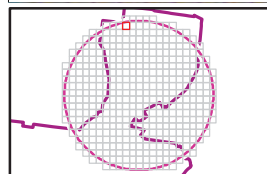






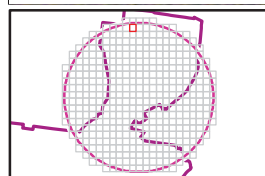
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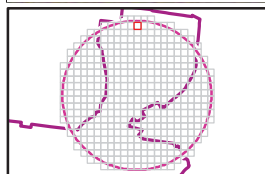
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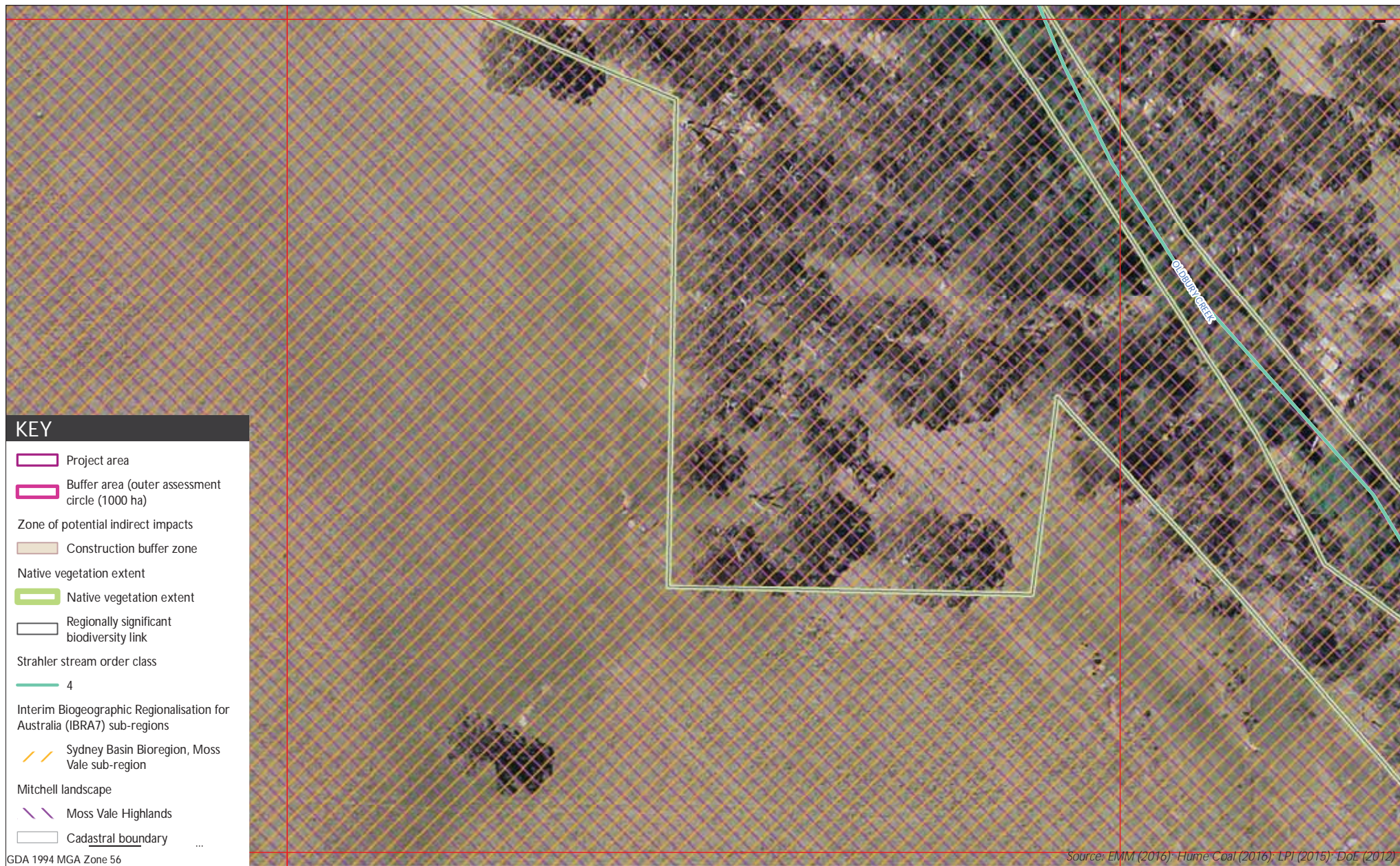




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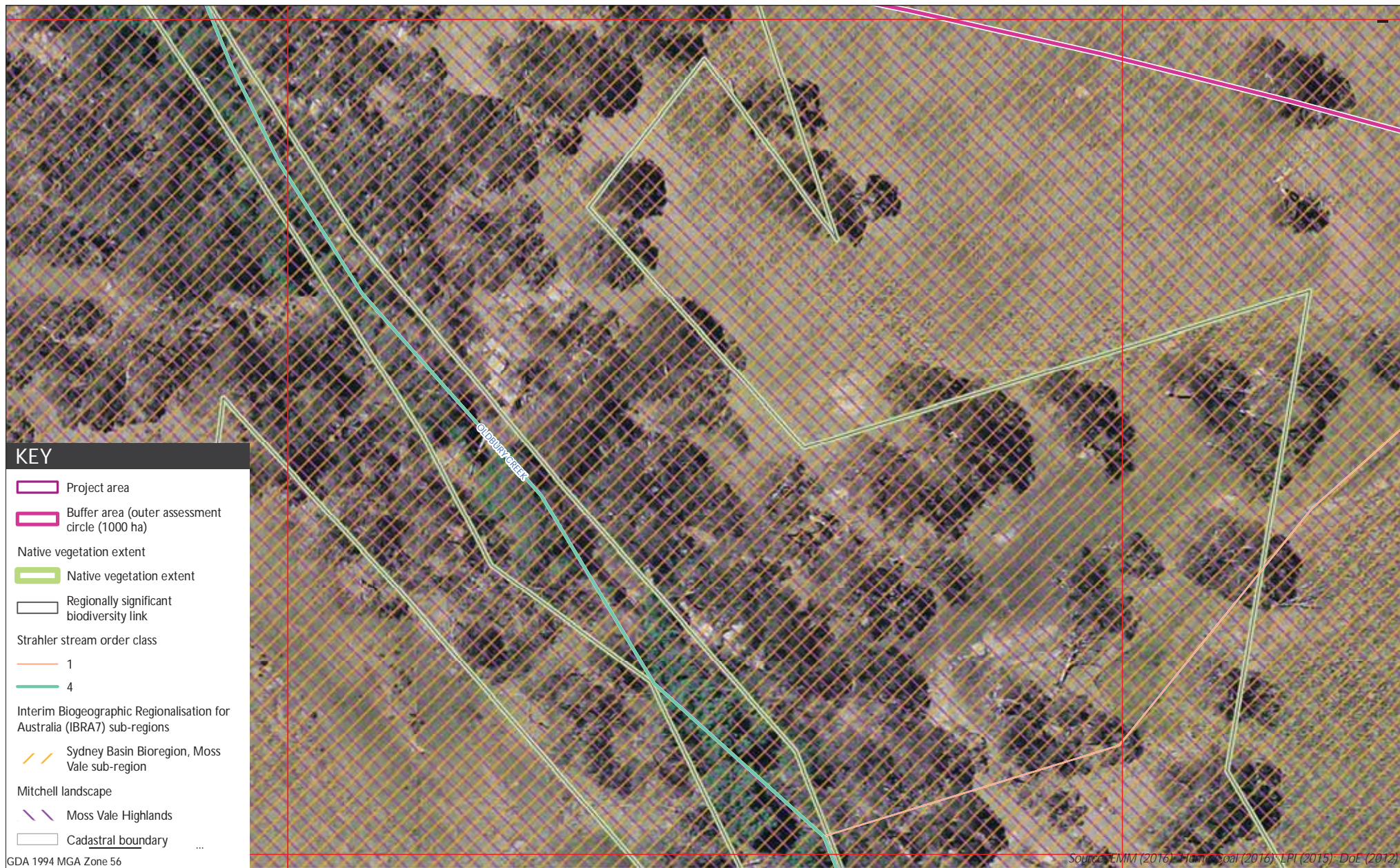




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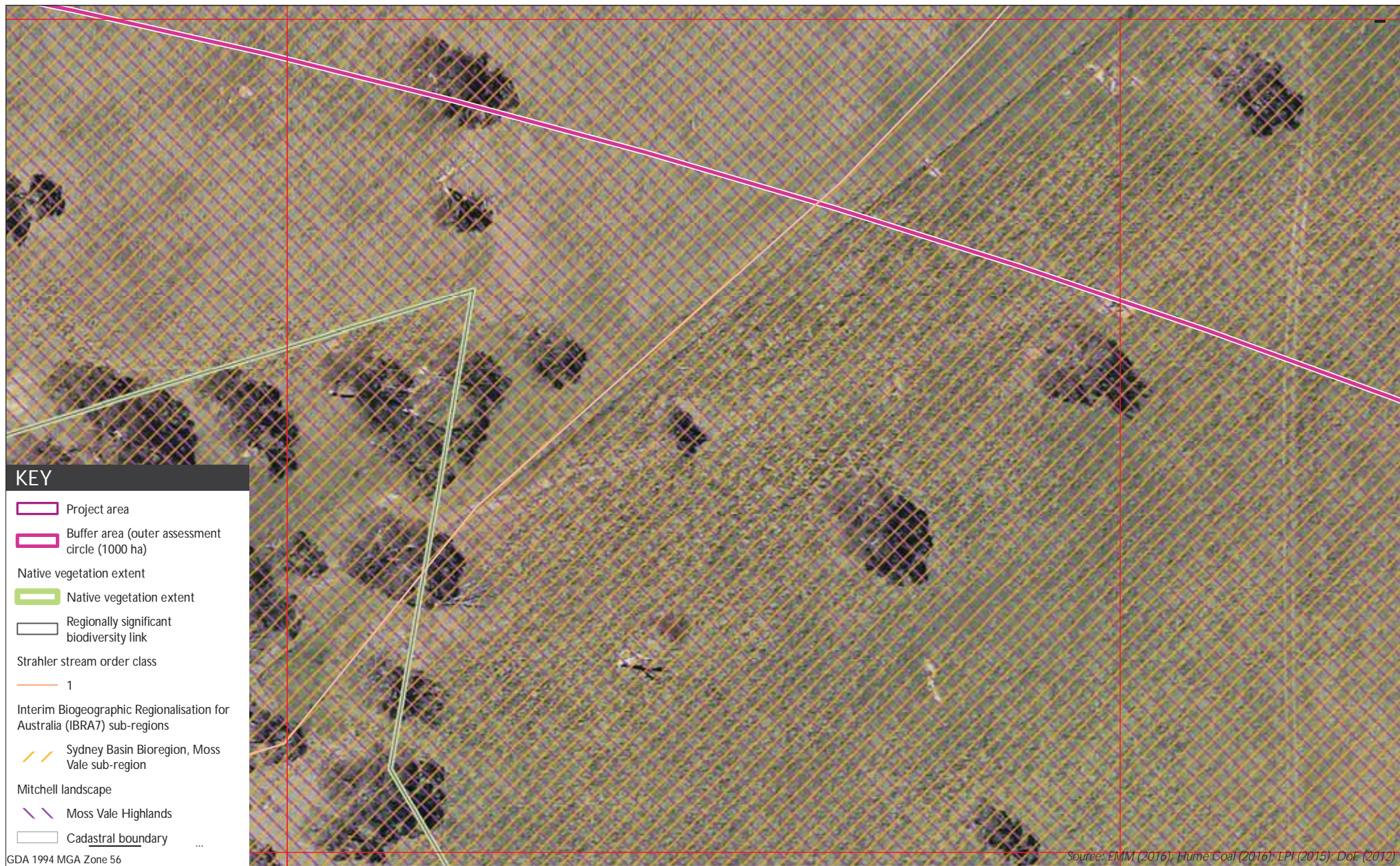




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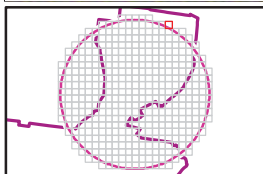




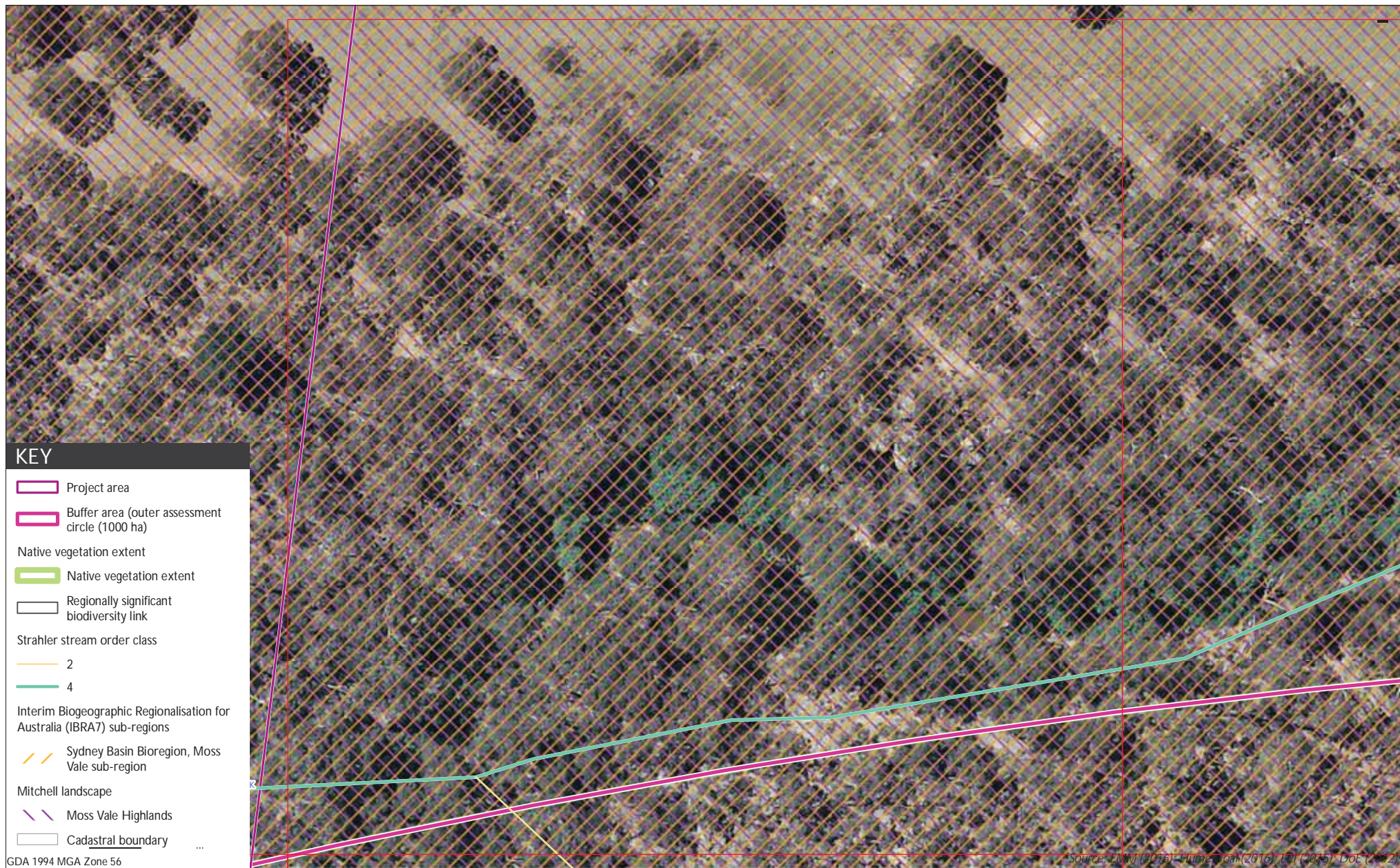
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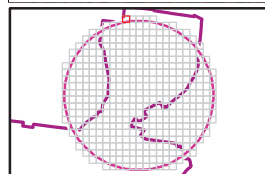








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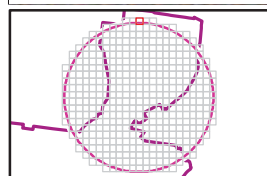




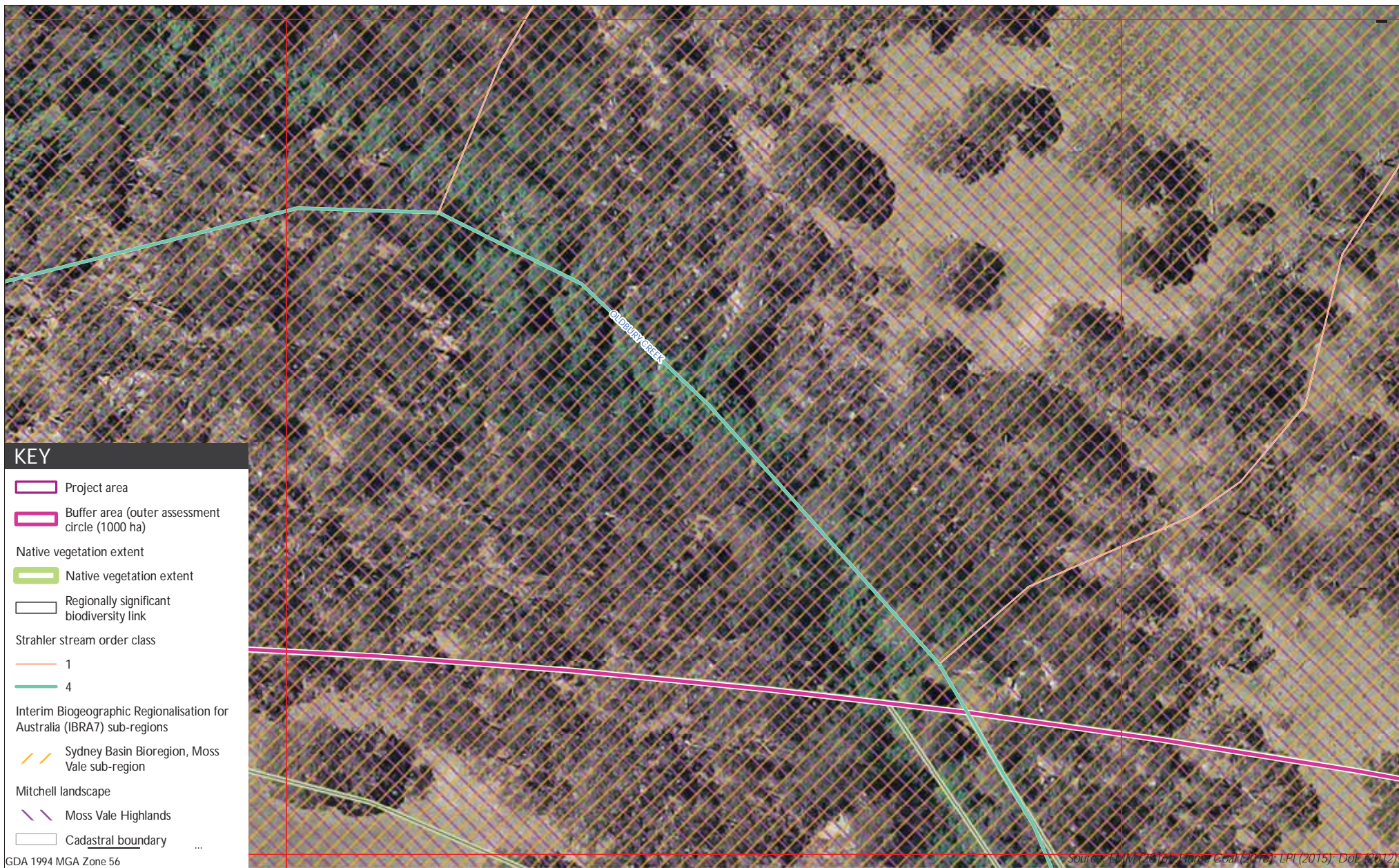




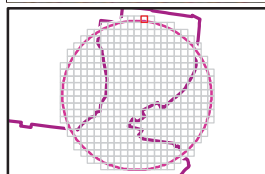
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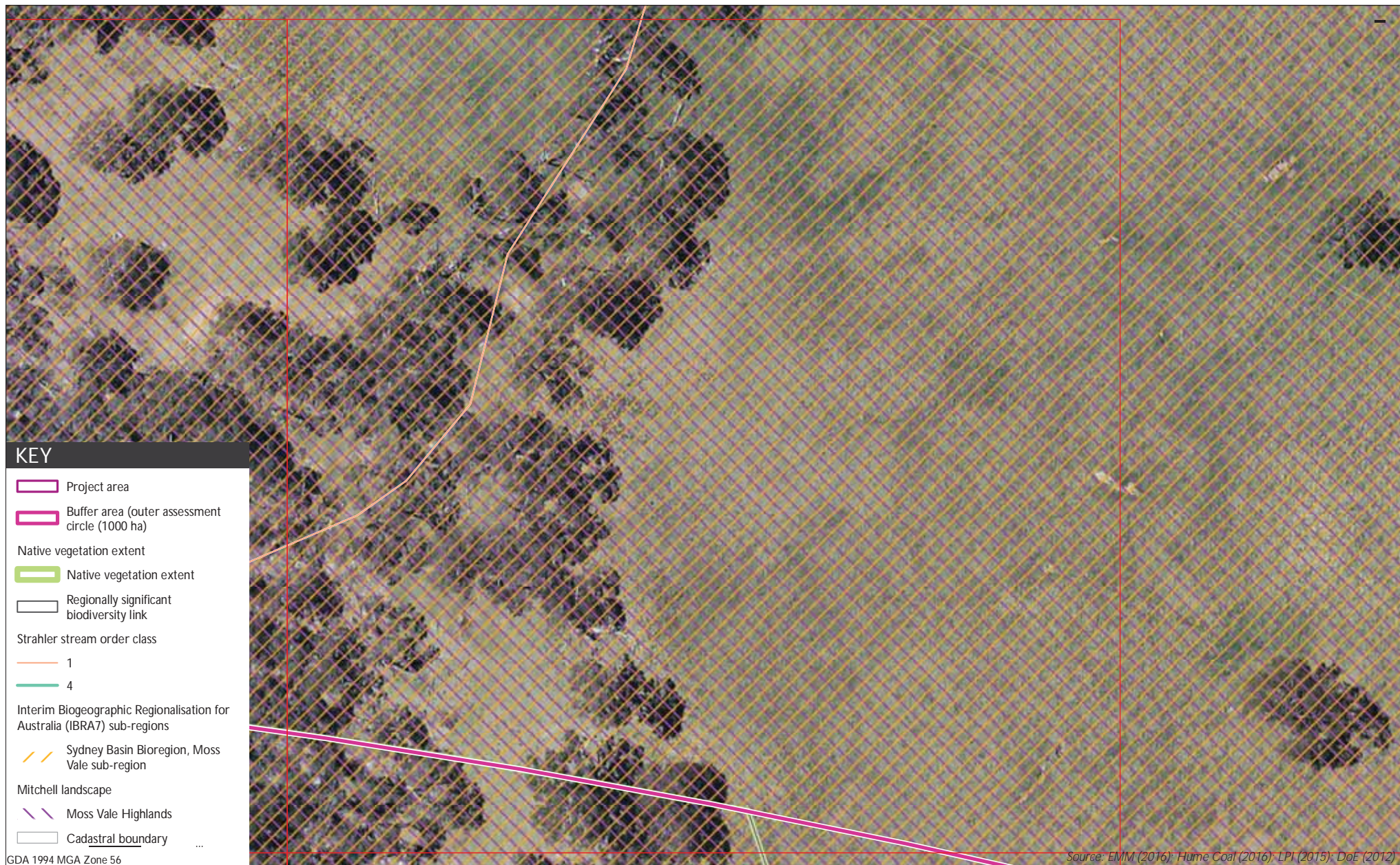




