/2020))

Appendix B Macroinvertebrate data

Order/Class	Family	SIGNAL2	BC1	BC2	CC1	WC1	WC2	WC6	WC7	WC8	WO1	WO2	WO3	WO4
Acarina	*Hydracarina*		1	1		1	1		2					1
	Trombidioidea										1			1
Arachnida	*Pisauridae*		3		3						1	1	1	1
	Tetragnathidae		2	1							1			
Cladocera			14	1		2	12	1	2	1	2	1	5	27
Coleoptera	*Dytiscidae*	2	13	6	14	8	6	4	11	3	8	4	4	4
	Gyrinidae	4		4			3	4				3	3	
	Haliplidae	2		18										
	Hydrenidae		3	3		5	3	6	1	2	5	6	1	4
	Hydrochidae	4		1	15						1	5		
	Hydrophilidae	2		13				1						
	Hygrobiidae	1	3			2	1			1				1
	Psephenidae	6									1			1
	Ptilodactylidae	10	1						1					1
	Staphylinidae				7									
Collembola				1	9			2		1	5	1		2
Copepoda	*Calanoida*								4					
	Cyclopodia					1	2	6						91
			27	9	181	2	13	19	8	3	8	7	6	45
Decapoda	*Atyidae*	3									2		8	
Diptera	*Ceratopogonidae*	4	3	8	2	2	2	12	1	2	12	18	4	1

Order/Class	Family	SIGNAL2	BC1	BC2	CC1	WC1	WC2	WC6	WC7	WC8	WO1	WO2	WO3	WO4
	Chironomidae	3	21	37	21	14	37	19	24	49	39	65	22	18
	Culicidae	1	1	3	1	2	4	1		1		2		1
	Dolichopodidae	3		1	1		1						1	
	Empididae	5			2									
	Simuliidae	5	1	1			4	3		1			1	
	Stratiomyidae	2	1	1	3		1				2	1	1	
	Tabanidae	3											2	
	Tipulidae	5		1										
Ephemeroptera	*Baetidae*	5	14	6	1	2	2	1	6	3	6	1	4	3
	Caenidae	4		1			1	4	8	1	2	2	11	18
	Leptophlebidae	8		7			1						1	1
	Siphlonuridae	10											2	
Gastropoda	*Lymnaeidae*	1	1	1	1									
	Physidae	1	7	4	5	1	2	2	1		3	3	1	7
					1									
Hemiptera	*Corixidae*	2	8	3		6	17	5	45	5	11	5	3	12
	Gerridae	4	1											
	Hydrometridae				2							1		
	Notonectidae	1	4	8		1	7	2	3	2	3		10	3
	Saldidae	1			1									
	Veliidae	3	5	3	10	5	6			3	3	2	1	3
Hirudinea			1								2			
Lepidoptera	*Crambidae*					1	1						1	
Megaloptera	*Sialidae*	5		1										

Order/Class	Family	SIGNAL2	BC1	BC2	CC1	WC1	WC2	WC6	WC7	WC8	WO1	WO2	WO3	WO4
Odonata	*Aeshnidae*	4	3	4	7	1	1		1	1	2	1		1
	Austrocorduliidae		6	6	11	5	3	3	1	1	8	4	3	4
	Gomphidae	5		2	0							1		
	Lestidae	1		1										
	Petaluridae			1										
	Protoneuridae	4	13	1	16	9	18	3	14	13	12	8	15	2
	Pseudocorduliidae									2				
	Telephlebiidae	9	1							1	2			
Oligochaeta			1					1			1		1	
Ostracoda			24	3	19	10	7	9	8	4	6	18	12	22
Platyhelminthes						1					1	2	1	1
Symphypleona	*Sminthurididae*		4											
Trichoptera	*Calocidae*	9							1					
	Helicopsychidae	8		1										1
	Hydrobiosidae	8		3									1	1
	Hydropsychidae	6		1			7	2					4	15
	Hydroptilidae	4	1	1							1	1		
	Leptoceridae	6	3	9	1	4	6	2	3	5	6	3	4	1
	Philopotamidae	8	1											