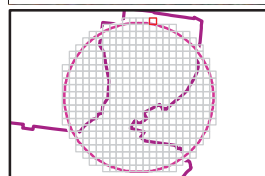
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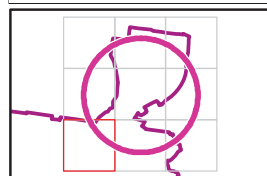
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T:\Jobs\2012\12035 - Hume Coal Project EIS\Background Information\GIS\02\_Maps\2017\_BARBAR030\_DOP\_LocationMaps\_20170203\_05.mxd 3/02/2017



Location map - 436  
 Hume Coal Project  
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 Figure 436





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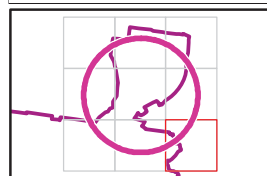
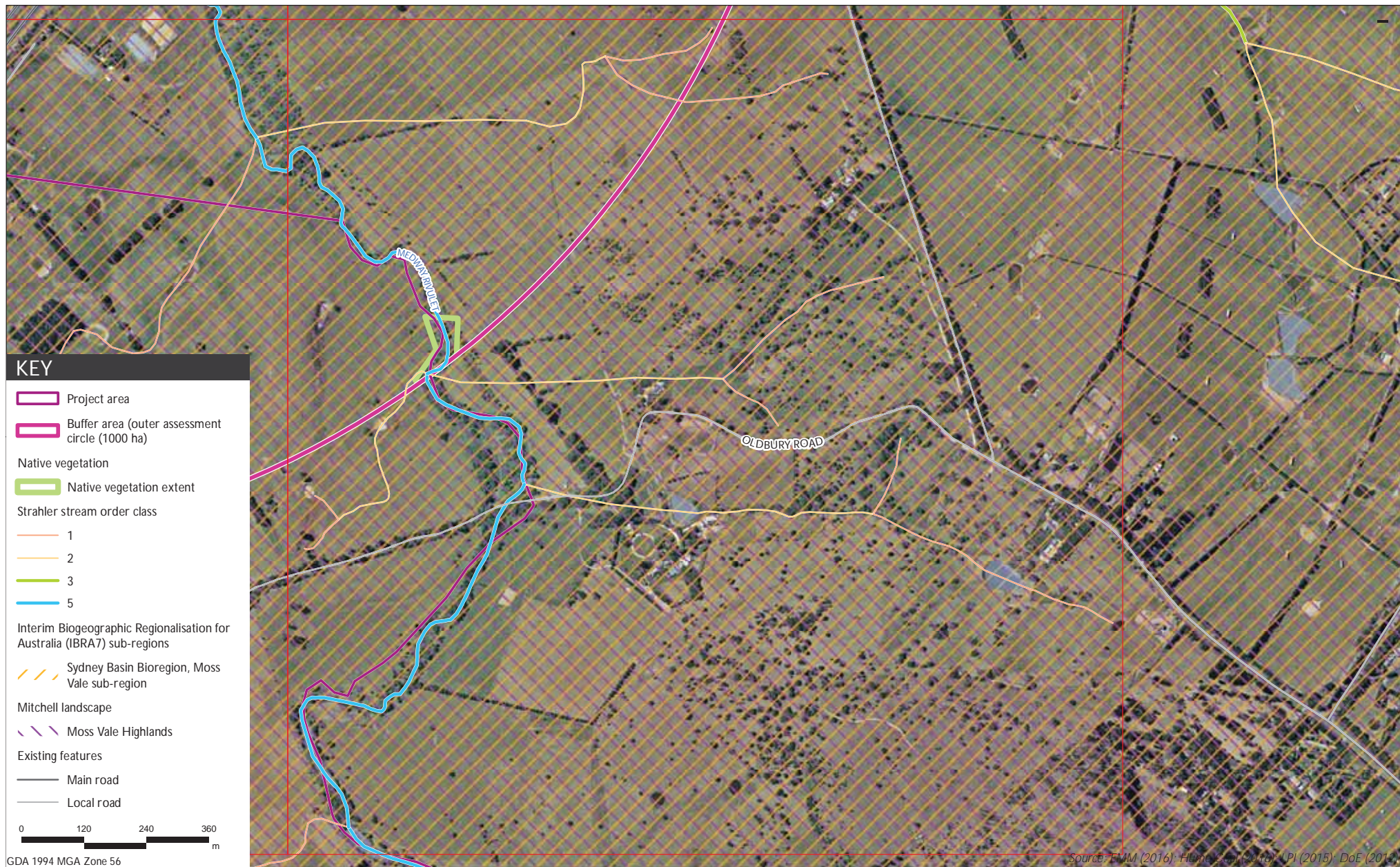
Location map - 437

Hume Coal Project  
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Appendix A

Figure 437





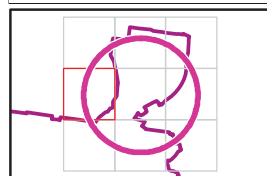
Location map - 438  
 Hume Coal Project  
 Environmental Impact Statement  
 Appendix A  
 Figure 438

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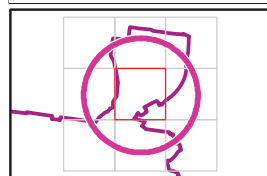




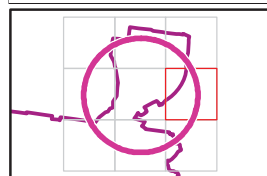
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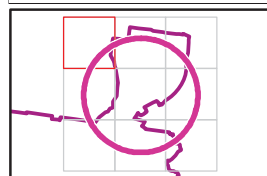


Location map - 441  
 Hume Coal Project  
 Environmental Impact Statement  
 Appendix A  
 Figure 441

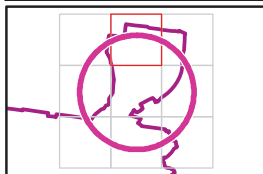
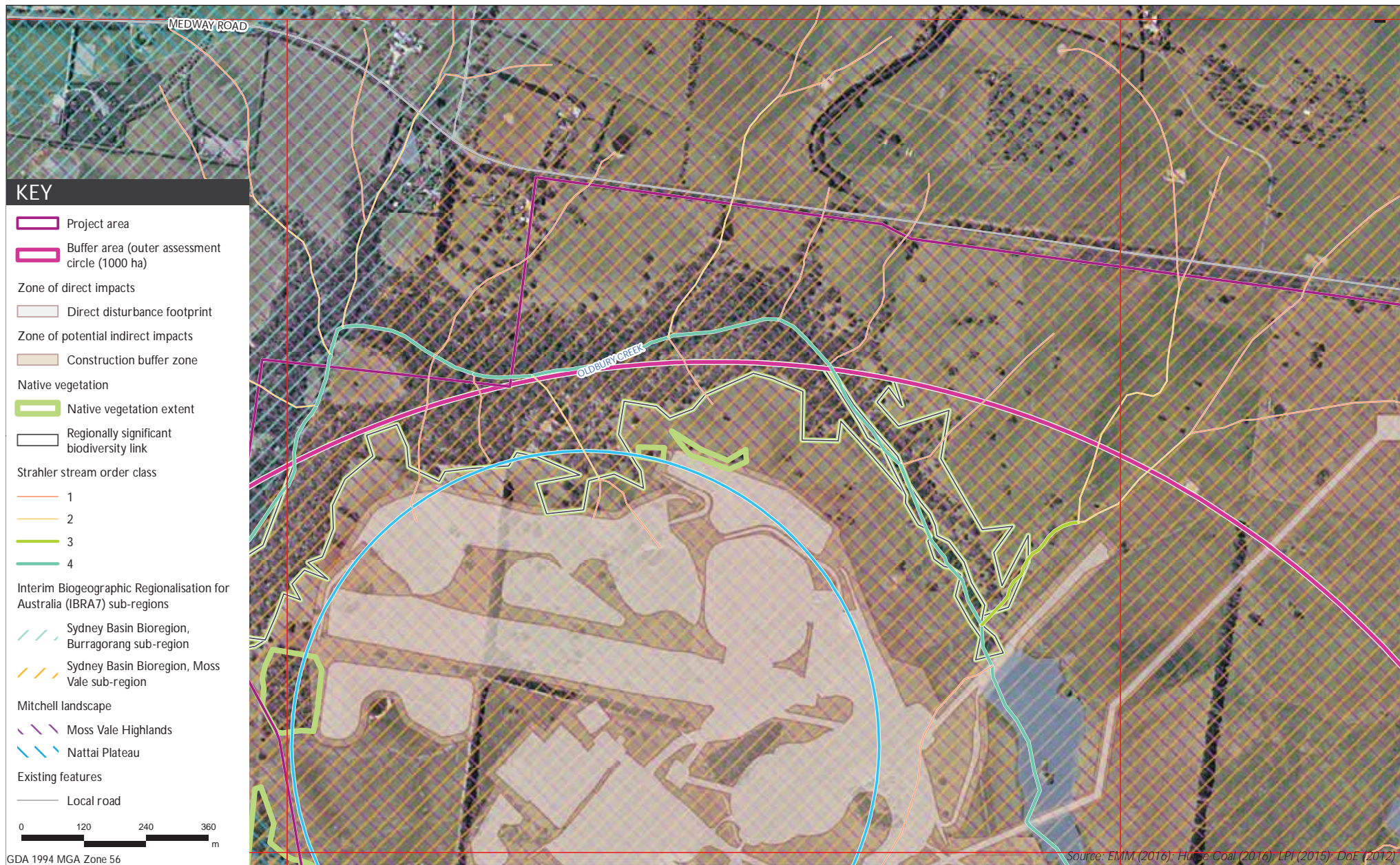




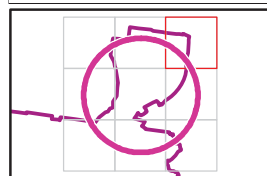
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Location map - 444

Hume Coal Project  
Environmental Impact Statement  
Appendix A  
Figure 444



## A.2 Compliance of the assessment against the FBA mapping requirements

This section demonstrates the compliance of the assessment against the FBA mapping requirements. The assessment is provided in Table A.1 to Table A.3.

**Table A.1** Assessment of compliance with FBA requirements for the site map

FBA ref	Requirement	Comply?	EIS Ref
3.2.1.2	Digital aerial photography	Yes	Figure 1.4 and Appendix A
3.2.1.2(a)	1:1000 or finer	Yes	Figure 1.4 and Appendix A
3.2.1.2(a)(i)	Boundary of development site	Yes	Figure 1.4 and Appendix A
3.2.1.2(a)(ii)	Cadastre	Yes	Figure 1.4 and Appendix A
4.1.1.2(a)	IBRA bioregions and IBRA subregions	Yes	Figure 1.4 and Appendix A
4.1.1.2(b)	Mitchell landscapes	Yes	Figure 1.4 and Appendix A
4.1.1.2(c)	Rivers and streams	Yes	Figure 1.4 and Appendix A
4.1.1.2(d)	Wetlands	N/A. There are no important wetlands in the outer assessment circle.	N/A
4.1.1.2(e)	Extent of native vegetation in the outer assessment circle or the buffer area surrounding the development footprint	Yes	Figure 1.4 and Appendix A
4.1.1.2(f)	Any other landscape features that are required by the SEARs for assessment at a development site.	N/A. No other landscape features are required by the SEARs.	N/A
4.1.1.3	All IBRA bioregions and IBRA subregions within the development site must be identified and shown on the Site Map.	Yes	Figure 1.4 and Appendix A
4.1.1.5	All Mitchell landscapes within the development site must be identified and shown on the Site Map.	Yes	Figure 1.4 and Appendix A
4.1.1.8	All rivers, streams and estuaries that occur within the development site, and their riparian buffer areas, must be identified and shown on the Site Map.	Yes	Figure 1.4 and Appendix A
4.1.1.11	All important and local wetlands that occur within the development site must be identified and shown on the Site Map.	N/A. There are no important or local wetlands in the outer assessment circle.	N/A
4.1.1.13	Important wetlands must also be separately identified and shown on the Site Map and the Location Map.	N/A. There are no important wetlands in the outer assessment circle.	N/A
4.1.1.16	All state or regionally significant biodiversity links that occur within the development site must be identified and shown on the Site Map.	Yes	Figure 1.4 and Appendix A
4.1.1.18	Other landscape features should be mapped on both the Site Map and Location Map if this is a requirement of the SEARs.	N/A. There are no other landscape features identified in the SEARs.	N/A
5.1.1.2	The native vegetation extent on the development site must be shown on the Site Map, which must include all land in the development site.	Yes	Figure 1.4 and Appendix A



**Table A.2 Assessment of compliance with FBA requirements for the location map**

FBA ref	Requirement	Comply?	EIS Ref
3.2.1.2	Digital aerial photography	Yes	Figure 1.5 and Appendix A
3.2.1.2(b)	1:10,000 or finer	Yes	Figure 1.5 and Appendix A
3.2.1.2(b)(i)	All landscape features assessed in Chapter 4	Yes	Figure 1.5 and Appendix A
3.2.1.2(b)(ii)	Boundary of the development site	Yes	Figure 1.5 and Appendix A
3.2.1.2(b)(iii)	Local area boundaries or other base data relevant at this scale	Yes. Cadastral boundaries are shown on the map.	Figure 1.5 and Appendix A
3.2.1.3	Area covered by the outer assessment circle according to Appendix 4, or the buffer area surrounding the development footprint according to Appendix 5	Yes	Figure 1.5 and Appendix A
4.1.1.2(a)	IBRA bioregions and IBRA subregions	Yes	Figure 1.5 and Appendix A
4.1.1.2(b)	Mitchell landscapes	Yes	Figure 1.5 and Appendix A
4.1.1.2(c)	Rivers and streams	Yes	Figure 1.5 and Appendix A
4.1.1.2(d)	Wetlands	N/A. There are no important wetlands in the outer assessment circle.	N/A
4.1.1.2(e)	Extent of native vegetation in the outer assessment circle or the buffer area surrounding the development footprint	Yes	Figure 1.5 and Appendix A
4.1.1.2(f)	Any other landscape features that are required by the SEARs for assessment at a development site.	N/A. No other landscape features are required by the SEARs.	N/A
4.1.1.4	Any other regions within the outer assessment circle must be identified and shown on the Location Map.	Yes. The two relevant IBRA subregions are shown on the location map.	Figure 1.5 and Appendix A
4.1.1.6	Any other Mitchell landscapes that occur within the outer assessment circle must be identified and shown on the Location Map.	Yes. The two relevant Mitchell Landscapes are shown on the location map.	Figure 1.5 and Appendix A
4.1.1.9	All other rivers, streams and estuaries that occur within the outer assessment circle, and their riparian buffer areas, must be identified and shown on the Location Map.	Yes. The riparian buffer of Medway Rivulet and Wells Creek which represents a regionally significant biodiversity link is shown on the location map.	Figure 1.5 and Appendix A
4.1.1.12	Any other important and local wetlands that are adjacent to or downstream from the development site and within the outer assessment circle must be identified and shown on the Location Map.	N/A. There are no important wetlands in the outer assessment circle.	N/A
4.1.1.13	Important wetlands must also be separately identified and shown on the Site Map and the Location Map.	N/A. There are no important wetlands in the outer assessment circle.	N/A



**Table A.2**      **Assessment of compliance with FBA requirements for the location map**

FBA ref	Requirement	Comply?	EIS Ref
4.1.1.14	The extent of native vegetation within the outer assessment circle, or the buffer area surrounding the development footprint, must be mapped onto digital aerial photography (such as ADS-40 imagery) or the best available imagery of the development site, and shown on the Location Map.	Yes	Figure 1.5 and Appendix A
4.1.1.17	All state or regionally significant biodiversity links that occur within the outer assessment circle must be identified and shown on the Location Map.	Yes	Figure 1.5 and Appendix A
4.1.1.18	Other landscape features should be mapped on both the Site Map and Location Map if this is a requirement of the SEARs.	N/A. No other landscape features are required by the SEARs.	N/A

**Table A.3**      **Assessment of compliance with other mapping and data requirements of the FBA**

FBA ref	Requirement	Comply?	EIS Ref
5.1.1.1	The extent of native vegetation within the development site must be mapped onto digital aerial photography (such as ADS-40 imagery) or the best available imagery of the development site, using existing maps of native vegetation in the area and an assessment of the site. The capture scale should be 1:1,000 – 1:5,000, and not greater than 1:10,000.	Yes	Figure 1.4, Figure 1.5 and Appendix A
Table 20	Map of Plant Community Type (PCT)s within the development site	Yes	Figure 5.2
Table 20	Map of condition class and subcategory (where relevant)	Yes	Figure 5.2
Table 20	Map of plot and transect locations relative to PCTs and condition class	Yes	Figure 5.2
Table 20	Map of EECs	Yes	Figure 4.3 and 5.1
Table 20	Plot and transect field data (MS Excel format)	Yes. This has been provided to OEH through the BioBanking Calculator.	N/A. This data is in the biobanking calculator. A summary of plot data is provided in Appendix C.
Table 20	Plot and transect field data sheets	Yes.	Appendix C.
Table 20	Table of current site value scores for each vegetation zone within the development site	Yes.	Table 5.1
Table 20	Map of vegetation zones with a current site value score of <17	N/A. All vegetation zones have a current site value of >17.	N/A



**Table A.3 Assessment of compliance with other mapping and data requirements of the FBA**

FBA ref	Requirement	Comply?	EIS Ref
Table 20	Table of vegetation zones and landscape Tg values, particularly indicating where these have changed due to species exclusion	Yes	Vegetation zones are shown in Table 5.1. Landscape Tg values are provided in Table 5.3 for ecosystem credit species. No species were excluded.
Table 20	Targeted survey locations	Yes	Figure 2.2
Table 20	Table detailing the list of species credit species and presence status on site as determined by targeted survey, indicating also where presence was assumed and/or where presence was determined by expert report	Yes	Table 5.4
6.5.1.17	The species polygon must: (a) be mapped using a satellite (ADS-40) or the best available ortho-rectified aerial image of the development site (b) use the unit of measurement identified for that species in the Threatened Species Profile Database (c) include the locations of the species or areas occupied by the species (d) contain the specific habitat feature or habitat component associated with that species on the development site (e) utilise GPS to confirm the location of the species polygon on the best available ortho-rectified aerial image of the development site.	Yes	Figure 5.2
Table 20	Species credit species polygons (as described in Paragraph 6.5.1.18)	Yes	Figure 5.2
Table 20	Table detailing species and habitat feature/component associated with species and its abundance on site (as described in Paragraph 6.5.1.18).	Yes	Table 5.4
Table 20	Species polygons for species that cannot withstand a loss	N/A. All species impacted can withstand loss.	N/A
Table 20	Table of measures to be implemented before, during and after construction to avoid and minimise the impacts of the project, including action, outcome, timing and responsibility.	Yes	Table 6.1
Table 20	Map of final project footprint, including construction and operation	Yes	Figure 1.4, Figure 1.5 and Appendix A
Table 20	Maps demonstrating indirect impact zones where applicable	Yes. The construction buffer zone shown represents the area of indirect impact.	Figure 5.2 and 5.3
Table 20	Map of areas not requiring assessment	Yes	Figure 5.3
Table 20	Map of PCTs and species polygons not requiring offset	Yes	Figure 5.3
Table 20	Map of PCTs and species polygons requiring offset	Yes	Figure 5.2
Table 20	Map of the occurrence of the entity or impact that requires further consideration	Yes	Figure 7.3



**Table A.3 Assessment of compliance with other mapping and data requirements of the FBA**

FBA ref	Requirement	Comply?	EIS Ref
Table 20	Table of PCTs requiring offset and the number of ecosystem credits required	Yes	Table 5.1
Table 20	Table of species and populations requiring offset and the number of species credits required	Yes.	Table 5.3 and Table 5.4. There are no populations requiring offset.
Table 20	Full biodiversity credit calculator output	Yes	Appendix H
Table 20	Submitted proposal in the credit calculator	Yes	The assessment was submitted on 6/03/2017 submitted just prior to lodgement.
Table 20	Table of credit type and matching credit profile	Yes. A potential offset package for the Hume Coal Project and Berrima Rail Project is presented in the report.	Table 9.2
Table 20	Biodiversity credit report from the credit calculator	Yes	Appendix H
5.2.1.8	The assessor is required to provide justification in the BAR of evidence used to identify a PCT at the development site. This includes: ... (c) a map showing the distribution of the PCTs on the development site.	Yes	Figure 5.1 and 5.2. Detailed vegetation profiles and justification for the selection of PCTs is provided in Appendix C.
5.2.1.9	The assessor must identify any threatened ecological communities that are associated with a PCT, and map the distribution of the ecological community on the development site.	Yes	Figure 5.1
5.2.1.12	The distribution of PCTs classified under the saline wetland formation must be shown on the map.	N/A. Saline wetlands are absent from the project area and buffer area.	N/A
5.2.2.1	The assessor must use the map of PCTs referred to in Subsection 5.2.1, to identify and map the area of each PCT into a vegetation zone on the development site.	Yes	Figure 5.2
5.2.2.7	Vegetation zones that are in low condition, or are in a derived grassland form, or have a current site value score of less than 17 in accordance with Section 5.3, must be identified as a separate vegetation zone and shown on the map of vegetation zones.	N/A. All vegetation zones have a current site value >17.	N/A
10.3.1.3	The assessor may calculate a different future site value score for separate parts of a vegetation zone to allow for any variation in the impact of development across the vegetation zone. This includes where the impact of development will result in partial clearing of the native vegetation and includes areas such as asset protection zones and easements. The assessor must map these areas of the vegetation zone as a management zone and include this in the BAR.	N/A. The project does not require asset protection zones.	N/A



## Appendix B

### Compliance of survey effort against guidelines

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**Table B.1**      **Comparison against survey effort guideilnes for threatened fauna species**

<b>Birds</b>	<b>TSC</b>	<b>EPBC</b>	<b>Guidelines</b>	<b>Completed</b>
Blue-billed Duck	V		Area search in each stratification unit	54 person hours across all stratification units
Australasian Bittern	E	E	Area search in each stratification unit	54 person hours across all stratification units
Flame Robin	V	MA	Area search in each stratification unit	54 person hours across all stratification units
Scarlet Robin	V		Area search in each stratification unit	54 person hours across all stratification units
Diamond Firetail	V		Area search in each stratification unit	54 person hours across all stratification units
Gang-gang Cockatoo	V		Area search in each stratification unit	54 person hours across all stratification units
Glossy Black-cockatoo	V		Area search in each stratification unit	54 person hours across all stratification units
Masked Owl	V		At least 6 visits per site (habitat area)	96 person hours over 8 nights
Barking Owl	V		At least 6 visits per site (habitat area)	96 person hours over 8 nights
Powerful Owl	V		At least 6 visits per site (habitat area)	96 person hours over 8 nights
Sooty Owl	V		At least 6 visits per site (habitat area)	96 person hours over 8 nights
Speckled Warbler	V		Area search in each stratification unit	54 person hours across all stratification units
Brown Treecreeper	V		Area search in each stratification unit	54 person hours across all stratification units
Varied Sittella	V		Area search in each stratification unit	54 person hours across all stratification units
Little Eagle	V		Area search in each stratification unit	54 person hours across all stratification units
Square-tailed Kite	V		Area search in each stratification unit	54 person hours across all stratification units
Regent Honeyeater	CE	E	20 hours over 5 days	54 person hours across all stratification units
Great Egret		MI	Area search in each stratification unit	54 person hours across all stratification units
Cattle Egret		MI	Area search in each stratification unit	54 person hours across all stratification units
Rainbow Bee-eater		MI	Area search in each stratification unit	54 person hours across all stratification units
Satin Flycatcher		MI	Area search in each stratification unit	54 person hours across all stratification units
Rufous Fantail		MI	Area search in each stratification unit	54 person hours across all stratification units
Turquoise Parrot	V		Area search in each stratification unit	54 person hours across all stratification units



**Table B.1 Comparison against survey effort guideilnes for threatened fauna species**

Birds	TSC	EPBC	Guidelines	Completed
<b>Mammals</b>				
Koala	V	V	Koala survey, habitat assessment and spot assessments	60 spot assessments, spotlighting and diurnal surveys.
Spotted-tailed Quoll	V	E	Cameras left on site for a minimum of three weeks	Cameras left on site for a minimum of three weeks.
Yellow-bellied Glider	V		2 x 1 hour and 1 km up to 200 ha of stratification unit spotlighting and call playback	96 person hours of spotlighting and call playback covering a total of 16 km across stratification units
Southern Myotis	V		4 trap nights over two consecutive nights per 100 ha Two detectors for 2 nights per 100 ha	57 detector nights and 32 trap nights
Eastern Bentwing Bat	V		4 trap nights over two consecutive nights per 100 ha Two detectors for 2 nights per 100 ha	57 detector nights and 32 trap nights
Eastern False Pipistrelle	V		4 trap nights over two consecutive nights per 100 ha Two detectors for 2 nights per 100 ha	57 detector nights and 32 trap nights
Large-eared Pied Bat	V	V	16 trap and detector nights per 50 ha of habitat	57 detector nights and 32 trap nights
Greater Broad-nosed Bat	V		4 trap nights over two consecutive nights per 100 ha Two detectors for 2 nights per 100 ha	57 detector nights and 32 trap nights.
Grey-headed Flying-fox	V	V	2 x 1 hour and 1 km up to 200 ha of stratification unit spotlighting and call playback Desktop search, daytime camp survey, surveys for vegetation communities and food plants, spotlighting	96 person hours over 8 nights spotlighting, desktop searches, diurnal searches for food plants at 60 plot locations.
<b>Frogs</b>				
Giant Burrowing Frog	V	V	September to March within one week of heavy rain. Minimum of four nights under ideal conditions. Spotlighting.	50.8 mm 1.5 weeks before with 4 nights.
Stuttering Frog (Giant Barred Frog)	E	V	September to March. Minimum of two nights under ideal weather conditions, one week after heavy rain.	50.8 mm 1.5 weeks before with 4 nights.
Littlejohns Tree Frog	V	V	Spotlighting, call detection habitat assessment. Minimum of 4 nights under ideal conditions	50.8 mm 1.5 weeks before with 4 nights.
<b>Reptiles</b>				
Broad-headed Snake	E	V	No EPBC guidelines 30 minute search on two separate days targeting specific habitat per stratification unit up to 100 ha	400 ha of potential habitat. 55 person hours far exceeds required timing.
Rosenberg's Goanna	V		30 minute search on two separate days targeting specific habitat per stratification unit up to 100 ha	400 ha of potential habitat. 55 person hours far exceeds required timing.

Notes 1. Source of guidelines: DEWHA (2010a; 2010b; 2010c) and SEWPaC (2011a; 2011b).



## Appendix C

### Vegetation data

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[illegible]















Plot

[illegible]



Plot

[illegible]



## C.1 Plot data – Flora survey

The following plot data was collected across the project area.



PlotName	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL	Easting	Northing	Zone
Zone 1 Plot 55	18	14.5	0	30	0	50	60	0	0	15	251770	6178762	56
Zone 2 Plot 56	2	23	0	40	0	20	90	2	0	20	250922	6179106	56
Zone 2 Plot 58	7	24	0	20	0	20	60	11	0	6	251291	6178890	56



## C.2 BioBanking transect data

The following table comprises the raw data plot and transect data collected in the field, and entered into the BioBanking calculator.



### C.3 Vegetation community profiles

Vegetation in the project area was compared to all plant community types (PCTs) listed on the VIS Classification Database (OEH 2016) for the Burragorang and Moss Vale IBRA subregions to determine which PCTs were present. The nine vegetation types recorded were classified into five different plant community types. These are described in the following sections.

#### a. Dry sclerophyll forests (shrub/grass sub-formation)

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Community name	Grey Gum Blue-leaved Stringybark open forest
Vegetation class (Keith 2004)	Central Gorge Dry Sclerophyll Forest
Dominant canopy species	Blue-leaved Stringybark ( <i>Eucalyptus agglomerata</i> ), Grey Gum ( <i>E. punctata</i> ), White Stringybark ( <i>E. globoidea</i> ), Silvertop Ash ( <i>E. sieberi</i> )
Dominant mid stratum species	Black She-oak ( <i>Allocasuarina littoralis</i> ), Hairpin Banksia ( <i>Banksia spinulosa</i> ), Narrow-leaved Geebung ( <i>Persoonia linearis</i> ), Sydney Golden Wattle ( <i>Acacia longifolia</i> subsp. <i>longifolia</i> )
Dominant ground stratum species	Lance Beard Heath ( <i>Leucopogon lanceolatus</i> ), Wiry Panic ( <i>Entolasia stricta</i> ), <i>Hydrocotyle peduncularis</i> , Small St John's Wort ( <i>Hypericum gramineum</i> ), Forest Goodenia ( <i>Goodenia hederacea</i> subsp. <i>hederacea</i> )

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Plant community type ID	This community aligns with PCT 838 Grey Gum – Blue-leaved Stringybark open forest on gorge slopes, southern Sydney Basin Bioregion and north east South Eastern Highlands Bioregion. A comparison against the PCT is provided below.		
	<b>Number of characteristic canopy species recorded in plots vs. PCT description</b>	<b>Number of characteristic midstorey species recorded in plots vs. PCT description</b>	<b>Number of characteristic groundcover species recorded in plots vs. PCT description</b>
	3 of 3	5 of 5	8 of 8
Biometric vegetation type (BVT) ID	This community aligns with HN531 Grey Gum – Blue-leaved Stringybark open forest on gorge slopes, southern Sydney Basin Bioregion and north east South Eastern Highlands Bioregion. A comparison against the BVT is provided below.		
	<b>Number of dominant canopy species recorded in plots vs. BVT description</b>	<b>Main associated species</b>	<b>Number of characteristic midstorey species recorded in plots vs. BVT description</b>
	2 of 2	1 of 1	5 of 5
			<b>Number of characteristic groundcover species recorded in plots vs. BVT description</b>
			8 of 8
Structure	<b>Stratum</b>	<b>Height range (m)</b>	<b>Average cover abundance of native species (%)</b>
	Trees	15 – 20	37
	Large shrubs	1 - 3	21
	Small shrubs	0.5 - 1	12
	Ground covers	0.1 – 0.5	15
Landscape position	Occurs on dry upper slopes of rocky gorges between 400 and 850 m elevation		
Percentage cleared in MCA (OEI 2012)	20%		
Condition (as defined in OEI 2014)	Moderate to good		
Conservation status	N/A		



Community name Gully Gum Scribbly Gum open woodland  
Vegetation class (Keith 2004) Central Gorge Dry Sclerophyll Forest



Dominant canopy species Gully Gum (*E. smithii*), Scribbly Gum (*E. racemosa*)  
Dominant mid stratum species Hairpin Banksia, Broad-leaved Hakea (*Hakea dactyloides*)  
Dominant ground stratum species Bracken, Spiny-headed Mat Rush (*Lomandra longifolia*), Forest Goodenia, Weeping Meadow Grass  
Plant community type ID This community shares some affinities with PCT 1093 Red Stringybark – Brittle Gum – Inland Scribbly Gum dry open forest of the tableland, South Eastern Highlands Bioregion, however is not a good match. The PCT type has a confidence level of 5 (very low) on the VIS Classification Database (OEH 2016), and therefore has not been well defined by surveys that inform the database. A comparison with the PCT is provided below.

Number of characteristic canopy species recorded in plots vs. PCT description	Number of characteristic midstorey species recorded in plots vs. PCT description	Number of characteristic groundcover species recorded in plots vs. PCT description
2 of 5	2 of 3	3 of 5



Biometric vegetation type ID	PCT 1093 is linked with HN 570 Red Stringybark – Brittle Gum – Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands. However, the community observed in the terrestrial study area only shares some affinities with that BVT, as described above.			
	Number of dominant canopy species recorded in plots vs. BVT description	Main associated species	Number of characteristic midstorey species recorded in plots vs. BVT description	Number of characteristic groundcover species recorded in plots vs. BVT description
	1 of 3	1 of 2	2 of 3	3 of 7
Structure	Stratum	Height range (m)		Average cover abundance of native species (%)
	Trees	25 - 35		25
	Large shrubs	2 - 4		7
	Small shrubs	0.5 - 2		11
	Ground covers	0.1 – 0.5		5
Landscape position	Rocky outcrops above creeks at approximately 550 m elevation			
Percentage cleared in MCA (OEH 2012)	55%			
BBAM condition class	Moderate to good			
Conservation status	N/A			



Community name Brittle Gum Scribbly Gum Shrubby Woodland

Vegetation class Southern Tableland Dry Sclerophyll Forest  
(Keith 2004)



Dominant canopy species Brittle Gum (*Eucalyptus mannifera* subsp. *gullickii*), Narrow-leaved Scribbly Gum (*E. racemosa*), Broad-leaved Peppermint (*E. dives*)

Mid stratum species Hairpin Banksia, Broad-leaved Hakea, Tantoon (*Leptospermum polygafolium* subsp. *polygafolium*), *Leptospermum trinervium*, *Bossiaea rhombifolia* subsp. *rhombifolia*

Ground stratum species Shrubby Platysace (*Platysace lanceolata*), Forest Goodenia, *Dampiera purpurea*, Silky Purple Flag (*Patersonia sericea*), Spiny-headed Mat Rush

Plant community type ID This community shares some affinities with PCT 1093 Red Stringybark – Brittle Gum – Inland Scribbly Gum dry open forest of the tableland, South Eastern Highlands Bioregion, however is not a good match. The PCT type has a confidence level of 5 (very low) on the VIS Classification Database (OEH 2016), therefore has not been well defined by surveys that inform the database. A comparison with the PCT is provided below.

Number of characteristic canopy species recorded in plots vs. PCT description	Number of characteristic midstorey species recorded in plots vs. PCT description	Number of characteristic groundcover species recorded in plots vs. PCT description
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2 of 5

1 of 3

2 of 5

Biometric vegetation type ID PCT 1093 is linked with HN 570 Red Stringybark – Brittle Gum – Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands. The community only shares some affinities with the BVT, as discussed above.

Number of dominant canopy species recorded in plots vs. BVT description	Main associated species	Number of characteristic midstorey species recorded in plots vs. BVT description	Number of characteristic groundcover species recorded in plots vs. BVT description
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1 of 3

1 of 2

1 of 3

3 of 7



Structure	Stratum	Height range (m)	Average cover abundance of native species (%)
	Trees	15 - 20	21
	Large shrubs	2 - 4	12
	Small shrubs	0.5 - 2	19
	Ground covers	0.1 – 0.5	4
Landscape position	Sandy loams on elevated sandstone plateaux from 600 to 1,050 m elevation		
Percentage cleared in MCA (OEI 2012)	55%		
Condition (as per OEI 2014)	Moderate to good		
Conservation status	N/A		

**b. Wet sclerophyll forest (shrubby sub-formation)**

Community name	River Peppermint Narrow-leaved Peppermint tall open forest
Vegetation class (Keith 2004)	Southern Escarpment Wet Sclerophyll Forest



Dominant canopy species	All stands are dominated by River Peppermint ( <i>E. elata</i> ) and either Brown Barrel ( <i>E. fastigata</i> ) or Narrow-leaved Peppermint
Dominant mid stratum species	River Lomatia ( <i>Lomatia myricoides</i> ), Dolly Bush ( <i>Cassinia aculeata</i> ), Lance Beard Heath ( <i>Leucopogon lanceolatus</i> ), <i>Notelaea longifolia</i> f. <i>longifolia</i>
Dominant ground stratum species	Weeping Meadow Grass ( <i>Microlaena stipoides</i> var. <i>stipoides</i> ), <i>Hydrocotyle peduncularis</i> , Spiny-headed Mat Rush ( <i>Lomandra longifolia</i> ), Bracken ( <i>Pteridium esculentum</i> )



Plant community type ID	This community aligns with PCT 1107 River Peppermint – Narrow-leaved Peppermint open forest on sheltered escarpment slopes, Sydney Basin Bioregion and South East Corner Bioregion. A comparison against the PCT is provided below.		
	<b>Number of characteristic canopy species recorded in plots vs. PCT description</b>	<b>Number of characteristic midstorey species recorded in plots vs. PCT description</b>	<b>Number of characteristic groundcover species recorded in plots vs. PCT description</b>
	4 of 6	3 of 3	10 of 13
Biometric vegetation type ID	This community aligns with HN 575 River Peppermint – Narrow-leaved Peppermint open forest on sheltered escarpment slopes, Sydney Basin Bioregion and South East Corner Bioregion. A comparison against the BVT is provided below.		
	<b>Number of dominant canopy species recorded in plots vs. BVT description</b>	<b>Main associated species</b>	<b>Number of characteristic midstorey species recorded in plots vs. BVT description</b>
	3 of 3	1 of 3	10 of 13
Structure	<b>Stratum</b>	<b>Height range (m)</b>	<b>Average cover abundance of native species (%)</b>
	Trees	25 - 40	20
	Large shrubs	2 - 5	9
	Small shrubs	0.5 - 3	20
	Ground covers	0.1 – 0.5	17
Landscape position	Occurs on sheltered slopes on high ranges of the escarpment, mainly between 600 and 1,100 m elevation		
Percentage cleared in MCA	10%		
Condition (as per OEH 2014)	Moderate to good		
Conservation status	N/A		



c. Grassy woodlands

Community name	Gully Gum Narrow-leaved Peppermint open woodland
Vegetation class (Keith 2004)	Southern Tablelands Grassy Woodland



Dominant canopy species	Narrow-leaved Peppermint ( <i>Eucalyptus radiata</i> ), Gully Gum ( <i>E. smithii</i> )
Mid stratum species	Spearthistle ( <i>Cirsium vulgare</i> *), Prickly Sowthistle ( <i>Sonchus asper</i> *)
Ground stratum species	<i>Austrostipa rudis</i> subsp. <i>nervosa</i> , Wallaby Grass ( <i>Rhytidosperma fulvum</i> ), Kangaroo Grass ( <i>Themeda australis</i> ), <i>Cyperus sphaerioideus</i> , Swamp Dock ( <i>Rumex brownii</i> ), Sand Couch ( <i>Cynodon dactylon</i> ), Weeping Meadow Grass, Canary Grass ( <i>Phalaris aquatica</i> *), Goose Grass ( <i>Eleusine tristachya</i> *), Wimmera Ryegrass ( <i>Lolium rigidum</i> *), Cocksfoot ( <i>Dactylis glomerata</i> *), Capeweed ( <i>Arctotheca calendula</i> *), Catsear ( <i>Hypochaeris radicata</i> *), Chilean Whitlow Wort ( <i>Paronychia brasiliiana</i> *), White Clover ( <i>Trifolium repens</i> *), Subterranean Clover ( <i>Trifolium subterraneanum</i> *), Plantain ( <i>Plantago lanceolata</i> *), Prairie Grass ( <i>Bromus cartharticus</i> *), Blackberry ( <i>Rubus fruticosus</i> spp. agg)
Plant community type ID	This community shares some affinities with PCT 731 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion. However, the community has been highly modified within the project area and does not correlate well with the PCT. It is likely that Gully Gum Narrow-leaved Peppermint Open Woodland is a lower condition version of Broad-leaved Peppermint Argyle Apple grassy woodland, described later in this report. A comparison against the PCT is provided below.

Number of characteristic canopy species recorded in plots vs. PCT description	Number of characteristic midstorey species recorded in plots vs. PCT description	Number of characteristic groundcover species recorded in plots vs. PCT description
0 of 6	0 of 1	2 of 9



Biometric vegetation type ID	The community shares some affinities with HN514 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands. However, the community has been highly modified within the project area and does not correlate well with the BVT. It is likely that Gully Gum Narrow-leaved Peppermint Open Woodland is a lower condition version of Broad-leaved Peppermint Argyle Apple grassy woodland, described later in this report. A comparison against the BVT is provided below.			
	Number of dominant canopy species recorded in plots vs. BVT description	Main associated species	Number of characteristic midstorey species recorded in plots vs. BVT description	Number of characteristic groundcover species recorded in plots vs. BVT description
	0 of 2	0 of 4	0 of 1	2 of 9
Structure	Stratum	Height range (m)	Average cover abundance of native species (%)	
	Trees	15 - 40	19	
	Large shrubs	-	-	
	Small shrubs	-	-	
	Ground covers	0.1 – 0. 4	4	
Landscape position	Undulating land between 600 and 650 m elevation			
Percentage cleared in MCA	80%			
Condition (as per OEH 2014)	Low			
Conservation status	It is acknowledged that PCT 731 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion is linked with the Southern Highlands Shale Woodland in the Sydney Basin Bioregion endangered ecological community (EEC). However, Gully Gum Narrow-leaved Peppermint Open Woodland does not represent the listed community as it lacks a native shrub and groundcover. Further discussion is provided in Section 3.3.7.			



Community name	Broad-leaved Peppermint Argyle Apple grassy woodland
Vegetation class (Keith 2004)	Southern Tablelands Grassy Woodland



Dominant canopy species Argyle Apple (*E. cinerea*), Broad-leaved Peppermint, Brittle Gum, Scribbly Gum, Narrow-leaved Peppermint, Candlebark (*E. rubida*)

Mid stratum species Dolly Bush, *Daviesia latifolia*

Ground stratum species Weeping Meadow Grass, Snowgrass (*Poa sieberiana* var. *cyanophylla*), Kangaroo Grass (*Themeda australis*), Bluebottle Daisy (*Lagenophora stipitata*), Small St John's Wort, Forest Goodenia, *Lomandra filiformis* subsp. *coriacea*

Plant community type ID This community aligns with PCT 731 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion. A comparison against the PCT is provided below.

Number of characteristic canopy species recorded in plots vs. PCT description	Number of characteristic midstorey species recorded in plots vs. PCT description	Number of characteristic groundcover species recorded in plots vs. PCT description
3 of 6	0 of 1	7 of 9

Biometric vegetation type ID The community also aligns with HN514 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands, containing many of the required groundcover species. A comparison against the BVT is provided below.

Number of dominant canopy species recorded in plots vs. BVT description	Main associated species	Number of characteristic midstorey species recorded in plots vs. BVT description	Number of characteristic groundcover species recorded in plots vs. BVT description
1 of 2	2 of 4	0 of 1	7 of 9

Structure	Stratum	Height range (m)	Average cover abundance of native species (%)
	Trees	15 – 20	17
	Large shrubs	-	-
	Small shrubs	0.5 - 1	1
	Ground covers	0.1 – 0.6	30

Landscape position	Undulating hills between 550 and 1100 m
Percentage cleared in MCA (OEH 2012)	80%
Condition (as per OEH 2012)	Moderate to good
Conservation status	This community is a component of the Southern Highlands Shale Woodland in the Sydney Basin Bioregion EEC. Further discussion on this EEC is provided in Section 4.3.