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Review of BMP Management Schedule for 2020

Management Strategy	Objectives	2020	Comments
Cultural Heritage Management	Identification of cultural heritage sites within the Biodiversity Offset Areas to avoid potential harm	• Undertake Due Diligence cultural heritage surveys in accordance with Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW to identify cultural heritage sites if works are required.	• Not required in 2020
	Cultural heritage items within the approved disturbance area, ECAs, Regeneration and Rehabilitation Areas are managed in accordance with the WCPL ACHMP (within DA boundaries) and Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW for areas elsewhere	• Continue implementation of WCPLs ACHMP, Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW and WCPLs GDP Process	• Due diligence surveys were conducted in Regen Area 1, 2, 4, 5 and 9 during 2020 and in ECA-B (along Wilpinjong Creek).
Fencing, Gates and Signage	Clearly delineate all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Install signage	• Not required in 2020 – signs in place
	Prevent unauthorised human access and exclude livestock from areas of native regeneration (unless being used as within management program i.e. crash grazing) to all Management Domains	• Repair, replace or install new fences • Undertake annual and opportunistic security inspections (fences, gates and signage). Schedule and undertake necessary repairs	• Annual inspection completed in late 2020 • Inspection determined no further need for repairs
	Access to the Management Domains is retained for maintenance and safety purposes	• Repair, replace or install new gates • Undertake annual and opportunistic security inspections. Schedule and undertake necessary repairs	• Annual inspection completed in late 2020 • Inspection determined no further need for repairs

Management Strategy	Objectives	2020	Comments
Access Tracks	Reduce and rehabilitate unnecessary access tracks in all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Decommission and rehabilitate all unnecessary access tracks as required • Undertake annual and opportunistic rehabilitation inspection. Schedule and undertake necessary repairs	• No decommissioning of tracks required in 2020 (insitu tracks remaining are required for bush fire management) • One section of track within ECA-B needs repair due to wash outs, scheduled for repair in 2021
	Provide safe, unimpeded access for monitoring and maintenance, bushfire management, and asset protection in all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Repair existing access tracks required for safe and ongoing access as required • Construct new access tracks • Undertake annual and opportunistic access track inspection. Schedule and undertake necessary repairs	• No decommissioning of tracks required in 2020 (insitu tracks remaining are required for bush fire management) • One section of track within ECA-B needs repair due to wash outs, scheduled for repair in 2021
Waste Management	All Biodiversity Offset Areas, ECAs and Regeneration Areas are free of waste, disused buildings and redundant farm equipment	• Removal of all identified waste, disused buildings and redundant farm equipment as required • Rehabilitation of disused building sites • Undertake annual and opportunistic waste inspections. Schedule and commission removal of all additional waste	• Annual inspection completed in late 2020, outstanding waste for removal recorded with GPS and scheduled for staged removal in 2021.