Community name	Snow Gum Black Sallee grassy woodland
Vegetation class (Keith 2004)	Subalpine Woodland



Dominant species	canopy	Paddys River Box ( <i>Eucalyptus macarthurii</i> ), Snow Gum, Black Sallee ( <i>E. stellulata</i> ), White Stringybark
Mid species	stratum	Glossy Nightshade ( <i>Solanum americanum</i> )
Ground species	stratum	Paddock Lovegrass ( <i>Eragrostis leptostachya</i> ), Weeping Meadow Grass, <i>Rytidosperma racemosum</i> var. <i>racemosum</i> , Kangaroo Grass ( <i>Themeda australis</i> ), Spiny-headed Mat Rush, <i>Oxalis</i> spp.



Plant community type ID	This community shares some affinities with PCT 677 Black Gum Grassy Woodland of damp flats and drainage lines of the Southern Highlands. However, it is in a highly disturbed state, and therefore only broadly conforms to this PCT. A comparison against the PCT is provided below.		
	<b>Number of characteristic canopy species recorded in plots vs. PCT description</b>	<b>Number of characteristic midstorey species recorded in plots vs. PCT description</b>	<b>Number of characteristic groundcover species recorded in plots vs. PCT description</b>
	2 of 3	0 of 6	6 of 31
Biometric vegetation type ID	The community aligns with HN504 Black Gum grassy woodland of damp flats and drainage lines of the eastern Southern Tablelands, South-eastern Highlands Bioregion. A comparison against the BVT is provided below.		
	<b>Number of dominant canopy species recorded in plots vs. BVT description</b>	<b>Main associated species</b>	<b>Number of characteristic midstorey species recorded in plots vs. BVT description</b>
	1 of 2	2 of 4	0 of 1
			<b>Number of characteristic groundcover species recorded in plots vs. BVT description</b>
			7 of 9
Structure	<b>Stratum</b>	<b>Height range (m)</b>	<b>Average cover abundance (%)</b>
	Trees	15 – 20	16
	Large shrubs	-	-
	Small shrubs	0.5 - 1	2
	Ground covers	0.1 – 0.6	5
Landscape position	Drainage lines and associated flats		
Percentage cleared in MCA (OEH 2012)	80%		
Condition (as per OEH 2014)	Low		
Conservation status	This community is a component of the TSC Act-listed Tableland Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions EEC. Further discussion on this EEC is provided in Section 4.3.		

Community name	Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland
Vegetation class	Southern Tablelands Grassy Woodland
(Keith 2004)	



Dominant canopy species	Broad-leaved Peppermint ( <i>Eucalyptus dives</i> ), Narrow-leaved Peppermint ( <i>E. radiata</i> ),
Mid stratum species	None
Ground stratum species	Kikuyu ( <i>Pennisetum clandestinum</i> *), Finger Grass ( <i>Dactyloctenium radulans</i> ), Cocksfoot ( <i>Dactylis glomerata</i> *) and Lambs Tongues ( <i>Plantago lanceolata</i> *).
Plant community type ID	This community aligns with PCT 731 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion. A comparison against the PCT is provided below.

Number of characteristic canopy species recorded in plots vs. PCT description	Number of characteristic midstorey species recorded in plots vs. PCT description	Number of characteristic groundcover species recorded in plots vs. PCT description
1 of 6	0 of 1	0 of 9

Biometric vegetation type ID	The community also aligns with HN514 Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands, containing many of the required groundcover species. A comparison against the BVT is provided below.
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Number of dominant canopy species recorded in plots vs. BVT description	Main associated species	Number of characteristic midstorey species recorded in plots vs. BVT description	Number of characteristic groundcover species recorded in plots vs. BVT description
1 of 2	0 of 4	0 of 1	0 of 9



Structure	Stratum	Height range (m)	Average cover abundance of native species (%)
	Trees	15 – 20	17
	Large shrubs	-	-
	Small shrubs	0.5 - 1	1
	Ground covers	0.1 – 0.6	30
Landscape position	Undulating hills between 550 and 1100 m		
Percentage cleared in MCA (OEH 2012)	80%		
Condition (as per OEH 2012)	Low		
Conservation status	N/A		

#### d. Exotic vegetation types

Community name	Pine Forest
Vegetation class (Keith 2004)	N/A



Dominant canopy species	Radiata Pine ( <i>Pinus radiata</i> ), Maritime Pine ( <i>P. pinaster</i> )		
Mid stratum species	-		
Ground stratum species	-		
Plant community type ID	N/A		
Biometric vegetation type ID	N/A		
Structure	<b>Stratum</b>	<b>Height range (m)</b>	<b>Average cover abundance (%)</b>
	Trees	15 - 20	75
Landscape position	Flats and small rises		
Percentage cleared in MCA (OEH 2012)	N/A		
Condition (as per OEH 2014)	Cleared land		
Conservation status	N/A		

<b>Community name</b>	<b>Cleared</b>
Vegetation class (Keith 2004)	N/A





Dominant canopy species	N/A		
Mid stratum species	N/A		
Ground stratum species	Catsear ( <i>Hypochaeris radicata</i> ), Subterranean Clover ( <i>Trifolium subterraneanum</i> ), Paspalum ( <i>Paspalum dilatatum</i> ), Couch ( <i>Cynodon dactylon</i> ), Kentucky Bluegrass ( <i>Poa pratensis</i> ), Perennial Ryegrass ( <i>Lolium perenne</i> ), Hairy Hawkbit ( <i>Leontodon taraxacoides</i> )		
Plant community type ID	N/A		
Biometric vegetation type ID	N/A		
Structure	<b>Stratum</b>	<b>Height range (m)</b>	<b>Average cover abundance of exotic species (%)</b>
	Exotic ground covers	0.1 – 0.4	33
Landscape position	Flats and undulating land		
Percentage cleared in MCA (OEH 2012)	N/A		
Condition (as per OEH 2014)	Cleared land		
Conservation status	N/A		





## Appendix D

### Fauna species list

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Count	CLASS	Family	Scientific Name	Common Name	TSC Act conservation status	EPBC Act conservation status
<b>Fish</b>						
1	Actinopterygii	Galaxiidae	<i>Galaxias olidus</i>	mountain galaxias		
2	Actinopterygii	Poeciliidae	<i>Gambusia holbrooki</i> *	Gambusia		
<b>Frogs</b>						
	Anura	Hylidae	<i>Litoria dentata</i>	Bleating Tree Frog		
4	Anura	Hylidae	<i>Litoria peronii</i>	Peron's Tree Frog		
5	Anura	Hylidae	<i>Litoria verreauxii</i>	Verreaux's Tree Frog		
6	Anura	Myobatrachidae	<i>Crinia signifera</i>	Common Eastern Froglet		
7	Anura	Myobatrachidae	<i>Limnodynastes dumerilii</i>	Pobblebonk		
	Anura	Myobatrachidae	<i>Limnodynastes peronii</i>	Striped Marsh Frog		
8	Anura	Myobatrachidae	<i>Limnodynastes tasmaniensis</i>	Spotted Grass Frog		
9	Anura	Myobatrachidae	<i>Paracrina haswellii</i>	Red-groined Froglet		
10	Anura	Myobatrachidae	<i>Pseudophryne bibronii</i>	Brown Toadlet		
11	Anura	Myobatrachidae	<i>Uperoleia laevisgata</i>	Smooth Toadlet		
12	Anura	Myobatrachidae	<i>Uperoleia rugosa</i>	Wrinkled Toadlet		
<b>Reptiles</b>						
12	Reptilia	Scincidae	<i>Bassiana platynota</i>	Red-throated Skink		
13	Reptilia	Scincidae	<i>Cryptoblepharus virgatus</i>	Wall Skink		
14	Reptilia	Scincidae	<i>Ctenotus taeniolatus</i>	Copper-tailed Skink		
15	Reptilia	Scincidae	<i>Lampropholis delicata</i>	Grass Skink		
16	Reptilia	Scincidae	<i>Lampropholis guichenoti</i>	Garden Skink		
17	Reptilia	Scincidae	<i>Saproscincus mustelina</i>	Weasel Skink		
	Reptilia	Scincidae	<i>Eulamprus quoyii</i>	Eastern Water Skink		
18	Reptilia	Agamidae	<i>Physignathus lesueurii</i>	Eastern Water Dragon		
19	Reptilia	Gekkonidae	<i>Oedura lesueurii</i>	Lesueur's Velvet Gecko		
20	Reptilia	Varanidae	<i>Varanus varius</i>	Lace Monitor		
21	Reptilia	Cheloniidae	<i>Chelodina longicollis</i>	Eastern Long-necked Tortoise		
<b>Mammals</b>						
22	Mammalia	Tachyglissidae	<i>Tachyglossus aculeatus</i>	Short-beaked Echidna		
24	Mammalia	Dasyuridae	<i>Antechinus stuartii</i>	Brown Antechinus		
25	Mammalia	Phascolatidae	<i>Phascogaleos cinereus</i>	Koala	V	V
26	Mammalia	Vombatidae	<i>Vombatus ursinus</i>	Common Wombat		
27	Mammalia	Pseudocheiridae	<i>Pseudocheirus peregrinus</i>	Common Ringtail Possum		
28	Mammalia	Phalangeridae	<i>Trichosurus vulpecula</i>	Common Brushtail Possum		
29	Mammalia	Acrobatidae	<i>Acrobates pygmaeus</i>	Feathertail Glider		
30	Mammalia	Petauridae	<i>Petaurides volans</i>	Greater Glider		
31	Mammalia	Petauridae	<i>Petaurus breviceps</i>	Sugar Glider		
32	Mammalia	Macropodidae	<i>Macropus giganteus</i>	Eastern Grey Kangaroo		
33	Mammalia	Macropodidae	<i>Macropus robustus</i>	Common Wallaroo		
34	Mammalia	Macropodidae	<i>Macropus rufogriseus</i>	Red-necked Wallaby		
35	Mammalia	Macropodidae	<i>Wallabia bicolor</i>	Swamp Wallaby		
36	Mammalia	Muridae	<i>Hydromys chrysogaster</i>	Water Rat		
37	Mammalia	Muridae	<i>Rattus rattus</i> *	Black Rat		
38	Mammalia	Muridae	<i>Rattus fuscipes</i>	Bush Rat		
39	Mammalia	Molossidae	<i>Tadarida australis</i>	White-striped Freetail Bat		
40	Mammalia	Vespertilionidae	<i>Chalinolobus morio</i>	Chocolate Wattled Bat		
41	Mammalia	Vespertilionidae	<i>Vespertilio regulus</i>	Southern Forest Bat		
42	Mammalia	Vespertilionidae	<i>Vespertilio vultur</i>	Little Forest Bat		
43	Mammalia	Vespertilionidae	<i>Myotis macropus</i>	Southern Myotis	V	
44	Mammalia	Vespertilionidae	<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V	
45	Mammalia	Vespertilionidae	<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat		
46	Mammalia	Vespertilionidae	<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat		
	Mammalia	Vespertilionidae	<i>Vespertilio darlingtoni</i>	Large Forest Bat		
	Mammalia	Vespertilionidae	<i>Vespertilio vultur</i>	Little Forest Bat		
	Mammalia	Miniopteridae	<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing Bat	V	
	Mammalia	Miniopteridae	<i>Miniopterus australis</i>	Little Bentwing Bat	V	
	Mammalia	Vespertilionidae	<i>Chalinolobus gouldi</i>	Gould's Wattled Bat		
	Mammalia	Vespertilionidae	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V
	Mammalia	Rhinophoridae	<i>Rhinolophus megaphyllus</i>	Eastern Horseshoe Bat		
	Mammalia	Molossidae	<i>Mormopterus ozimops ridei</i>			
48	Mammalia	Canidae	<i>Canis familiaris</i>	Dingo and Dog (feral)		
49	Mammalia	Canidae	<i>Vulpes vulpes</i> *	Fox		
50	Mammalia	Felidae	<i>Felis catus</i> *	Cat (feral)		
51	Mammalia	Cervidae	<i>Dama dama</i> *	Fallow Deer		
52	Mammalia	Cervidae	<i>Cervus elaphus</i> *	Red Deer		
53	Mammalia	Equidae	<i>Equus caballus</i> *	Horse		
54	Mammalia	Leporidae	<i>Oryctolagus cuniculus</i> *	Rabbit		
55	Mammalia	Leporidae	<i>Lepus europeaus</i> *	Brown Hare		
<b>Birds</b>						
56	Aves	CASUARIIDAE	<i>Dromaius novaehollandiae</i>	Emu		
57	Aves	ANATIDAE	<i>Chenonetta jubata</i>	Australian Wood Duck		
58	Aves	ANATIDAE	<i>Anas superciliosa</i>	Pacific Black Duck		
59	Aves	ANATIDAE	<i>Anas gracilis</i>	Grey Teal		
60	Aves	ANATIDAE	<i>Anas castanea</i>	Chestnut Teal		
61	Aves	ANATIDAE	<i>Aythya australis</i>	Hardhead		
	Aves	ARDEIDAE	<i>Nycticorax caledonicus</i>	Nankeen Night Heron		
62	Aves	PODICIPEDIDAE	<i>Tachybaptus novaehollandiae</i>	Australasian Grebe		
63	Aves	PODICIPEDIDAE	<i>Polioccephalus poliocephalus</i>	Hoary-headed Grebe		
64	Aves	PHALACROCORACIDAE	<i>Phalacrocorax melanoleucos</i>	Little Pied Cormorant		
65	Aves	PHALACROCORACIDAE	<i>Phalacrocorax varius</i>	Pied Cormorant		
	Aves	PHALACROCORACIDAE	<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant		
66	Aves	ARDEIDAE	<i>Egretta novaehollandiae</i>	White-faced Heron		
67	Aves	ARDEIDAE	<i>Ardea pacifica</i>	White-necked Heron		
68	Aves	ACCIPITRIDAE	<i>Aquila audax</i>	Wedge-tailed Eagle		
	Aves	ACCIPITRIDAE	<i>Circus assimilis</i>	Spotted Harrier	V	
69	Aves	ACCIPITRIDAE	<i>Hieraaetus morphnoides</i>	Little Eagle	V	
	Aves	ACCIPITRIDAE	<i>Haliaeetus sphenurus</i>	Whistling Kite		
	Aves	ACCIPITRIDAE	<i>Haliaeetus leucogaster</i>	White-bellied Sea Eagle		
	Aves	ESTRILDIDAE	<i>Stagnopleura guttata</i>	Diamond Firetail		
70	Aves	FALCONIDAE	<i>Falco peregrinus</i>	Peregrine Falcon		
71	Aves	FALCONIDAE	<i>Falco berigora</i>	Brown Falcon		
72	Aves	FALCONIDAE	<i>Falco longipennis</i>	Australian Hobby		
73	Aves	FALCONIDAE	<i>Falco cenchroides</i>	Nankeen Kestrel		
74	Aves	RALLIDAE	<i>Fulica atra</i>	Eurasian Coot		
75	Aves	CHARADRIIDAE	<i>Elsetornis melanops</i>	Black-fronted Dotterel		
76	Aves	CHARADRIIDAE	<i>Vanellus miles</i>	Masked Lapwing		
	Aves	COLUMBIDAE	<i>Columba leucomela</i>	White-headed Pigeon		
77	Aves	COLUMBIDAE	<i>Ocyphaps lophotes</i>	Crested Pigeon		
78	Aves	COLUMBIDAE	<i>Geopelia striata</i>	Peaceful Dove		
79	Aves	COLUMBIDAE	<i>Leucosarcia melanoleuca</i>	Wonga Pigeon		
80	Aves	COLUMBIDAE	<i>Phaps chalcopter</i>	Common Bronzewing Pigeon		
	Aves	COLUMBIDAE	<i>Macropygia amboinensis</i>	Brown Cuckoo-dove		
		CORACIIDAE	<i>Eurystomus orientalis</i>	Dollarbird		

Count	CLASS	Family	Scientific Name	Common Name	TSC Act conservation status	EPBC Act conservation status
81	Aves	CACATUIDAE	<i>Calyptrorhynchus lathamii</i>	Glossy Black-cockatoo	V	
82	Aves	CACATUIDAE	<i>Calyptrorhynchus funereus</i>	Yellow-tailed Black-cockatoo		
83	Aves	CACATUIDAE	<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo	V	
84	Aves	CACATUIDAE	<i>Cacatua roseicapilla</i>	Galah		
85	Aves	CACATUIDAE	<i>Cacatua sanguinea</i>	Little Corella		
86	Aves	CACATUIDAE	<i>Cacatua galerita</i>	Sulphur-crested Cockatoo		
	Aves	FRINGILLIDAE	<i>Carduelis carduelis</i> *	European Goldfinch		
87	Aves	PSITTACIDAE	<i>Glossopsitta pusilla</i>	Little Lorikeet	V	
88	Aves	PSITTACIDAE	<i>Alisterus scapularis</i>	Australian King-Parrot		
89	Aves	PSITTACIDAE	<i>Platycercus elegans</i>	Crimson Rosella		
90	Aves	PSITTACIDAE	<i>Platycercus eximius</i>	Eastern Rosella		
91	Aves	PSITTACIDAE	<i>Psephotus haematonotus</i>	Red-rumped Parrot		
92	Aves	CUCULIDAE	<i>Cuculus pallidus</i>	Pallid Cuckoo		
93	Aves	CUCULIDAE	<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo		
94	Aves	CUCULIDAE	<i>Chrysococcyx basalis</i>	Horsfield's Bronze-Cuckoo		
95	Aves	CUCULIDAE	<i>Eudynamis scolopacea</i>	Common Koel		
96	Aves	CUCULIDAE	<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo		
97	Aves	STRIGIDAE	<i>Ninox strenua</i>	Powerful Owl	V	
98	Aves	STRIGIDAE	<i>Ninox novaeseelandiae</i>	Southern Boobook Owl		
99	Aves	PODARGIDAE	<i>Podargus strigoides</i>	Tawny Frogmouth		
100	Aves	AEGOTHELIDAE	<i>Aegothales cristatus</i>	Australian Owlet-nightjar		
101	Aves	HALCYONIDAE	<i>Dacelo novaeguineae</i>	Laughing Kookaburra		
	Aves	HALCYONIDAE	<i>Todiramphus macleayii</i>	Forest Kingfisher		
102	Aves	HALCYONIDAE	<i>Todiramphus sanctus</i>	Sacred Kingfisher		
103	Aves	MENURIDAE	<i>Menura novaehollandiae</i>	Superb Lyrebird		
104	Aves	CLIMACTERIDAE	<i>Cormobates leucophaeus</i>	White-throated Treecreeper		
105	Aves	MALURIDAE	<i>Malurus cyaneus</i>	Superb Fairy-wren		
106	Aves	MALURIDAE	<i>Malurus lamberti</i>	Variegated Fairy-wren		
	Aves	MOTACILLIDAE	<i>Anthus novaeseelandiae</i>	Australasian Pipit		
	Aves	MELIPHAGIDAE	<i>Manorina melanophrys</i>	Bell Miner		
107	Aves	PARDALOTIDAE	<i>Pardalotus punctatus</i>	Spotted Pardalote		
108	Aves	PARDALOTIDAE	<i>Pardalotus striatus</i>	Striated Pardalote		
109	Aves	PARDALOTIDAE	<i>Origma solitaria</i>	Rockwarbler		
110	Aves	PARDALOTIDAE	<i>Sericornis frontalis</i>	White-browed Scrubwren		
111	Aves	PARDALOTIDAE	<i>Smicromis brevirostris</i>	Weebill		
112	Aves	PARDALOTIDAE	<i>Gerygone olivacea</i>	White-throated Gerygone		
113	Aves	PARDALOTIDAE	<i>Acanthiza pusilla</i>	Brown Thornbill		
114	Aves	PARDALOTIDAE	<i>Acanthiza reguloides</i>	Buff-rumped Thornbill		
115	Aves	PARDALOTIDAE	<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill		
116	Aves	PARDALOTIDAE	<i>Acanthiza nana</i>	Yellow Thornbill		
117	Aves	PARDALOTIDAE	<i>Acanthiza lineata</i>	Striated Thornbill		
118	Aves	MELIPHAGIDAE	<i>Anthochaera camunculata</i>	Red Wattlebird		
119	Aves	MELIPHAGIDAE	<i>Anthochaera chrysoptera</i>	Little Wattlebird		
120	Aves	MELIPHAGIDAE	<i>Philemon corniculatus</i>	Noisy Friarbird		
121	Aves	MELIPHAGIDAE	<i>Manorina melanocephala</i>	Noisy Miner		
122	Aves	MELIPHAGIDAE	<i>Meliphaga lewinii</i>	Lewin's Honeyeater		
123	Aves	MELIPHAGIDAE	<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater		
124	Aves	MELIPHAGIDAE	<i>Lichenostomus leucotis</i>	White-eared Honeyeater		
125	Aves	MELIPHAGIDAE	<i>Lichenostomus fuscus</i>	Fuscous Honeyeater		
126	Aves	MELIPHAGIDAE	<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater		
127	Aves	MELIPHAGIDAE	<i>Melithreptus lunatus</i>	White-naped Honeyeater		
128	Aves	MELIPHAGIDAE	<i>Lichmera indistincta</i>	Brown Honeyeater		
129	Aves	MELIPHAGIDAE	<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill		
130	Aves	PETROICIDAE	<i>Microeca fascians</i>	Jacky Winter		
131	Aves	PETROICIDAE	<i>Petroica boodang</i>	Scarlet Robin	V	
132	Aves	PETROICIDAE	<i>Petroica rosea</i>	Rose Robin		
133	Aves	PETROICIDAE	<i>Eopsaltria australis</i>	Eastern Yellow Robin		
135	Aves	CINCLOSOMATIDAE	<i>Psophodes olivaceus</i>	Eastern Whipbird		
136	Aves	CINCLOSOMATIDAE	<i>Cinclosoma punctatum</i>	Spotted Quail-thrush		
137	Aves	NEOSITTIDAE	<i>Daphoenositta chrysoptera</i>	Varied Sittella	V	
	Aves	OXYURINAE	<i>Biziura lobata</i>	Musk Duck		
138	Aves	PACHYCEPHALIDAE	<i>Falcunculus frontatus</i>	Crested Shrike-tit		
139	Aves	PACHYCEPHALIDAE	<i>Pachycephala pectoralis</i>	Golden Whistler		
140	Aves	PACHYCEPHALIDAE	<i>Pachycephala rufiventris</i>	Rufous Whistler		
141	Aves	PACHYCEPHALIDAE	<i>Colluricincla harmonica</i>	Grey Shrike-thrush		
142	Aves	DICRURIDAE	<i>Myiagra rubecula</i>	Leaden Flycatcher		
143	Aves	DICRURIDAE	<i>Myiagra inquieta</i>	Restless Flycatcher		
144	Aves	DICRURIDAE	<i>Grallina cyanoleuca</i>	Magpie-lark		
145	Aves	DICRURIDAE	<i>Rhipidura fuliginosa</i>	Grey Fantail		
146	Aves	DICRURIDAE	<i>Rhipidura leucophrys</i>	Willie Wagtail		
	Aves	DICRURIDAE	<i>Dicrurus bracteatus</i>	Spangled Drongo		
147	Aves	CAMPEPHAGIDAE	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike		
148	Aves	CAMPEPHAGIDAE	<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike		
149	Aves	CAMPEPHAGIDAE	<i>Coracina tenuirostris</i>	Cicadabird		
	Aves	ARTAMIDAE	<i>Artamus personatus</i>	Masked Woodswallow		
150	Aves	ARTAMIDAE	<i>Cracticus torquatus</i>	Grey Butcherbird		
151	Aves	ARTAMIDAE	<i>Gymnorhina tibicen</i>	Australian Magpie		
152	Aves	ARTAMIDAE	<i>Strepera graculina</i>	Pied Currawong		
153	Aves	ARTAMIDAE	<i>Strepera versicolor</i>	Grey Currawong		
154	Aves	CORVIDAE	<i>Corvus coronoides</i>	Australian Raven		
155	Aves	CORVIDAE	<i>Corvus mellori</i>	Little Raven		
156	Aves	CORCORACIDAE	<i>Corcorax melanorhamphos</i>	White-winged Chough		
157	Aves	PTILONORHYNCHIDAE	<i>Ptilonorhynchus violaceus</i>	Satin Bowerbird		
158	Aves	PASSERIDAE	<i>Neochmia temporalis</i>	Red-browed Finch		
159	Aves	DICAEDAE	<i>Dicaeum hirundinaceum</i>	Mistletoebird		
160	Aves	HIRUNDINIDAE	<i>Hirundo neoxena</i>	Welcome Swallow		
161	Aves	HIRUNDINIDAE	<i>Hirundo nigricans</i>	Tree Martin		
162	Aves	HIRUNDINIDAE	<i>Hirundo ariel</i>	Fairy Martin		
	Aves	RALIDAE	<i>Porphyrio porphyrio</i>	Purple Swamphen		
163	Aves	SYLVIIDAE	<i>Acrocephalus australis</i>	Australian Reedwarbler		
164	Aves	SYLVIIDAE	<i>Cincloramphus cruralis</i>	Brown Songlark		
165	Aves	ZOSTEROPIDAE	<i>Zosterops lateralis</i>	Silvereye		
166	Aves	MUSCICAPIDAE	<i>Zoothera lunulata</i>	Bassian Thrush		
167	Aves	MUSCICAPIDAE	<i>Turdus merula</i> *	Common Blackbird		
168	Aves	STURNIDAE	<i>Sturnus vulgaris</i> *	Common Starling		
169	Aves	STURNIDAE	<i>Acridotheres tristis</i> *	Common Myna		
170	Aves	TYTONIDAE	<i>Tyto novaehollandiae</i>	Masked Owl	V	



## Appendix E

### Likelihood of occurrence for threatened species

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## E.1 Threatened species habitat assessment

The likelihood of occurrence for each threatened species previously recorded or predicted to occur within a 20 km radius of the project area, by the sources listed in Section 2.3, was assessed against the criteria in Table E.1 which were developed by EMM. The results are provided in Table E.2.

**Table E.1**      **Assessment criteria**

Likelihood	Description	Further assessment required?
Recorded	The species was observed in the study areas during the current survey.	Yes
High	It is highly likely that the species inhabits the study area due to the presence of suitable habitat, and the fact that it has been recorded recently in the study areas.	Yes
Moderate	Potential habitat is present in the study areas, although the species has not been recorded recently in the study area or its surrounds. The species is unlikely to be dependent (ie for breeding) on habitat within the study areas.	Yes
Low	It is unlikely that the species inhabits the study areas, though it may be an occasional visitor. Habitat similar to the study areas is widely distributed in the local area, meaning that the species is not dependent (ie for breeding) on that contained within the study areas.	No
None	Suitable habitat is absent from the study areas.	No

**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Flora							
<i>Asterolasia elegans</i>	SPRAT	E	E	Not known from the terrestrial study area or surrounds. Occurs north of Sydney in the Baulkham Hills, Hawkesbury and Hornsby local government areas. <i>Asterolasia elegans</i> is found in sheltered forests on mid- to lower slopes and valleys, for example in or adjacent to gullies which support sheltered forest.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Dense Cord Rush <i>Baloskion longipes</i>	SPRAT	V	V	This species is found in the Blue Mountains National Park, Kanangra-Boyd National Park, Penrose State Forest (in Hanging Rock Swamp), Morton National Park (The Vines), the Clyde Mountain area and Ballalaba (south of Braidwood). Commonly found in swamps or depressions in sandy alluvium, sometimes growing with sphagnum moss. Also occurs in swales within tall forest, and in Black Gum ( <i>Eucalyptus aggregata</i> ) Woodland.	None. No populations recorded nearby and habitat is unsuitable.	Low. Known from Hanging Rock Swamp, outside the terrestrial study area.	None required.
Thick-lipped Spider Orchid <i>Caladenia tessellata</i>	SPRAT	E	V	Not known from the study area or surrounds. The Thick Lip Spider Orchid is generally found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil. The single leaf regrows each year.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Klaphake's Sedge <i>Carex klaphakei</i>	DECC southern coalfields enquiry submission	E	-	Not known from the study area or surrounds. Recorded in only three locations, two in the Blue Mountains (at Blackheath and Mt Werong) and one in the Southern Highlands (at Penrose). Grows with other native sedges and rushes in swamps on sandstone at altitudes of greater than 600 m.	None. No populations recorded nearby and habitat is unsuitable.	Low. Known from Hanging Rock Swamp, outside the terrestrial study area.	None required.
Dwarf Kerrawang <i>Commersonia prostrata</i>	SPRAT	E	E	Dwarf Kerrawang occurs on the Southern Highlands and Southern Tablelands at Penrose State Forest, Tallong, near the Corang River, Rows Lagoon, and on the North Coast at the Tomago sandbeds north of Newcastle. Associated native species may include <i>Imperata cylindrica</i> , <i>Empodisma minus</i> and <i>Leptospermum continentale</i> .	None. No populations recorded nearby and habitat is unsuitable.	Low. Known from Hanging Rock Swamp, outside the terrestrial study area.	None required.



**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Leafless Tongue Orchid <i>Cryptostylis hunteriana</i>	SPRAT	V	V	Not known from the terrestrial study area or surrounds. The Leafless Tongue Orchid does not appear to have well defined habitat preferences and is known from a range of communities, including swamp-heath and woodland. The larger populations typically occur in woodland dominated by Scribbly Gum ( <i>Eucalyptus sclerophylla</i> ), Silvertop Ash ( <i>E. sieberi</i> ), Red Bloodwood ( <i>Corymbia gummifera</i> ) and Black Sheoak ( <i>Allocasuarina littoralis</i> ).	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Pale Golden Moths <i>Diuris ochroma</i>	SPRAT	E	V	Not known from the terrestrial study area or surrounds. Pale Golden Moths occurs in the alpine plains of Kosciuszko National Park and the Kybean area. It occurs in open grassy woodland containing Ribbon Gum and Snow Gum.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Paddys River Box <i>Eucalyptus macarthurii</i>	Atlas of NSW Wildlife	E	E	Recorded in 1985 at Sutton Forest and also during the current study. Occurs on grassy woodland on relatively fertile soils on broad cold flats.	Recorded.	High. Recorded previously north of Long Swamp.	Assessment of significance completed (Appendix G).
Black Gum <i>Eucalyptus aggregata</i>	Atlas of NSW Wildlife	V	V	Recorded 2 km to the west of Berrima and also multiple records at Oldbury Road near Medway Rivulet. In NSW it occurs in the South Eastern Highlands Bioregion and on the western fringe of the Sydney Basin Bioregion. Black Gum has a moderately narrow distribution, occurring mainly in the wetter, cooler and higher parts of the tablelands. Often grows with other cold-adapted eucalypts, such as Snow Gum or White Sallee ( <i>Eucalyptus pauciflora</i> ), Manna or Ribbon Gum ( <i>E. viminalis</i> ), Candlebark ( <i>E. rubida</i> ), Black Sallee ( <i>E. stellulata</i> ) and Swamp Gum ( <i>E. ovata</i> ). Black Gum usually occurs in an open woodland formation with a grassy groundlayer dominated either by River Tussock ( <i>Poa labillardierei</i> ) or Kangaroo Grass ( <i>Themeda australis</i> ), but with few shrubs.	None. Targeted searches failed to detect any individuals.	High. Previously recorded on Medway Road, directly north of the terrestrial study area.	Assessed in Section 7.3.
Broad-leaved Sally <i>Eucalyptus aquatica</i>	Atlas of NSW Wildlife	V	V	Found primarily in the Penrose area near Goulburn where all records are either from State Forest or private property. Occurs as scattered plants on open, swampy flats. Essential habitat is peat swamps and their tributaries.	None. Targeted searches failed to detect any individuals.	High. Known from Stingray Swamp.	Assessment of significance completed (Appendix G).

**Table E.2** Threatened species recorded or predicted to occur within 20 km radius of the project area

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Bynoe's Wattle <i>Acacia bynoeana</i>	BBCC	E	V	The habitat where it occurs includes Castlereagh Woodland. Associated overstorey species include <i>Eucalyptus gummifera</i> , <i>E. haemastoma</i> , <i>E. parramattensis</i> , <i>E. sclerophylla</i> , <i>Banksia serrata</i> and <i>Angophora bakeri</i> . Associated shrubs include <i>Banksia spinulosa</i> , <i>Acacia oxycedrus</i> , <i>A. myrtifolia</i> and <i>Kunzea</i> spp. (Wimming 1992 in NSW NPWS 1999ah).	Low. The area contains one canopy tree normally associated with this species, namely Scribbly Gum. However, targeted surveys for the species failed to detect any individuals.	<b>High. May occur in Belanglo State Forest and surrounding Scribbly Gum Woodland.</b>	Discussed in Section 7.4.1.
Yellow Gnat Orchid <i>Genoplesium baueri</i>	SPRAT	E	E	Not known from the terrestrial study area or surrounds. The Yellow Gnat orchid has been recorded at locations between Ulladulla and Port Stephens. Grows in dry sclerophyll forest and moss gardens over sandstone.	None. No populations recorded nearby and habitat is unsuitable.	None. Targeted searches failed to detect any individuals.	None required.
Wingecarribee Gentian <i>Gentiana wingecarribeiensis</i>	SPRAT	CE	E	Not known from the terrestrial study area or surrounds. The Wingecarribee Gentian is only known from Hanging Rock Swamp and Wingecarribee Swamp, south of the terrestrial study area. It grows in bogs, sphagnum moss humps and in sedge communities.	None. No populations recorded nearby and habitat is unsuitable.	Low. Only known from Hanging Rock Swamp and Wingecarribee Swamp, outside the wider project area.	None required.
Juniper-leaved Grevillea <i>Grevillea juniperina</i> subs. <i>juniperina</i>	DECC southern coalfields enquiry submission	V	-	Endemic to Western Sydney, centred on an area bounded by Blacktown, Erskine Park, Londonderry and Windsor, with outlier populations at Kemps Creek and Pitt Town. Grows on reddish clay to sandy soils derived from Wianamatta Shale and Tertiary alluvium (often with shale influence), typically containing lateritic gravels.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Wingello Grevillea <i>Grevillea molyneuxii</i>	SPRAT	V	E	Not known from the terrestrial study area or surrounds. The Wingello Grevillea is restricted to a small area south of Penrose, above Tallowa Gully and Bundanoon Creek in Morton National Park and on Crown Land. It occurs in low heathland on sandstone where it grows in skeletal soil on flat, wet sandstone shelves above dissected valleys.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.



**Table E.2** Threatened species recorded or predicted to occur within 20 km radius of the project area

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Wingless Raspwort <i>Haloragis exalata</i> subsp. <i>exalata</i>	SPRAT	V	V	Not known from the terrestrial study area or surrounds. The Square Raspwort occurs in the central coast, south coast, and north western slopes of NSW. It appears to require protected and shaded damp situations in riparian habitats. Flowering specimens in NSW are recorded from November to January.	Low. No populations recorded nearby.	Low. No populations.	None required.
Cabbage Kunzea <i>Kunzea cabbagei</i>	Atlas of NSW Wildlife	V	V	Last recorded in 1999 at Loch Catherine Colliery. Several records within 2 km of this location. <i>Kunzea cabbagei</i> mainly occurs in the western and southern parts of the NSW Blue Mountains, namely the Yerranderie/Mt Werong area. Populations are also located west of Berrima, along the Wingecarribee River; Loombah Plateau east of Mount Werong; the Oberon-Colong Stock Route within Kanangra-Boyd National Park (NP); and Wangaderry Plateau within the Nattai NP. It is restricted to damp, sandy soils in wet heath or mallee open scrub at higher altitudes on sandstone outcrops or Silurian group sediments.	None. The habitat is unsuitable.	<b>Moderate. Previously recorded at Loch Catherine Colliery, within 2 km of the terrestrial study area.</b>	<b>Discussed in Section 7.4.1.</b>
Omeo's Storksbill <i>Pelargonium</i> sp. <i>Striatellum</i>	SPRAT	E	E	Not known from the terrestrial study area or surrounds. The Omeo Storksbill is known from only three locations in NSW, with two on lake-beds on the basalt plains of the Monaro and one at Lake Bathurst.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Mittagong Geebung <i>Persoonia glaucescens</i>	Atlas of NSW Wildlife	E	V	Last recorded in 2012 off Wombeyan Caves Road in High Range. Also recorded on the outskirts of Berrima. The Mittagong Geebung is distributed from Berrima in the south to Buxton in the north. The Mittagong Geebung grows in woodland to dry sclerophyll forest on clayey and gravely laterite. The preferred topography is ridge-tops, plateaux and upper slopes.	None. The habitat is unsuitable.	<b>Moderate. Previously recorded from Berrima, within the terrestrial study area.</b>	<b>Discussed in Section 7.4.1.</b>
Dwarf Phyllota <i>Phyllota humifusa</i>	Atlas of NSW Wildlife	V	V	Dwarf Phyllota is known from the southern Blue Mountains (Bimlow Tableland), the Joadja area west of Mittagong and Penrose area near Paddys River. The species occurs in dry sclerophyll forest, sometimes near swamps, in deep sandy soils or gravely loams over a sandstone substrate. Accompanying trees are often Brittle Gum <i>Eucalyptus mannifera</i> , Narrow-leafed Peppermint <i>E. radiata</i> and Sydney Peppermint <i>E. piperita</i> .	None. Targeted searches failed to detect the species.	<b>High . Known from Stingray Swamp and Long Swamp.</b>	<b>Assessment of significance completed (Appendix G).</b>

**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Cotoneaster Pomaderris <i>Pomaderris cotoneaster</i>	Atlas of NSW Wildlife	E	E	Recorded in 2005 at Canyonleigh on the outskirts of Bangadilly NP. Cotoneaster Pomaderris has a very disjunct distribution, being known from the Nungatta area, northern Kosciuszko National Park (near Tumut), the Tantawangalo area in South-East Forests National Park and adjoining freehold land, Badgery's Lookout near Tallong, the Yerranderie area, the Canyonleigh area and Ettrema Gorge in Morton National Park. Cotoneaster Pomaderris has been recorded in a range of habitats in predominantly forested country. The habitats include forest with deep, friable soil, amongst rock beside a creek, on rocky forested slopes and in steep gullies between sandstone cliffs.	None. Targeted searches failed to detect the species.	<b>Moderate. Potentially suitable habitat is present in steep gullies in the north-west and central northern parts of the terrestrial study area, however targeted searches failed to detect the species.</b>	Discussed in Section 7.4.1.
Bent Pomaderris <i>Pomaderris sericea</i>	SPRAT	E	V	Not known from the terrestrial study area or surrounds. In NSW, it is only known from Morton National Park in Bundanoon and Wollemi National Park. There is also a population in north-east Victoria. Both populations in NSW were in open forest on sandstone. Flowers in October.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Tawny Leek Orchid <i>Prasophyllum fuscum</i>	SPRAT	CE	V	Not known from the terrestrial study area or surrounds. The Tawny Leek Orchid grows in moist heath, often along seepage lines. The known population grows in moist sandy soil over sandstone, among sedges and grasses.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Tarengo Leek Orchid <i>Prasophyllum petilum</i>	SPRAT	E	E	Grows in open sites within Natural Temperate Grassland at Boorowa and Delegate in the NSW Southern Tablelands. Also grows in grassy woodland in association with River Tussock <i>Poa labillardieri</i> , Black Gum <i>Eucalyptus aggregata</i> and tea-trees <i>Leptospermum</i> spp. at Captains Flat, and within a grassy groundlayer dominated by Kangaroo Grass under Box-Gum Woodland at Ilford (and Hall, ACT).	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
<i>Prasophyllum</i> sp. Wybong	SPRAT	-	CE	Endemic to NSW, it is known from near Ilford, Premer, Muswellbrook, Wybong, Yeoval, Inverell, Tenterfield, Currabubula and the Pilliga area. A perennial orchid, appearing as a single leaf over winter and spring.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.



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Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Pretty Greenhood <i>Pterostylis pulchella</i>	SPRAT	V	V	Not known from the terrestrial study area or surrounds. The Pretty Greenhood has only been recorded at Fitzroy Falls, Belmore Falls, upper Bundanoon Creek and Minnamurra Falls. It is found on cliff faces close to waterfalls, creek banks and mossy rocks near running water. It flowers from February to May.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Elusive Bush-pea <i>Pultenaea elusa</i>	SPRAT	CE	E	Not known from the terrestrial study area or surrounds. The Elusive Bush Pea has only been recorded at two locations in Penrose and Wingello. Both locations were in swamps. Flowering is from September to October.	None. No populations recorded nearby and habitat is unsuitable.	Moderate potential to occur in Paddys River Swamps, around 7 km to the south west.	None required.
Siah's Backbone <i>Streblus pendulinus</i>	SPRAT	-	E	Not known from the terrestrial study area or surrounds. Siah's Backbone grows in well developed rainforest, gallery forest and drier, more seasonal rainforest.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Kangaloon Sun Orchid <i>Thelymitra kangaloonica</i>	SPRAT	CE	CE	Not known from the terrestrial study area or surrounds. The Kangaloon Sun-orchid is found in swamps in sedgeland over grey silty grey loam soils. It is thought to be a short-lived perennial, flowering in late October and early November.	None. No populations recorded nearby and habitat is unsuitable.	None. Restricted to Wingecarribee Swamp, outside the study areas.	None required.
Austral Toadflax <i>Thesium australe</i>	SPRAT	V	V	Not known from the terrestrial study area or surrounds. Austral Toadflax occurs in grassland on coastal headlands, and inland grassy woodlands, often in association with Kangaroo Grass ( <i>Themeda australis</i> ).	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.

**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Velvet Zieria <i>Zieria murphyi</i>	Atlas of NSW Wildlife	V	V	Velvet Zieria is found in the Blue Mountains at Mt Tomah and in the Southern Highlands where it has been recorded in Morton National Park in the Bundanoon area, and at Penrose. The Velvet Zieria is found in gullies in dry sclerophyll forest with sandy soil.	None. Targeted surveys failed to detect any individuals.	<b>Moderate.</b> Potentially suitable habitat is present in steep gullies in the north-west and central northern parts of the terrestrial study area, however targeted searches failed to detect the species.	Discussed in Section 7.4.1.
Hoary Sunray <i>Leucochrysum albicans</i> var. <i>tricolor</i>	SPRAT	-	E	The Hoary Sunray occurs in the Natural Temperate Grassland of the Southern Tablelands of NSW and the ACT, White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, and the Natural Temperate Grassland of the Victorian Volcanic Plain.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
<b>Birds</b>							
Little Eagle <i>Hieraetus morphnoides</i>	Atlas of NSW Wildlife	V	-	Last recorded nearby in 2009 at Exeter. It is found throughout the Australian mainland, excepting the most densely forested parts of the Dividing Range escarpment. It occurs as a single population throughout NSW. Occupies open eucalypt forest, woodland or open woodland. Sheoak or <i>Acacia</i> woodlands and riparian woodlands of interior NSW are also used.	<b>High. Recorded in terrestrial study area.</b>	<b>Recorded in terrestrial study area at Medway Dam.</b>	<b>Offsets will be provided for this ecosystem species in accordance with the FBA. See Section 8.2.1.</b>
Gang-gang Cockatoo <i>Callocephalon fimbriatum</i>	Atlas of NSW Wildlife	V	-	Recorded nearby in 2008 at Comfort Hill, Moss Vale. It has also been recorded around the study area in Moreton NP, Bangadilly NP, Penrose Sate Forest (SF), Joadja NR and Nattai NP. In NSW, the Gang-gang Cockatoo is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes. In summer, it is generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In winter, it may occur at lower altitudes in drier more open eucalypt forests and woodlands, and is often found in urban areas.	<b>High. Recorded in the project area.</b>	<b>Recorded in terrestrial study area.</b>	<b>Offsets will be provided for this ecosystem species in accordance with the FBA. See Section 8.2.1.</b>



**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Glossy Black-Cockatoo <i>Calyptrorhynchus lathamii</i>	Atlas of NSW Wildlife	V	-	Recently recorded in 2007 at Bangadilly NP. Additionally there are several records in and around Wollondilly NR and Joadja NR. The species is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW, with a small population in the Riverina. Inhabits open forest and woodlands of the coast and the Great Dividing Range up to 1000 m in which stands of She-oak species, particularly Black She-oak ( <i>Allocasuarina littoralis</i> ), Forest She-oak ( <i>A. torulosa</i> ) and/or Drooping She-oak ( <i>A. verticillata</i> ) occur.	None. Suitable habitat is absent.	Recorded in project area.	Offsets will be provided for this ecosystem species in accordance with the FBA. See Section 8.2.1.
Barking Owl <i>Ninox connivens</i>	Atlas of NSW Wildlife	V	-	Only one record nearby in Canyonleigh, in 1986. The Barking Owl is found throughout continental Australia, with the exception of the central arid regions. Although common in parts of northern Australia, the species has declined greatly in southern Australia and now occurs in a wide but sparse distribution in NSW. Core populations exist on the western slopes and plains (especially the Pilliga) and in some northeast coastal and escarpment forests. Inhabits woodland and open forest, including fragmented remnants and partly cleared farmland. It is flexible in its habitat use, and hunting can extend into closed forest and more open areas. Sometimes able to successfully breed along timbered watercourses in heavily cleared habitats (eg in western NSW) due to the higher density of prey on these fertile soils.	None. Suitable habitat is absent.	Low. Targeted searches failed to detect any individuals.	None required.