Management Strategy	Objectives	2020	Comments
Erosion, Sedimentation and Soil Management	Erosion, sediment or soil (ie. Salinity) risks are identified and mapped in all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Erosion, sediment or soil risks are categorised and included in WCPLs GIS database • Undertake annual and opportunistic erosion, sediment and soil inspections. Update GIS database with necessary changes	• In 2019 high resolution mapping of Wilpinjong Creek (erosion profiling) was completed. • In 2020 ongoing targeted tree planting along sections of Wilpinjong Creek within Regen Area 4, ECA_B, ECA_A and Regen Area 2.
	A risk based monitoring and management plan is developed for erosion, sediment and soil risks in all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Develop a risk based monitoring and management plan for erosion, sediment or soil risks as part of WCPLs Erosion and Sediment Control Plan • Implement management measures for high risk areas • Undertake annual and opportunistic erosion, sediment or soil inspections. Schedule and undertake necessary repairs	• In 2019 high resolution mapping of Wilpinjong Creek (erosion profiling) was completed. • In 2020 ongoing targeted tree planting along sections of Wilpinjong Creek within Regen Area 4, ECA_B, ECA_A and Regen Area 2. • Annual inspections completed in late 2020 to monitor high risk erosion areas e.g. ECB_B. Ongoing development of suitable remediation plan in 2021.
Grazing and Stock Management	Exclude livestock from areas of native regeneration in all Biodiversity Offset Areas, ECAs and Regeneration Areas (unless being used as within management program)	• Repair, replace or install new livestock exclusion fences • Undertake opportunistic and annual inspections. Schedule and undertake necessary repairs	• Annual inspection completed in late 2020 • Inspection determined no further need for repairs
	Consider livestock as a rehabilitation management tool	• Review rehabilitation performance towards completion criteria • If deemed appropriate, seek technical advice regarding the use of livestock as a rehabilitation management tool	• Not required in 2020

Management Strategy	Objectives	2020	Comments
Seed Collection and Propagation	All seed collectors are appropriately qualified and trained	• Confirm training records for engaged seed collectors	• Seed collecting methodology and supplier details formed part of the 2020 seed tendering contract process.
	Local species are included in revegetation and rehabilitation seed mixes	• Identify available seed species • Species collected to align with BVT species list and as required for site rehabilitation	• WCPL has maintained an ongoing seed collecting and seed storage program since 2015 • During 2020, applicable BVT seed species were identified from WCPL's seed bank and approximately 5,000 seedlings were propagated at a local nursey in Wollar
	Locally sourced seed is available for revegetation and rehabilitation works within all Management Domains	• Implement Seed Collection Program	• See above • During 2020 the seed collecting program continued (refer to **Section 8** of the Annual Review)
Habitat Augmentation	Habitat augmentation opportunities are identified and assessed	• Implement Habitat Augmentation Procedure and recommendations where applicable	• Ongoing refer to **Section 8** of the Annual Review

Management Strategy	Objectives	2020	Comments
Revegetation and Regeneration	Increase overall native plant species richness in ECAs, Regeneration and Rehabilitation Areas	**ECA-B** Continue revegetation works of local species **Regeneration Area 1** Opportunistic supplementary tree planting **Regeneration Area 2** Implement revegetation works of local native over-storey and shrub species within poor condition areas **Regeneration Area 4** Implement planting/seeding of mid-storey native plant species in areas of no to low resilience **Regeneration Area 5** Implement planting/seeding of mid-storey native plant species in areas of no to low resilience **Regeneration Area 9** Implement planting/seeding of native grasses, herbs and shrubs in poor condition areas Undertake annual and opportunistic revegetation and regeneration inspections.	• Throughout 2020 a total of 10,875 tube stock were planted across various land management domains (new and replacement), specifically Enhancement and Conservation Areas (ECA) A, ECA B, Regeneration Area 2, Regeneration Area 4 & Regeneration Area 5 • Refer to **Section 8** of the Annual Review for more information • Monitoring in 2020, verified natural recruitment of native species in Regen 9, schedule for further monitoring in 2021 to determine if rehabilitation works are required

Management Strategy	Objectives	2020	Comments
Weed Management	Noxious and environmental weeds are identified and mapped in all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Undertake quarterly weed inspections. Update GIS database with necessary changes	• Refer to **Section 8** of the Annual Review
	A risk based weed management program is developed for all Biodiversity Offset Areas, ECAs, Regeneration and Rehabilitation Management Domains	• Implement weed management program • Undertake weed inspections • Schedule and undertake necessary weed treatment	• In July 2020 a weed management map was developed • Weed control ongoing and in accordance with the weed management map
	Reduced presence of noxious and environmental weeds	• Implement weed management program Specific Actions include: • Continued Control of St Johns Wort, Blackberry and Juncus acutus (Spiny Rush) along Cumbo Creek within ECA-A and Regeneration Area 2 • Continued Control of St Johns Wort, Blackberry and Juncus acutus (Spiny Rush) along Wilpinjong Creek within ECA-B and Regeneration Areas 1, 5 and 9 • Broad-leaf weed treatment in poor condition native pastures within ECA-B, and Regeneration Areas 1 and 9 • Targeted spraying of blackberry and Juncus acutus (Spiny Rush) along Wilpinjong Creek within ECA-B and Regeneration Areas 1 and 5 • Continue control of St Johns Wort in 'pre-strip' areas 2 years ahead of mining	• Refer to **Section 8** of the Annual Review