**Table E.2** Threatened species recorded or predicted to occur within 20 km radius of the project area

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Powerful Owl <i>Ninox strenua</i>	Atlas of NSW Wildlife	V	-	Several records in Moreton NP, Bangadilly NP and around the outskirts of Nattai NP. The Powerful Owl is endemic to eastern and south-eastern Australia, mainly on the coastal side of the Great Dividing Range from Mackay to south-western Victoria. In NSW, it is widely distributed throughout the eastern forests from the coast inland to tablelands, with scattered, mostly historical records on the western slopes and plains. Now uncommon throughout its range where it occurs at low densities. It roosts by day in dense vegetation comprising species such as Turpentine <i>Syncarpia glomulifera</i> , Black She-oak <i>Allocasuarina littoralis</i> , Blackwood <i>Acacia melanoxylon</i> , Rough-barked Apple <i>Angophora floribunda</i> , Cherry Ballart <i>Exocarpus cupressiformis</i> and a number of eucalypt species.	Moderate. The species was recorded in the terrestrial study area.	Recorded in project area.	Offsets will be provided for this ecosystem species in accordance with the FBA. See Section 8.2.1.
Striated Fieldwren <i>Calamanthus fuliginosus</i>	Atlas of NSW Wildlife	E	-	Recorded in 1992 near Joadja Creek, north of the terrestrial study area. The Striated Fieldwren is found in coastal swamp heaths and tussock fields of south-eastern NSW, into southern Victoria and the south-east of South Australia. It is also found in Tasmania. There are four recognised subspecies, but only one ( <i>albiloris</i> ) occurs in NSW. Three to four eggs are laid in nests hidden on the ground under tussocks or shrubs. Nests are dome-like structures constructed from coarse grasses and other fibres and the interior is lined with softer grasses, feathers and down.	None. Suitable habitat is absent.	None. Suitable habitat is absent.	None required.
Regent Honeyeater <i>Anthochaera phrygia</i>	NPWS Atlas	CE	E	Recorded in 2001 near the Wollondilly River NR. The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. Every few years non-breeding flocks are seen foraging in flowering coastal Swamp Mahogany and Spotted Gum forests, particularly on the central coast and occasionally on the upper north coast. Birds are occasionally seen on the south coast.	None. No individuals recorded nearby and habitat is unsuitable. Targeted surveys were completed for winter flowering eucalypts and the Regent Honeyeater, and neither were detected.	None. No individuals recorded nearby and habitat is unsuitable. Targeted surveys were completed for winter flowering eucalypts and the Regent Honeyeater, and neither were detected.	None required.



**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Swift Parrot <i>Lathamus discolor</i>	SPRAT	E	E	Not known from the terrestrial study area or surrounds. The Swift Parrot migrates to the Australian south-east mainland between March and October. On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. They return to Tasmania to breed between September and December.	None. No individuals recorded nearby and habitat is unsuitable. Targeted surveys were completed for winter flowering eucalypts and the Swift Parrot, and neither were detected.	None. No individuals recorded nearby and habitat is unsuitable. Targeted surveys were completed for winter flowering eucalypts and the Swift Parrot, and neither were detected.	None required.
Hooded Robin (south-eastern form) <i>Melanodryas cucullata cucullata</i>	Atlas of NSW Wildlife	V	-	Last recorded in 2008 in Marulan. The south-eastern form (subspecies <i>cucullata</i> ) is found from Brisbane to Adelaide and throughout much of inland NSW, with the exception of the extreme north-west, where it is replaced by subspecies <i>picata</i> . Two other subspecies occur outside NSW. Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas.	<b>Moderate likelihood due to the presence of grassy woodlands in the surface infrastructure area. None were recorded.</b>	<b>Moderate likelihood due to the presence of grassy woodlands in the terrestrial study area. None were recorded.</b>	<b>Although not predicted by the BBCC, offsets provided for other ecosystem species in accordance with the FBA will compensate for any impacts. See Section 8.2.1.</b>
Scarlet Robin <i>Petroica boodang</i>	Atlas of NSW Wildlife	V	-	The Scarlet Robin is found from south-east Queensland to south-east South Australia and also in Tasmania and south west Western Australia. In NSW, it occurs from the coast to the inland slopes. This species lives in both mature and regrowth vegetation. It occasionally occurs in mallee or wet forest communities, or in wetlands and tea-tree swamps. The Scarlet Robin habitat usually contains abundant logs and fallen timber, which are important components of its habitat.	<b>Moderate. This species was recorded in the terrestrial study area.</b>	<b>Recorded in Belanglo State Forest.</b>	<b>Offsets will be provided for this ecosystem species in accordance with the FBA. See Section 8.2.1.</b>

**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Diamond Firetail <i>Stagnopleura guttata</i>	Atlas of NSW Wildlife	V	-	Recorded recently (in 2011) at Canyonleigh. Several records also exist around this area including from Moreton NP and Joadja NR. The Diamond Firetail is endemic to south-eastern Australia, extending from central Queensland to the Eyre Peninsula in South Australia. It is widely distributed in NSW, with a concentration of records from the Northern, Central and Southern Tablelands, the Northern, Central and South Western Slopes and the North West Plains and Riverina. Found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum <i>Eucalyptus pauciflora</i> Woodlands. Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities.	High. The species was recorded adjacent to the surface infrastructure area.	High. The species has been recorded recently in Canyonleigh, south of the terrestrial study area.	Although not predicted by the BBCC, offsets provided for other ecosystem species in accordance with the FBA will compensate for any impacts. See Section 8.2.1.
Blue-billed Duck <i>Oxyura australis</i>	Atlas of NSW Wildlife	V	-	Recorded north of Wingello SF in 1989. The Blue-billed Duck is endemic to south-eastern and south-western Australia. It is widespread in NSW, but most common in the southern Murray-Darling Basin area. Birds disperse during the breeding season to deep swamps up to 300 km away. The Blue-billed Duck prefers deep water in large permanent wetlands and swamps with dense aquatic vegetation. The species is completely aquatic, swimming low in the water along the edge of dense cover. Blue-billed Ducks will feed by day far from the shore, particularly if dense cover is available in the central parts of the wetland.	None. Suitable habitat is absent.	High. May occur in farm dams in the terrestrial study area.	Discussed in Section 7.4.1.
Australasian Bittern <i>Botaurus poiciloptilus</i>	Atlas of NSW Wildlife	E	E	Recorded close to the terrestrial study area in 1999, in Cecil Hoskins Nature Reserve near Moss Vale. Australasian Bitterns are widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state, the exception being the far north-west. They favour permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes ( <i>Typha</i> spp.) and spikerushes ( <i>Eleocharis</i> spp.). They hide during the day amongst dense reeds or rushes and feed mainly at night on frogs, fish, yabbies, spiders, insects and snails.	None. Suitable habitat is absent.	Moderate likelihood to occur in Long Swamp and Stingray Swamp.	Assessment of significance completed (Appendix G).



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Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Flame Robin <i>Petroica phoenicea</i>	Atlas of NSW Wildlife	V	-	Scattered records around Marulan and also in Morton NP. The Flame Robin is endemic to south-eastern Australia, and ranges from near the Queensland border to south-east South Australia and also in Tasmania. In NSW, it breeds in upland areas and in winter, many birds move to the inland slopes and plains. It is likely that there are two separate populations in NSW, one in the Northern Tablelands, and another ranging from the Central to Southern Tablelands. It prefers clearings or areas with open groundcovers. It often occurs in recently burnt areas, however, habitat becomes unsuitable as vegetation closes up following regeneration.	Low. Targeted surveys failed to detect any individuals in the surface infrastructure area.	High likelihood. Recently recorded from Penrose State Forest, around 7 km south west of the project area.	Offsets will be provided for this ecosystem species in accordance with the FBA. See Section 8.2.1.
Masked Owl <i>Tyto novaehollandiae</i>	Atlas of NSW Wildlife	V	-	Extends from the coast where it is most abundant to the western plains. Overall records for this species fall within approximately 90% of NSW, excluding the most arid north-western corner. Lives in dry eucalypt forests and woodlands from sea level to 1100 m. A forest owl, but often hunts along the edges of forests, including roadsides. The typical diet consists of tree-dwelling and ground mammals, especially rats.	Moderate likelihood as the species may have been recorded in the wider project area.	Unconfirmed record in terrestrial study area. Precautionary principle used in assuming presence.	Offsets will be provided for this ecosystem species in accordance with the FBA. See Section 8.2.1.
Sooty Owl <i>Tyto tenebricosa</i>	Atlas of NSW Wildlife	V	-	Recorded in 2009 between Bangadilly NP and Joadja NR. Occupies the easternmost one-eighth of NSW, occurring on the coast, coastal escarpment and eastern tablelands. Occurs in rainforest, including dry rainforest, subtropical and warm temperate rainforest, as well as moist eucalypt forests.	Low. Targeted surveys failed to detect any individuals in the surface infrastructure area.	Low. Rainforest is absent from the terrestrial study area.	None required.
Turquoise Parrot <i>Neophema pulchella</i>	Field surveys	V	-	Not known from the terrestrial study area or surrounds prior to the survey. The Turquoise Parrot's range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range. Lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland. Prefers to feed in the shade of a tree and spends most of the day on the ground searching for the seeds of grasses and herbaceous plants, or browsing on vegetable matter.	Moderate. This species was recorded in the wider project area.	Recorded along Hume Highway and in Belanglo State Forest.	Offsets will be provided for this ecosystem species in accordance with the FBA. See Section 8.2.1.

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Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Speckled Warbler <i>Chthonicola sagittata</i>	Atlas of NSW Wildlife	V	-	Recorded south west of the terrestrial study area at Marulan. The Speckled Warbler has a patchy distribution throughout south-eastern Queensland, the eastern half of NSW and into Victoria, as far west as the Grampians. The species is most frequently reported from the hills and tablelands of the Great Dividing Range, and rarely from the coast. The Speckled Warbler lives in a wide range of <i>Eucalyptus</i> dominated communities that have a grassy groundcover, often on rocky ridges or in gullies. Typical habitat includes scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy.	Low. Targeted surveys failed to detect any individuals in the surface infrastructure area.	<b>Moderate. Recorded recently from Marulan.</b>	Discussed in Section 7.4.1.
Brown Treecreeper (eastern subspecies) <i>Climacteris picumnus victoriae</i>	Atlas of NSW Wildlife	V	-	Recorded in Marulan in 2005 and Wollondilly NR. The eastern subspecies lives in eucalypt woodlands in eastern NSW and in coastal areas with drier open woodlands such as the Snowy River Valley, Cumberland Plains, Hunter Valley and parts of the Richmond and Clarence valleys in central NSW. Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range, where it mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy groundcover and sometimes with one or more shrub species. It is also found in mallee and River Red Gum ( <i>Eucalyptus camaldulensis</i> ) Forest bordering wetlands with an open groundcover of acacias, saltbush, lignum, cumbungi and grasses. It is usually not found in woodlands with a dense shrub layer. Fallen timber is an important habitat component for foraging. It is also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains.	Low. Targeted surveys failed to detect any individuals in the surface infrastructure area.	<b>Recorded in Belanglo State Forest.</b>	Discussed in Section 7.4.1.
Varied Sittella <i>Daphoenositta chrysoptera</i>	Atlas of NSW Wildlife	V	-	Scattered records around Marulan, Moreton NP, Wollondilly NR and Nattai NP outskirts. The Varied Sittella is sedentary and inhabits most of mainland Australia except the treeless deserts and open grasslands. Distribution in NSW is nearly continuous from the coast to the far west. Inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and <i>Acacia</i> woodland. Feeds on arthropods gleaned from crevices in rough or decortivating bark, dead branches, standing dead trees and small branches and twigs in the tree canopy.	<b>Moderate. The species was recorded in the terrestrial study area.</b>	<b>Recorded in Belanglo State Forest.</b>	Offsets will be provided for this ecosystem species in accordance with the FBA. See Section 8.2.1.



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Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Great Egret <i>Ardea alba</i>	SPRAT	-	Mi	Not recorded in the terrestrial study area or nearby surrounds. Great Egrets occur in swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pastures or agricultural lands; reservoirs; sewage treatment ponds; and drainage channels. They frequent shallow water when foraging.	Low. Targeted surveys failed to detect any individuals in the surface infrastructure area.	<b>Moderate likelihood to occur in Long Swamp and Stingray Swamp.</b>	Assessment of significance completed (Appendix G).
Cattle Egret <i>Ardea ibis</i>	SPRAT	-	Mi	Not recorded in the terrestrial study area or nearby surrounds. Two major distributions have been recorded, from north-east Western Australia to the Top End of the Northern Territory and around south-east Australia. It occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands. High numbers have been observed in moist, low-lying poorly drained pastures with an abundance of high grass. It avoids low grass pastures.	Low. Targeted surveys failed to detect any individuals in the surface infrastructure area.	<b>Moderate likelihood to occur in Long Swamp and Stingray Swamp.</b>	Assessment of significance completed (Appendix G).
Rainbow Bee-eater <i>Merops ornatus</i>	SPRAT	-	Mi	Not recorded in the terrestrial study area or nearby surrounds. The Rainbow Bee-eater is distributed across much of mainland Australia, and occurs on several near-shore islands. It usually occurs in open, cleared or lightly-timbered areas that are often, but not always, located in close proximity to permanent water. The Rainbow Bee-eater is also common in cleared and semi-cleared habitats such as farmland.	Low. Targeted surveys failed to detect any individuals in the surface infrastructure area.	<b>Moderate potential to occur in creeks and gullies in the terrestrial study area.</b>	Discussed in Section 7.4.1.
Satin Flycatcher <i>Myiagra cyanoleuca</i>	SPRAT	-	Mi	Not recorded in the terrestrial study area or nearby surrounds. The Satin Flycatcher is widespread in eastern Australia and vagrant to New Zealand (Blakers et al. 1984; Coates 1990). Satin Flycatchers inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, and on migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests.	Low. Targeted surveys failed to detect any individuals in the surface infrastructure area.	<b>Moderate potential to occur in creeks and gullies in the north-west and central northern parts of the terrestrial study area.</b>	Discussed in Section 7.4.1.

**Table E.2** Threatened species recorded or predicted to occur within 20 km radius of the project area

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Rufous Fantail <i>Rhipidura rufifrons</i>	SPRAT	-	Mi	Not recorded in the terrestrial study area or nearby surrounds. The Rufous Fantail occurs in coastal and near coastal districts of northern and eastern Australia (Lindsey 1992). In east and south-east Australia, the Rufous Fantail mainly inhabits wet sclerophyll forests, often in gullies dominated by eucalypts such as Tallow-wood ( <i>Eucalyptus microcorys</i> ), Mountain Grey Gum ( <i>E. cypellocarpa</i> ), Narrow-leaved Peppermint ( <i>E. radiata</i> ), Mountain Ash ( <i>E. regnans</i> ), Alpine Ash ( <i>E. delegatensis</i> ), Blackbutt ( <i>E. pilularis</i> ) and/or Red Mahogany ( <i>E. resinifera</i> ), usually with a dense shrubby groundcover often including ferns.	Low. Targeted surveys failed to detect any individuals in the surface infrastructure area.	<b>Moderate potential to occur in creeks and gullies in the north-west and central northern parts of the terrestrial study area.</b>	Discussed in Section 7.4.1.
Freckled Duck <i>Stictonetta naevosa</i>	DECC southern coalfields enquiry submission	V	-	Recorded in Moss Vale in 2011. The Freckled Duck is found primarily in south-eastern and south-western Australia, and occurs as a vagrant elsewhere. Prefers permanent freshwater swamps and creeks with heavy growth of Bullrushes ( <i>Typha spp</i> ) Lignum ( <i>Muelenbeckia spp</i> ) and/or Tea-tree ( <i>Melaleuca spp</i> ). During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds.	Low. Targeted surveys failed to detect any individuals in the surface infrastructure area.	<b>Moderate. Species may occur occasionally in farm dams in the eastern part of the project area.</b>	Discussed in Section 7.4.1.
Black Falcon <i>Falco subniger</i>	Atlas of NSW Wildlife	V	-	Recorded in 1986 in Exeter. It occurs over most of the Australian mainland, with the exception of densely forested parts. The Black Falcon mostly eats other birds, but also mammals, large insects and carrion.	Low. Targeted surveys failed to detect any individuals.	Low. There is only one record of the species from Exeter in 1986.	None required.
Little Lorikeet <i>Glossopsitta pusilla</i>	Field surveys	V	-	Not previously known from the terrestrial study area or surrounds. The Little Lorikeet is distributed widely across the coastal and Great Divide regions of eastern Australia from Cape York to South Australia. Forages primarily in the canopy of open Eucalypt ( <i>Eucalyptus spp</i> ) forest and woodland, yet also finds food in Apple ( <i>Angophora spp</i> ), Tea Trees ( <i>Melaleuca spp</i> ) and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity.	<b>High likelihood as the species was recorded in the terrestrial study area.</b>	<b>Recorded in Belanglo State Forest.</b>	<b>Offsets will be provided for this ecosystem species in accordance with the FBA. See Section 8.2.1.</b>



**Table E.2** Threatened species recorded or predicted to occur within 20 km radius of the project area

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Eastern Bristlebird <i>Dasyornis brachypterus</i>	SPRAT	E	E	Not recorded in the terrestrial study area or nearby surrounds. The distribution of the Eastern Bristlebird has contracted to three disjunct areas of south-eastern Australia: southern Queensland/northern NSW; the Illawarra Region; and the vicinity of the NSW/Victorian border. Habitat is characterised by dense, low vegetation including heath and open woodland with a heathy groundcover. In northern NSW it occurs in open forest with tussocky grass groundcover. The vegetation types it inhabits are fire prone.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Black-chinned Honeyeater (eastern subspecies) <i>Melithreptus gularis gularis</i>	Atlas of NSW Wildlife	V	-	Not recorded in the terrestrial study area or nearby surrounds. The eastern subspecies extends south from central Queensland, through NSW and Victoria into south-eastern South Australia, though it is very rare in the latter state. In NSW it is widespread, with records from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. Occupies mostly upper levels of drier open forests or woodlands dominated by box and ironbark eucalypt species, especially Mugga Ironbark ( <i>Eucalyptus sideroxylon</i> ), White Box ( <i>E. albens</i> ), Inland Grey Box ( <i>E. microcarpa</i> ), Yellow Box ( <i>E. melliodora</i> ), Blakely's Red Gum ( <i>E. blakelyi</i> ) and Forest Red Gum ( <i>E. tereticornis</i> ).	None. Suitable habitat is absent.	None. Suitable habitat is absent.	None required.
Australian Painted Snipe <i>Rostratula australis</i>	SPRAT	E	E	Recorded at a farm dam in Berrima in 2010. The Australian Painted Snipe prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. The Australian Painted Snipe nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.	Low. Targeted surveys failed to record any individuals.	<b>Moderate likelihood to occur in Long Swamp and Stingray Swamp.</b>	<b>Assessment of significance completed (Appendix G).</b>
Painted Honeyeater <i>Grantiella picta</i>	SPRAT	V	V	Inhabits Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests. A specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias. Prefers mistletoes of the genus <i>Amyema</i> .	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.

**Table E.2** Threatened species recorded or predicted to occur within 20 km radius of the project area

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
White-throated Needletail <i>Hirundapus caudacutus</i>	SPRAT	-	Mi	Recorded in Exeter (around 3 km south-west of the terrestrial study area) in 2010. The White-throated Needletail occurs in open forest, rainforest, heathland, grassland and swamps. The species breeds in wooded lowlands and sparsely vegetated hills, as well as mountains covered with coniferous forests. This species is almost exclusively aerial and rarely comes to the ground.	None. This species is almost exclusively aerial and rarely comes to the ground.	None. This species is almost exclusively aerial and rarely comes to the ground.	None required.
Black-faced Monarch <i>Monarcha melanopsis</i>	SPRAT	-	Mi	Last recorded in Bowral in 1995, approximately 10 km north-east of the terrestrial study area. The Black-faced Monarch occurs mainly in rainforest ecosystems but is sometimes found in nearby open eucalypt forests, in gullies with a dense, shrubby, or patchy groundcover.	None. The habitat is unsuitable.	Low. Rainforest is absent from the terrestrial study area.	None required.
<b>Frogs</b>							
Giant Burrowing Frog <i>Heleioporus australiacus</i>	SPRAT	V	V	Not known from the terrestrial study area or nearby surrounds. The closest record to the terrestrial study area is over 60 km away. The Giant Burrowing Frog is distributed across south-eastern NSW and Victoria, and appears to exist as two distinct populations: a northern population largely confined to the sandstone geology of the Sydney Basin and extending as far south as Ulladulla, and a southern population occurring from north of Narooma through to Walhalla, Victoria. Found in heath, woodland and open dry sclerophyll forest on a variety of soil type, other than those that are clay based. Spends more than 95% of its time in non-breeding habitat in areas up to 300 m from breeding sites. Whilst in non-breeding habitat it burrows below the soil surface or in the leaf litter.	None. The habitat is unsuitable and targeted surveys failed to record any individuals.	Low. Targeted surveys failed to record any individuals.	None required.
Stuttering Frog/Southern Barred Frog <i>Mixophyes balbus</i>	SPRAT	E	V	Not recorded in the terrestrial study area or nearby surrounds. The Stuttering Frog is restricted to the eastern slopes of the Great Divide, from the Cann River catchment in far East Gippsland, Victoria, to tributaries of the Timbarra River near Drake, NSW. It is found in association with permanent drainage lines through temperate and sub-tropical rainforest and wet sclerophyll forest, and rarely in dry open tableland riparian vegetation.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable. Targeted surveys failed to record any individuals.	None required.



**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Green and Golden Bell Frog <i>Litoria aurea</i>	SPRAT	E	V	Not known from the terrestrial study area. The Green and Golden Bell Frog inhabits marshes, dams and stream-sides, particularly those containing bullrushes ( <i>Typha</i> spp.) or spikerushes ( <i>Eleocharis</i> spp.). Optimum habitat for this species includes water-bodies that are unshaded, free of predatory fish such as Plague Minnow ( <i>Gambusia holbrooki</i> ), have a grassy area nearby and access to diurnal sheltering sites.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Littlejohns Tree Frog <i>Litoria littlejohni</i>	SPRAT	V	V	Not recorded in the terrestrial study area or nearby surrounds. Littlejohns Tree Frog has a distribution that includes the plateaus and eastern slopes of the Great Dividing Range from Watagan State Forest (90 km north of Sydney) south to Buchan in Victoria. Non-breeding habitat is heath based forests and woodlands where it shelters under leaf litter and low vegetation, and hunts for invertebrate prey either in shrubs or on the ground.	None. No populations recorded nearby and habitat is unsuitable.	<b>Moderate likelihood to occur in Long Swamp and Stingray Swamp.</b>	<b>Assessment of significance completed (Appendix G).</b>
<b>Mammals</b>							
Koala <i>Phascolarctos cinereus</i>	Atlas of NSW Wildlife	V	V	Several records in the terrestrial study area. The Koala has a fragmented distribution throughout eastern Australia from north-east Queensland to the Eyre Peninsula in South Australia. In NSW it mainly occurs on the central and north coasts, with some populations in the west of the Great Dividing Range. Inhabits eucalypt woodlands and forests. Feeds on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species.	<b>Moderate. The species was recorded adjacent to the surface infrastructure area.</b>	<b>Recorded in Belanglo State Forest.</b>	<b>Assessment of significance completed (Appendix G). Offsets will be provided for surface impacts on this species credit species in accordance with the FBA.</b>

**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Southern Myotis <i>Myotis macropus</i>	Atlas of NSW Wildlife	V	-	Patchy records around Marulan and Meryla SF. Southern Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. It is rarely found more than 100 km inland, except along major rivers. Generally roosts in groups of 10 to 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forages over drainage lines and pools, catching insects and small fish by raking their feet across the water surface.	High. The species was recorded adjacent to the surface infrastructure area.	Recorded in Belanglo State Forest.	Offsets will be provided for this species credit species in accordance with the FBA. See Section 8.2.2.
Eastern Bentwing Bat <i>Miniopterus schreibersii oceanensis</i>	Atlas of NSW Wildlife	V	-	Scattered records around Marulan and Joadja NR. Eastern Bentwing Bats occur along the east and north-west coasts of Australia. Caves are the primary roosting habitat, but they also use derelict mines, storm-water tunnels, buildings and other man-made structures. Form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young.	Moderate. This species was recorded in the terrestrial study area.	Recorded in Belanglo State Forest.	Offsets will be provided for this species credit species in accordance with the FBA. See Section 8.2.2.
Eastern False Pipistrelle <i>Falsistrellus tasmaniensis</i>	Atlas of NSW Wildlife	V	-	Scattered records around Joadja NR and also recorded in Meryla SF. The Eastern False Pipistrelle is found on the south-east coast and ranges of Australia, from southern Queensland to Victoria and Tasmania. Prefers moist habitats, with trees taller than 20 m. Generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings.	Moderate. This species was recorded in the terrestrial study area.	Recorded in Belanglo State Forest.	Offsets will be provided for this ecosystem credit species in accordance with the FBA. See Section 8.2.1.
Eastern Freetail-bat <i>Mormopterus norfolkensis</i>	Atlas of NSW Wildlife	V	-	Recorded in 2003 on the edge of Nattai NP. The Eastern Freetail-bat is found along the east coast from south Queensland to southern NSW. Occurs in dry sclerophyll forest, woodland, swamp forests and mangrove forests east of the Great Dividing Range. Roosts mainly in tree hollows but will also roost under bark or in man-made structures.	Moderate. This species was recorded in the terrestrial study area.	Recorded in Belanglo State Forest.	Offsets will be provided for this ecosystem credit species in accordance with the FBA. See Section 8.2.1.



**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Grey-headed Flying-fox <i>Pteropus poliocephalus</i>	Atlas of NSW Wildlife	V	V	Recorded in 1998 in Bundanoon. Grey-headed Flying-foxes are generally found within 200 km of the east coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria. In times of natural resource shortages, they may be found in atypical locations. Occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly in gullies, close to water, in vegetation with a dense canopy.	Low. Targeted surveys failed to detect the species in the surface infrastructure area.	Low. No roosting colonies are known from the terrestrial study area.	None required.
Large-eared Pied Bat <i>Chalinolobus dwyeri</i>	Atlas of NSW Wildlife	V	V	Recorded in 2006 at Bundanoon. Scattered records throughout Nattai NP, Wanganderry Tablelands and Joadja NR.	<b>This species was recorded adjacent to the surface infrastructure area.</b>	<b>Recorded in Belanglo State Forest.</b>	<b>Assessment of significance completed (Appendix G).</b>
Little Bentwing Bat <i>Miniopterus australis</i>	Atlas of NSW Wildlife	V	-	Recorded north of Marulan in 2005. Distributed on the east coast and ranges of Australia from Cape York in Queensland to Wollongong in NSW. Occur in moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Teatree ( <i>Melaleuca spp</i> ) swamps, dense coastal forests and banksia scrub. Generally found in well-timbered areas. Little Bentwing Bats roost in caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings during the day, and at night forage for small insects beneath the canopy of densely vegetated habitats.	Low. Targeted surveys failed to detect the species in the surface infrastructure area.	<b>Recorded in Belanglo State Forest.</b>	<b>Offsets will be provided for this ecosystem credit species in accordance with the FBA.</b>  See Section 8.2.1.
Spotted-tailed Quoll <i>Dasyurus maculatus</i>	Atlas of NSW Wildlife	V	E	Recorded in 2006 at Tallong. Also scattered records in Bundanoon, Bangadilly NP and Wanganderry Tableland. It is now found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland. Only in Tasmania is it still considered common. Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites.	Low. Native vegetation is highly cleared, making movement difficult for the species.	<b>Moderate. There is potentially suitable habitat in creeks and gullies of Belanglo State Forest.</b>	<b>Discussed in Section 7.4.1.</b>

**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Southern Brown Bandicoot <i>Isodon obselus obselus</i>	SPRAT	E	E	Not known from the terrestrial study area or surrounds. Southern Brown Bandicoots are largely crepuscular (active mainly after dusk and/or before dawn). They are generally only found in heath or open forest with a heathy groundcover on sandy or friable soils. They feed on a variety of ground-dwelling invertebrates and the fruit-bodies of hypogeous (underground-fruiting) fungi. Their searches for food often create distinctive conical holes in the soil.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Brush-tailed Rock Wallaby <i>Petrogale penicillata</i>	Atlas of NSW Wildlife	E	V	Several records since 2002 in Nattai NP, west of Wollondilly River and Basket Creek intersection. In NSW they occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit. Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges, often facing north. Browse on vegetation in and adjacent to rocky areas, eating grasses and forbs as well as the foliage and fruits of shrubs and trees.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Yellow-bellied Glider <i>Petaurus australis</i>	Atlas of NSW Wildlife	V	-	Recorded in 2004 at Bangadilly NP. Many records in Joadja NR and Nattai NP. The Yellow-bellied Glider is found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria. Occurs in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Forest type preferences vary with latitude and elevation, ranging from mixed coastal forests to dry escarpment forests in the north; and moist coastal gullies and creek flats to tall montane forests in the south.	None. Habitat is unsuitable in the surface infrastructure area.	<b>High. Evidence of old feed trees found in Belanglo State Forest.</b>	<b>Discussed in Section 7.4.1.</b>
Squirrel Glider <i>Petaurus norfolcensis</i>	Atlas of NSW Wildlife	V	-	Recorded in 2011 in Bundanoon. Also recorded in Wollondilly River NR. The species is widely, though sparsely, distributed in eastern Australia, from northern Queensland to western Victoria. Inhabits mature or old growth Box, Box-Ironbark Woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath groundcover in coastal areas. Prefers mixed species stands with a shrub or Acacia mid-storey.	<b>Presence has been assumed as this is a predicted species credit species, and targeted surveys were not completed.</b>	<b>Moderate likelihood of occurrence in Belanglo State Forest.</b>	<b>Offsets will be provided for this species credit species in accordance with the FBA. See Section 8.2.2.</b>



**Table E.2** Threatened species recorded or predicted to occur within 20 km radius of the project area

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Long-nosed Potoroo <i>Potorous tridactylus tridactylus</i>	SPRAT	V	V	Not known from the terrestrial study area or surrounds. The Long-nosed Potoroo inhabits coastal heaths and dry and wet sclerophyll forests. A dense groundcover with occasional open areas is an essential part of this species' habitat. It may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
New Holland Mouse <i>Pseudomys fumeus</i>	SPRAT	CE	E	Not known from the terrestrial study area or surrounds. The New Holland Mouse prefers open heathlands, woodland and forest with a heathland groundcover and vegetated sand dunes.	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Greater Broad-nosed Bat <i>Scoteanax rueppellii</i>	Atlas of NSW Wildlife	V	-	Recorded in 2009 at Canyonleigh. The Greater Broad-nosed Bat is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In NSW it is widespread on the New England Tablelands, however does not occur at altitudes above 500 m. Utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though is most commonly found in tall wet forest. Although this species usually roosts in tree hollows, it has also been found in buildings. It forages along creeks and rivers.	None. Habitat is unsuitable in the surface infrastructure area, and the species was not recorded during targeted surveys.	<b>Moderate likelihood of occurrence in Belanglo State Forest in creeks and gullies. Not detected during targeted surveys.</b>	<b>Discussed in Section 7.4.1.</b>
Eastern Pygmy Possum <i>Cercartetus nanus</i>	Atlas of NSW Wildlife	V	-	Recorded in 1998 at Bundanoon. The Eastern Pygmy-possum is found in south-eastern Australia, from southern Queensland to eastern South Australia and in Tasmania. In NSW it extends from the coast inland as far as the Pilliga, Dubbo, Parkes and Wagga Wagga on the western slopes. Found in a broad range of habitats from rainforest through to sclerophyll (including Box-Ironbark) forest and woodland to heath. In most areas woodlands and heath appear to be preferred, though in north-eastern NSW they are most frequently encountered in rainforest. Feeds largely on nectar and pollen collected from banksias, eucalypts and bottlebrushes, and is an important pollinator of heathland plants such as banksias. Soft fruits are eaten when flowers are unavailable.	None. Habitat is unsuitable in the surface infrastructure area.	<b>High. May occur in forested parts of the project area.</b>	<b>Discussed in Section 7.4.1.</b>

**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Yellow-bellied Sheathtail Bat	Recorded during surveys	V	-	Not previously known from within 20 km of the terrestrial study area. Roosts singly or in groups of up to six, in tree hollows and buildings. Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory.	High. Recorded adjacent to surface infrastructure area.	High. Recorded adjacent to surface infrastructure area.	Offsets will be provided for this ecosystem credit species in accordance with the FBA. See Section 8.2.1.
<b>Insects</b>							
Giant Dragonfly <i>Petalura gigantea</i>	Atlas of NSW Wildlife	E	-	Recorded in 2006 at Penrose SF. The Giant Dragonfly is found along the east coast of NSW from the Victorian border to northern NSW. It is not found west of the Great Dividing Range. There are known occurrences in the Blue Mountains and Southern Highlands, in the Clarence River catchment, and on a few coastal swamps from north of Coffs Harbour to Nadgee in the south. Lives in permanent swamps and bogs with some free water and open vegetation. Females lay eggs into moss, under other soft ground layer vegetation, and into moist litter and humid soils, often associated with groundwater seepage areas within appropriate swamp and bog habitats. The species does not utilise areas of standing water wetland, although may utilise suitable boggy areas adjacent to open water wetlands.	None. No populations recorded nearby and habitat is unsuitable.	High. Known from Stingray Swamp.	Assessment of significance completed (Appendix G).
<b>Reptiles</b>							
Broad-headed Snake <i>Hoplocephalus bungaroides</i>	SPRAT	E	V	Not known from the terrestrial study area or surrounds. The Broad-headed Snake is largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups in coastal regions and ranges in an area within approximately 250 km of Sydney. Shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring. Moves from the sandstone rocks to shelters in hollows in large trees within 200 m of escarpments in summer.	None. No populations recorded nearby and habitat is unsuitable.	Moderate likelihood of occurrence on the escarpments of Belanglo State Forest. Targeted surveys failed to detect the species.	Discussed in Section 7.4.1.



**Table E.2**      **Threatened species recorded or predicted to occur within 20 km radius of the project area**

Species	Source	Status		Historic records and habitat requirements	Likelihood of occurrence in surface infrastructure area	Likelihood of occurrence in the study areas	Further assessment required?
		TSC Act	EPBC Act				
Rosenbergs Goanna <i>Varanus rosenbergi</i>	DECC southern coalfields enquiry submission	V	-	Not known from the terrestrial study area or surrounds. Rosenberg's Goanna occurs on the Hawkesbury Sandstone in Wollemi National Park to the north-west of Sydney; in the Goulburn and ACT regions; and near Cooma in the south. There are records from the South West Slopes near Khancoban and Tooma River. It also occurs in South Australia and Western Australia. Found in heath, open forest and woodland. Associated with termites, the mounds of which this species nests in. Termite mounds are a critical habitat component.	None. No populations recorded nearby and habitat is unsuitable.	<b>Moderate likelihood of occurrence on the escarpments of Belanglo State Forest. Targeted surveys failed to detect the species.</b>	Discussed in Section 7.4.1.
Striped Legless Lizard <i>Delma impar</i>	SPRAT	V	V	Not known from the terrestrial study area or surrounds. This species is mainly found in natural temperate grassland but has also been captured in exotic grasslands. It is also occasionally found in Box Gum Woodland. Its optimal habitat is grassland dominated by perennial, tussock grasses including Kangaroo Grass ( <i>Themeda australis</i> ), Speargrasses ( <i>Austrostipa</i> spp.), <i>Poa</i> spp. and Wallaby Grasses ( <i>Rytidosperma</i> spp.).	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.
Pink-tailed Legless Lizard <i>Aprasia parapulchella</i>	SPRAT	V	V	Not known from the terrestrial study area or surrounds. Inhabits sloping, open woodland areas with predominantly native grassy groundlayers, particularly those dominated by Kangaroo Grass. Sites are typically well-drained, with rocky outcrops or scattered, partially-buried rocks. Commonly found beneath small, partially-embedded rocks and appear to spend considerable time in burrows below these rocks. The burrows have been constructed by, and are often still inhabited by, small black ants and termites (OEH 2012b).	None. No populations recorded nearby and habitat is unsuitable.	None. No populations recorded nearby and habitat is unsuitable.	None required.





## Appendix F

### Koala habitat assessment

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## F.1 Assessment in accordance with the Koala Referral Guidelines

The majority of the project area is cleared land that does not provide Koala habitat, while vegetation in the north-west and central northern parts of the project area contains remnant native vegetation, Koala habitat and Koalas. An assessment has been completed in accordance with the *EPBC Act referral guidelines for the vulnerable Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory)* (DoE 2014). Native vegetation, restricted to the north-west and central northern parts of the project area, contains habitat critical to the survival of the Koala (Table F.4).

### F.1.1 Koala habitat assessment for native vegetation in the project area

**Action:** Underground mining in the Southern Highlands, NSW. **Context:** Coastal

**Associated infrastructure:** Surface infrastructure facilities including a coal handling and processing plant and main infrastructure area

**Primary impacts:** Removal of isolated Koala feed trees on the edge of a larger continuous habitat area, potential localised impacts on an area of Koala habitat from groundwater drawdown in the event of prolonged drought

**Impact area:** As above

**Table F.1 Koala Referral Guidelines Assessment for native vegetation in the project area**

Attribute	Score	Data source	Habitat appraisal
Koala occurrence	+2 (high)	Desktop	<p>The NSW Atlas of Wildlife identifies three recent records (ie since 1980) in the project area.</p> <p>The Protected Matters Search Tool identifies that the species or its habitat is known to occur in the area.</p> <p>The Australian Koala Foundation Koala Map identifies that four healthy Koalas have been recorded directly south of Belanglo State Forest between 2008-2011. One sighting was of a female with a joey.</p>
		On-ground	<p>Vegetation communities containing Koala feed tree species for the SCKMA and CCKMA were mapped for the project area. Seventy two scat searches were completed in the project area using the Spot Assessment Technique (Phillips and Callaghan 2011). Only two Koala scats were found, one in Belanglo State Forest and one in vegetation along the upper reaches of Oldbury Creek. High rainfall in the project area is considered to affect the ability to detect Koala scats.</p> <p>Nocturnal spotlighting was completed over eight nights in the project area and searches for resting Koalas were completed in the day. Six adult Koalas (2 females and 4 males) were observed in the north-west part of the project area (Belanglo State Forest). All were in good health and showed no visible signs of Chlamydia. One male was observed calling along Belanglo Creek during the breeding season, indicating that Koalas may be breeding in the area.</p>
Vegetation structure and composition	+2 (high)	Desktop	<p>The project is on the boundary of the CCKMA and SCKMA. Primary food trees for the CCKMA include Parramatta Red Gum (<i>Eucalyptus parramattensis</i>), Forest Red Gum (<i>E. tereticornis</i>), Ribbon Gum (<i>E. viminalis</i>), Swamp Mahogany (<i>E. robusta</i>), Tallowwood (<i>E. microcorys</i>) and Cabbage Gum (<i>E. amplifolia</i>). Cabbage Gum, Ribbon Gum and Forest Red Gum are also primary food tree species for the SCKMA. The project area has native vegetation communities containing Cabbage Gum, a primary food tree species. It also contains Brittle Gum and Snow Gum (secondary feed tree species) and Blue-leaved Stringybark (a supplementary species).</p> <p>The Australian Koala Map (Koala Habitat) identifies all native vegetation in the north-west part of the project area (within Belanglo State Forest) as potential Koala habitat, while cleared areas (characteristic of the majority of the project area) are not identified as providing Koala habitat.</p>
		On-ground	<p>On-ground surveys confirmed that native vegetation in Belanglo State Forest and along Oldbury Creek contains Koala habitat. Koalas were nearly always observed near creeks, either in River Peppermint Narrow-leaved Peppermint Open Forest, Grey Gum Blue-leaved Stringybark Open Forest or Brittle Gum Scribbly Gum shrubby woodland.</p>

**Table F.1 Koala Referral Guidelines Assessment for native vegetation in the project area**

Attribute	Score	Data source	Habitat appraisal
Habitat connectivity	+2 (high)	Desktop	Koala habitat within Belanglo State Forest and along Oldbury Creek has connectivity to larger tracts of habitat in state forests and national parks to the north, west and south. Koala habitat west of Belanglo State Forest connects with Bangadilly National Park. There is a continuous corridor of Koala habitat (indicated by the Koala Map) stretching north of this area through Bangadilly National Park to Nattai, Blue Mountains and Kanangra-Boyd National Parks. Habitat also continues south of Belanglo State Forest into Penrose State Forest and Morton National Park. Koala habitat in the eastern part of Belanglo State Forest connects directly to the north with a large vegetated area associated with the Wingecarribee River.
Key existing threats	+1 (medium)	Desktop	No sick, injured or dead Koalas have been recorded by the AKF Koala Map. One Koala roadkill was observed at the entrance to Belanglo Road in 2014 in agricultural land. No other roadkills have been recorded. Chlamydia has been identified from Koalas 20 km west of Mittagong (Wildlife Health and Conservation Centre, University of Sydney).
		On-ground	All Koalas observed in the project area were healthy, with no signs of Chlamydia (eg clear eyes, dry bottom).
Recovery value	+1 (medium)	Desktop and on-ground	Koala habitat which is restricted to the north-west and central northern parts of the project area is located on the edge of a larger area of contiguous Koala habitat, and the rural interface. It is subject to edge effects and risk of vehicle strike. Therefore, there is uncertainty whether the habitat is important for achieving the interim Koala recovery objectives.
Total score	8		Native vegetation in the project area is part of a larger area of critical habitat for the Koala (ie score is greater than five).





## Appendix G

### Assessments of significance

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## G.1 Significant impact criteria in accordance with the EPBC Act

The following sections provide the criteria that must be considered in the assessment of potential impacts to threatened ecological communities and species listed under the EPBC Act. There are separate criteria for each listing category under the EPBC Act, in accordance with *'EPBC Act Policy Statement 1.1 Significant Impact Guidelines: Matters of National Environmental Significance'* (DoE 2013).

### G.1.1 Significant impact criteria for critically endangered and endangered ecological communities

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:

- reduce the extent of an ecological community;
- fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines;
- adversely affect habitat critical to the survival of an ecological community;
- modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns;
- cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting;
- cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to:
  - assisting invasive species, that are harmful to the listed ecological community, to become established; or
  - causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community; or
- interfere with the recovery of an ecological community.

### G.1.2 Significant impact criteria for critically endangered and endangered species

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of a population;
- reduce the area of occupancy of the species;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of a species;

- disrupt the breeding cycle of a population;
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;
- introduce disease that may cause the species to decline; or
- interfere with the recovery of the species.

### G.1.3 Significant impact criteria for vulnerable species

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of an important population of a species;
- reduce the area of occupancy of an important population;
- fragment an existing important population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of an important population;
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat;
- introduce disease that may cause the species to decline; or
- interfere substantially with the recovery of the species.

### G.1.4 Significant impact criteria for listed migratory species

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;
- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

### G.1.5 Assessments of significance

Assessments of significance of the project's potential impacts have been made for each of the threatened ecological communities and species listed under the EPBC Act known or with potential to occur in the project area and surrounds (Table D.4). The assessments have been made with reference to the criteria given in Sections D.4.1 to D.4.4 and the outcomes are provided in the following sections.

#### i Critically endangered and endangered ecological communities: Southern Highlands Shale Woodland and Forest, Temperate Highland Peat Swamps on Sandstone and Robertson Basalt Tall Open Forest

Southern Highlands Shale Woodland and Forest is listed as a critically endangered ecological community under the EPBC Act. The community is located in the project area, however will not be directly impacted by the project. As patches of the community are located adjacent to access roads and some surface infrastructure components, there may be indirect impacts on the community. One patch of Southern Highlands Shale Woodland and Forest is in an area that has a high risk of drawdown impact during periods of prolonged drought. Accordingly, this assessment of significance has been prepared to assess indirect impacts on the community.