Management Strategy	Objectives	2020	Comments
Vertebrate Pest Management	Control vertebrate pest species likely to pose a threat to the Biodiversity Offset Areas, ECAs and Regeneration and Rehabilitation Areas	• Implement vertebrate pest management program	• Refer to **Section 8** of the Annual Review
Bushfire Management	Maintain the environmental and habitat features of the Biodiversity Offset Areas, ECAs and Regeneration and Rehabilitation Areas	• Implement WCPL Bushfire Management • Install and maintain APZs	• A section of the fire trial in ECA_B to be repaired in 2021
Biodiversity Monitoring	Monitor biodiversity within the Biodiversity Offset Areas, ECAs and Regeneration and Rehabilitation Areas to assess progress against interim, performance and completion criteria	• Implement Biodiversity Monitoring Program and analyse results against interim, performance and completion criteria and undertake corrective actions where required. • Establish Local Benchmark Sites in consultation with OEH by September 2020.	• Refer to **Section 6.4** of the Annual Review • WCPL submitted Local Benchmark Sites in consultation with OEH in September 2020. BCSD (formerly OEH approved in January 2021)
Inspections and Document Control	Ensure implemented management actions are successful in progressing towards completion criteria	• Undertake and document inspections	• Completed in 2020 and ongoing in 2021
	All actions, monitoring data and performance outcomes are documented and reported	• Document all actions, monitoring data and performance outcomes	• Annual biodiversity monitoring reports and plant condition assessments, post tubestock plantings.

Management Strategy	Objectives	2020	Comments
Management of Biodiversity Offsets 1-5	Manage Biodiversity Offset Areas 1-5 and facilitate their transfer to the National Parks Estate.	• Remove internal fencing from the Biodiversity Offset Areas not required by the NPWS.	• Internal fencing removal has been completed.
Early establishment of Regent Honeyeater habitat in available areas	Establish Regent Honeyeater habitat within existing mine rehabilitation areas where rehabilitation to date has focussed on the establishment of productive pasture for grazing.	• Commence the control of non-native species and re-seeding of select existing rehabilitation areas to a combination of suitable native plant species (e.g. key canopy species of recognised target BVTs).	• 138ha of BVT species seeded in 2020. An additional 33ha of existing landforms converted with BVT seed species (refer to **Section 8** of the Annual Review regarding drone seed trail).
Rehabilitation of the Mine site to recognised habitat and ecosystem values	Establish recognised BVTs and Regent Honeyeater habitat in the Rehabilitation Areas.	• Develop target post-mining BVT mapping across the Mine site to satisfy the credit requirements. • Conduct BioMetric evaluation of select existing woodland rehabilitation areas to inform the implementation of residual measures.	• Completed (i.e. Post Mining BVT mapping) • BioMetric evaluation commenced in 2020 and is ongoing
Propagation of *Ozothamnus tesselatus*	Successfully propagate *Ozothamnus tesselatus* in suitable Mine site rehabilitation areas.	• Undertake propagation trials in germination trays with various soils and treatments.	• Refer to **Section 8** of the Annual Review
Revegetation works along Cumbo and Wilpinjong Creeks	Establish revegetation on sections of Cumbo and Wilpinjong Creeks in WCPL and Peabody ownership.	• Commence implementation of the works program.	• Refer to **Section 8** of the Annual Review