Temperate Highland Peat Swamps on Sandstone is listed as an endangered ecological community under the EPBC Act. The community is known to occur in the Long Swamp and Stingray Swamp. The project will not directly impact the community as it is located outside the surface infrastructure area.

Robertson Basalt Tall Open Forest is listed as an endangered ecological community under the EPBC Act. The community is predicted to occur along Black Bobs Creek. The project will not directly impact the community as it is located outside the surface infrastructure area.

Accordingly, this assessment of significance has been prepared to assess indirect impacts on these listed communities (Table G.1).

**Table G.1**      **Assessment of significance for Southern Highlands Shale Forest and Woodland, Temperate Highland Peat Swamps on Sandstone and Robertson Basalt Tall Open Forest**

Criteria	Discussion
1: reduce extent of EEC	<p>Several patches of Southern Highlands Shale Woodland and Forest are located in the project area. These patches will not be directly impacted as they are adjacent to the surface infrastructure area. Therefore, the project will not reduce the extent of the CEEC.</p> <p>Temperate Highland Peat Swamps on Sandstone occur in Long Swamp and Stingray Swamp in the terrestrial study area. The project does not involve any direct impacts to this ecological community as it is located outside the surface infrastructure area.</p> <p>Robertson Basalt Tall Open Forest is predicted to occur along Black Bobs Creek in the terrestrial study area. The project does not involve any direct impacts to this ecological community as it is located outside the surface infrastructure area.</p> <p>Therefore, the project will not reduce the extent of these listed communities.</p>
2: fragment an EEC	<p>The project does not involve any direct impacts to these ecological communities, and therefore fragmentation will not occur.</p>



**Table G.1      Assessment of significance for Southern Highlands Shale Forest and Woodland, Temperate Highland Peat Swamps on Sandstone and Robertson Basalt Tall Open Forest**

Criteria	Discussion
3: adversely affect critical habitat for an EEC	<p>Southern Highlands Shale Forest and Woodland in the project area provides habitat critical to the survival of the community as it meets the condition thresholds for moderate quality, in accordance with the approved conservation advice (DoE 2015). This critical habitat will not be directly impacted by the project as the patches are located outside the surface infrastructure footprint. Surface infrastructure components including a conveyor, ventilation shaft and dam will be constructed next to the critical habitat and will not have a direct impact on this EEC. The boundaries of the community will be clearly delineated and fenced to avoid adverse impacts from adjacent construction (ie accidental overclearing, stockpiling or vehicle parking).</p> <p>Critical habitat has not been declared for Temperate Highland Peat Swamps on Sandstone. Habitat critical to the survival of an EEC is defined as areas necessary for the long-term maintenance of the ecological community. Given the community's naturally restricted distribution, Long Swamp and Stingray Swamp are considered critical to the survival of the community in the Southern Highlands. This critical habitat will not be directly impacted by the project as it is outside the project boundary and surface infrastructure area.</p> <p>An area of Stingray Swamp has a low to moderate risk of water table drawdown. Stingray Swamp is likely to be a headwater swamp (following Commonwealth of Australia 2014) fed by perched groundwater systems that are not connected to the water table. Therefore, no drawdown-related impacts are expected to occur at Stingray Swamp.</p> <p>Long Swamp is likely to be a valley infill swamp (following Commonwealth of Australia 2014) that takes water from rainfall, surface runoff and groundwater. Although the water table is shallow at Long Swamp, it is outside the maximum drawdown footprint at Year 17 of mining. A low to moderate risk of drawdown is predicted in terrestrial vegetation upstream of Long Swamp. Groundwater flows through valley infill swamps are predicted to be along the surface of the peat, up through the peat or channels within the peat. Therefore, the low to moderate risk of drawdown in terrestrial vegetation upstream of Long Swamp is not predicted to result in drawdown-related impacts.</p> <p>Given the highly restricted nature of Robertson Basalt Tall Open Forest, all occurrences are considered important to the community's survival. There will be no direct impacts to the community as it is located outside the surface infrastructure areas. Drawdown-related impacts are not expected along Black Bobs Creek where the community is predicted to occur as there is only a low to moderate risk of drawdown impact, and the water table will stay within the root zone of the eucalypts which would be the main component of the ecosystem opportunistically drawing on groundwater.</p>
4: modify or destroy abiotic factors	<p>A patch of Southern Highlands Shale Forest and Woodland along Wells Creek has a facultative (opportunistic) dependence on the subsurface presence of groundwater. This area has a higher risk of drawdown impact. Facultative (opportunistic) ecosystems can respond to changes in the water table as they also take their water requirements from rainfall and surface flow. However, they may experience impacts during periods of prolonged drought. Should a period of prolonged drought be experienced during the project, monitoring and management triggers will be implemented. Therefore, the abiotic factors that the community has a facultative (opportunistic) dependence on will not be destroyed or substantially modified by the project.</p> <p>Drawdown-related impacts are not predicted for Stingray Swamp or Long Swamp (see response to Question 3). Therefore, the abiotic factors that Temperate Highlands Peat Swamps on Sandstone rely on will not be destroyed or substantially modified by the project.</p> <p>Drawdown-related impacts are not predicted for at Black Bob's Creek (see response to Question 3). Therefore, the abiotic factors that Robertson Basalt Tall Open Forest relies on will not be destroyed or substantially modified by the project.</p>

**Table G.1      Assessment of significance for Southern Highlands Shale Forest and Woodland, Temperate Highland Peat Swamps on Sandstone and Robertson Basalt Tall Open Forest**

Criteria	Discussion
5: substantial change in composition of an EEC	As the communities will not be directly impacted, groundwater-related impacts are not predicted for Temperate Highland Peat Swamps or Robertson Basalt Tall Open Forest, and potential impacts on Southern Highlands Shale Forest and Woodland can be effectively managed. No substantial change in composition of the communities is predicted to result from the project.
6: substantial reduction in quality or integrity of EEC	As the communities will not be directly impacted, groundwater-related impacts are not predicted for Temperate Highland Peat Swamps or Robertson Basalt Tall Open Forest, and potential impacts on Southern Highlands Shale Forest and Woodland can be effectively managed. No substantial reduction in the quality or integrity of the communities are predicted to result from the project.
7: interfere with recovery	<p>High priority recovery actions for Southern Highlands Shale Forest and Woodland in the approved conservation advice (DoE 2015) focus on protection and improvement of the community. The project is consistent with high priority recovery actions as direct impacts have been avoided, and indirect impacts can be effectively managed.</p> <p>Temperate Highland Peat Swamps on Sandstone does not currently have a recovery plan and no specific recovery actions have been identified for Long Swamp or Stingray Swamp. As no direct impacts will occur and groundwater-related impacts are not predicted, the project will not interfere with the EEC's recovery.</p> <p>Robertson Basalt Tall Open Forest does not currently have a recovery plan. However, as the community will not be directly or indirectly impacted by the project, it will not interfere with the recovery of the community.</p>
Conclusion	<p>The project is unlikely to result in significant impacts on Southern Highlands Shale Forest and Woodland, Temperate Highland Peat Swamps on Sandstone or Robertson Basalt Tall Open Forest as:</p> <ul style="list-style-type: none"> <li>• direct impacts on the communities have been avoided;</li> <li>• drawdown impacts are not expected on Temperate Highland Peat Swamps and Robertson Basalt Tall Open Forest;</li> <li>• drawdown impacts on Southern Highlands Shale Forest and Woodland are only expected to occur during periods of prolonged drought, and can be effectively managed through implementation of the proposed monitoring and management measures.</li> </ul>

ii      Endangered species associated with Temperate Highland Peat Swamps on Sandstone: Australasian Bittern and Australian Painted Snipe

The Australasian Bittern and Australian Painted Snipe are listed as endangered species under the EPBC Act. These species are known or predicted to be associated with the Temperate Highland Peat Swamps on Sandstone at Long Swamp and Stingray Swamp, in the study areas. An assessment of significance has been completed to assess potential impacts from the project on these endangered species (Table G.2).

**Table G.2      Assessment of significance for endangered species associated with Temperate Highland Peat Swamps on Sandstone: Australasian Bittern and Australian Painted Snipe**

Criteria	Discussion
1: long-term decrease in population size	<p>The Australasian Bittern and Australian Painted Snipe are predicted to occur in the Temperate Highland Peat Swamps on Sandstone at Long Swamp and Stingray Swamp.</p> <p>Given the location of the swamps outside the project area, direct impacts will not occur. An area of Stingray Swamp has a low to moderate risk of water table drawdown. Stingray Swamp is likely to be a headwater swamp (following Commonwealth of Australia 2014) fed by perched groundwater systems that are not connected to the water table. Therefore, no drawdown-related impacts are expected to occur at Stingray Swamp.</p> <p>Long Swamp is likely to be a valley infill swamp (following Commonwealth of Australia 2014) that takes water from rainfall, surface runoff and groundwater. Although the water table is shallow at Long Swamp, it is outside the maximum drawdown footprint at Year 17 of mining. A low to moderate risk of drawdown is predicted in terrestrial vegetation upstream of Long Swamp. Groundwater flows through valley infill swamps are predicted to be along the surface of the peat, up through the peat or channels within the peat. Therefore, the low to moderate risk of drawdown in terrestrial vegetation upstream of Long Swamp is not predicted to result in drawdown-related impacts.</p> <p>As their habitats will not be directly or indirectly impacted, the project is unlikely to result in a long-term decrease in population sizes of these endangered species.</p>
2: reduce area of occupancy	<p>Given the location of the swamps outside the project area, direct impacts will not occur. Therefore, the project is unlikely to reduce the area of occupancy of these endangered species.</p>
3: fragment a population	<p>Given the location of the swamps outside the project area, direct impacts will not occur. Therefore, populations of these endangered species will not be fragmented by the project.</p>
4: adversely affect critical habitat	<p>Critical habitat has not been declared for any of these endangered species. Habitat critical to the survival of a species is defined in DoE (2013) as areas necessary for the long-term maintenance of the species. As the Australasian Bittern and Australian Painted Snipe are mobile species that are not restricted to Long Swamp and Stingray Swamp, these areas are not considered to represent habitat critical to their survival. As no drawdown-related impacts are expected and the swamps do not represent habitat critical to their survival, critical habitat for the species is unlikely to be impacted by the project.</p>
5: disrupt the breeding cycle of a population	<p>The Australasian Bittern and Australian Painted Snipe are both known to breed and construct their nests in swamps. Given the location of the swamps outside the project area and that no drawdown-related impacts are predicted to result from the project, the breeding cycle of populations of these endangered species is unlikely to be disrupted.</p>
6: modify, destroy, remove, isolate or decrease availability or quality of habitat	<p>Given the swamp's location outside the project area, the availability and quality of habitat for these endangered species will not be modified, destroyed or isolated.</p>
7: result in invasive species	<p>Given the location of the swamps outside the project area, there will be no direct impacts. The project will not result in the introduction or spread of invasive plant or animal species.</p>
8: introduce disease	<p>These endangered species are not known to be subject to any diseases. Given the location of the swamps outside the project area, there will be no direct impacts. The project will not result in the introduction or spread of disease.</p>



**Table G.2**      **Assessment of significance for endangered species associated with Temperate Highland Peat Swamps on Sandstone: Australasian Bittern and Australian Painted Snipe**

Criteria	Discussion
9: interfere with recovery	Recovery plans have not been prepared for these endangered species. As no direct or indirect impacts will occur to their habitat, the project is unlikely to interfere with the recovery of their habitats and populations.
Conclusion	The project is unlikely to result in significant impacts on the Australasian Bittern as: <ul style="list-style-type: none"> <li>• there will be no direct impacts to the swamps as a result of the project; and</li> <li>• drawdown-related impacts are not predicted in swamp habitats.</li> </ul>

### iii      **Endangered species: Paddys River Box**

Paddys River Box is listed as an endangered species under the EPBC Act. It occurs in the Southern Highlands and the Blue Mountains. In the Southern Highlands, it occurs mainly on agricultural land and roadsides. It has been estimated that Paddys River Box trees on some agricultural properties are greater than 200 years old, with no regeneration occurring.

Thirty four Paddys River Box trees occur in the project area, and they are also known to occur at Long Swamp and Stingray Swamp. The species will not be directly impacted by the project. Therefore, an assessment of significance has been completed in accordance with the species conservation advice (DoE 2016b) to assess potential indirect impacts of the project on Paddys River Box (Table G.3).

**Table G.3**      **Assessment of significance for Paddys River Box**

Criteria	Discussion
1: long-term decrease in population size	<p>The Paddys River Box population in the Southern Highlands has been estimated at 10,000 individual trees (TSSC 2016). Given their endangered conservation status and the general absence of recruitment of mature trees, the placement of surface infrastructure has avoided direct impacts to Paddys River Box trees.</p> <p>Paddys River Box occurs along drainage lines in the terrestrial study area, indicating that surface water flow fulfils part of the species water requirements. Existing surface flows will be maintained at all drainage lines where Paddys River Box occurs in the terrestrial study area, with the exception of Oldbury Creek. Treated excess mine water will be discharged sporadically near Oldbury Creek. This is expected to have a negligible to positive impact on Paddys River Box as the area will receive additional (however sporadic) surface flows.</p> <p>Paddys River Box also occurs along Wells Creek and Medway Rivulet. They are part of the terrestrial vegetation that has a facultative (opportunistic) dependence on subsurface groundwater. Terrestrial vegetation along Medway Rivulet has a low to moderate risk of drawdown impact. No impacts are expected at Medway Rivulet as the water table is predicted to remain within the root zone (ie 10 mbgl) during mining.</p> <p>Terrestrial vegetation along Wells Creek has been identified as having a high risk and Medway Rivulet has a low to moderate risk of drawdown impact, as the water table will be greater than 10 mbgl during mining. As terrestrial vegetation has a facultative (opportunistic) dependence on groundwater, the ecosystem should be able to respond to changes in the water table outside of periods of prolonged drought. Should prolonged drought occur during mining, monitoring and management measures will be implemented to manage the Paddys River Box on Wells Creek.</p> <p>Paddys River Box is also known to occur at Long Swamp and Stingray Swamp. As these swamps are located outside the surface infrastructure areas, they will not be directly impacted by the project. In addition, drawdown-related impacts are not predicted at the swamps.</p>

**Table G.3      Assessment of significance for Paddys River Box**

Criteria	Discussion
	As the design avoids direct impacts to the species (see response to question 1), and potential indirect impacts can be effectively managed, the project will not lead to a long-term decrease in Paddys River Box population size.
2: reduce area of occupancy	The area of occupancy for Paddys River Box has been estimated at 144 km <sup>2</sup> . As the design largely avoids direct impacts to the species and indirect impacts can be effectively managed, the project will not reduce Paddys River Box area of occupancy.
3: fragment a population	Paddys River Box trees occur along Wells Creek, Medway Rivulet, and north of Oldbury Creek in the project area. The population of Paddys River Box along Medway Rivulet occurs on either side of the elevated conveyor, which has been designed to avoid direct impacts on the species. As the species is pollinated by mobile birds and insects, and seeds can be dispersed by wind (DoE 2016), the conveyor is unlikely to fragment the population.
4: adversely affect critical habitat	<p>Critical habitat has not been declared for Paddys River Box on the Register of Critical Habitat under the EPBC Act. Habitat critical to the survival of endangered species is defined by the <i>Matters of National Environmental Significance Significant Impact Guidelines 1.1</i> (DoE 2013) as areas that are necessary:</p> <ul style="list-style-type: none"> <li>• for activities such as foraging, breeding, roosting or dispersal;</li> <li>• for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators);</li> <li>• to maintain genetic diversity and long-term evolutionary development; or</li> <li>• for the re-introduction of populations or recovery of the species or ecological community.</li> </ul> <p>Such habitat may be, but is not limited to, habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act.</p> <p>Individuals in the project area are considered to represent habitat critical to the survival of the species given their occurrence in large aggregations. These individuals will not be directly impacted by the project and indirect impacts can be effectively managed during periods of prolonged drought through implementation of the proposed monitoring and management measures.</p>
5: disrupt the breeding cycle of a population	Paddys River Box flowers from January to February, and pollen is collected by birds and insects. Seeds are dispersed by wind and gravity (DoE 2016). As direct impacts will be avoided and potential indirect impacts can be effectively managed, mature Paddys River Box trees that would produce seed will not be impacted.
6: modify, destroy, remove, isolate or decrease availability or quality of habitat	All direct impacts on Paddys River Box have been avoided and potential indirect impacts can be effectively managed through implementation of the proposed monitoring and management measures. The project will not result in fragmentation of Paddys River Box trees. This is discussed further in the response to Question 3.
7: result in invasive species	Paddys River Box in the terrestrial study area occur in an agricultural setting that has an exotic-dominated understorey. Therefore, the disturbance of soil for construction is unlikely to introduce additional exotic species to the area.
8: introduce disease	Introduced individuals of Paddys River Box to Africa are susceptible to infection by a fungus, <i>Phytophthora nicotianae</i> . This fungus occurs in Australia, although has not been observed to impact Paddys River Box, and is not known to occur in the Southern Highlands (ALA 2016).

**Table G.3 Assessment of significance for Paddys River Box**

Criteria	Discussion
9: interfere with recovery	Recovery actions for Paddys River Box are outlined in the species conservation advice (DoE 2016b). Primary conservation actions relate to the prevention of habitat destruction, maintenance and enhancement of existing and potential habitats, prevention of grazing and weed management. As direct impacts will be avoided, and potential indirect impacts can be effectively managed, the project does not interfere with the species' recovery.
Conclusion	The project is unlikely to result in significant impacts on Paddys River Box as: <ul style="list-style-type: none"> <li>• direct impacts have been avoided by the project design; and</li> <li>• indirect impacts can be effectively managed through implementation of the proposed monitoring and mitigation measures.</li> </ul>

**iv Vulnerable species associated with Temperate Highland Peat Swamps on Sandstone: Dwarf Phyllota, Broad-leaved Sally and Littlejohns Tree Frog**

Dwarf Phyllota, Broad-leaved Sally and Littlejohns Tree Frog are listed as vulnerable species under the EPBC Act. These species are known or predicted to be associated with the Temperate Highland Peat Swamps on Sandstone at Long Swamp and Stingray Swamp in the study areas. The project will not directly impact these species as the swamps are located outside the surface infrastructure areas. Accordingly, this assessment of significance has been completed to assess potential indirect impacts of the project on these vulnerable species (Table G.4).

**Table G.4 Assessment of significance for vulnerable species associated with Temperate Highland Peat Swamps on Sandstone**

Criteria	Discussion
1: long-term decrease of an important population	<p>Long Swamp and Stingray Swamp are likely to contain important populations of the Dwarf Phyllota, as it is one of only three areas the species is known to occur. They are also likely to contain an important population of Broad-leaved Sally, which is only known to occur in the Penrose area. They are also likely to contain an important population of Littlejohns Tree Frog, as although the species has a wide distribution, remaining populations are small.</p> <p>Given the location of the swamps outside the project area, direct impacts will not occur to the habitat of these important populations. An area of Stingray Swamp has a low to moderate risk of water table drawdown. Stingray Swamp is likely to be a headwater swamp (following Commonwealth of Australia 2014) fed by perched groundwater systems that are not connected to the water table. Therefore, no drawdown-related impacts are expected to occur at Stingray Swamp.</p> <p>Long Swamp is likely to be a valley infill swamp (following Commonwealth of Australia 2014) that takes water from rainfall, surface runoff and groundwater. Although the water table is shallow at Long Swamp, it is outside the maximum drawdown footprint at Year 17 of mining. A low to moderate risk of drawdown is predicted in terrestrial vegetation upstream of Long Swamp. Groundwater flows through valley infill swamps are predicted to be along the surface of the peat, up through the peat or channels within the peat. Therefore, the low to moderate risk of drawdown in terrestrial vegetation upstream of Long Swamp is not predicted to result in drawdown-related impacts.</p> <p>As their habitats will not be directly or indirectly impacted, the project is unlikely to result in a long-term decrease in important populations of the Dwarf Phyllota, Broad-leaved Sally and Littlejohns Tree Frog.</p>



**Table G.4      Assessment of significance for vulnerable species associated with Temperate Highland Peat Swamps on Sandstone**

Criteria	Discussion
2: reduce area of occupancy of an important population	Given the location of the swamps outside the project area, direct impacts will not occur to the habitat of these important populations. Additionally, no indirect drawdown-related impacts are predicted for the swamps. Therefore, the project is unlikely to reduce the area of occupancy of important populations of the Dwarf Phyllota, Broad-leaved Sally and Littlejohns Tree Frog.
3: fragment an important population	Fragmentation of important populations of the Dwarf Phyllota, Broad-leaved Sally and Littlejohns Tree Frog will not occur as the swamps in which they are located are outside the project area, and thus direct impacts are avoided. Additionally, no indirect drawdown-related impacts are predicted in the habitat of these important populations. Therefore, important populations of these species will not be fragmented by the project.
4: adversely affect critical habitat	Critical habitat has not been listed for these species, and therefore critical habitat will not be adversely affected. Important habitat has been identified in Paddys River Swamps for Dwarf Phyllota, Broad-leaved Sally and Littlejohns Tree Frog due to their restricted distributions and small population sizes. This important habitat will not be directly or indirectly affected by the project.
5: disrupt the breeding cycle of an important population	<p>The important populations of Dwarf Phyllota and Broad-leaved Sally and Littlejohns Tree Frog would be dependent upon surface and groundwater availability to complete their breeding cycle. As no drawdown-related impacts are predicted to occur, the project is unlikely to disrupt the breeding cycle of these important populations.</p> <p>Given the location of the swamps outside the project area and that no indirect drawdown-related impacts are predicted to result from the project, the breeding cycle of populations of these endangered species is unlikely to be disrupted.</p>
6: modify, destroy, remove or isolate or decrease availability or quality of habitat	Given the swamp's location outside the project area, the availability and quality of habitat for these vulnerable species will not be modified, destroyed or isolated.
7: result in invasive species	As no direct impacts will occur at the swamps, invasive plant or animal species will not be introduced to the swamps.
8: introduce disease	Eucalypt species such as Broad-leaved Sally can be susceptible to <i>Phytophthora cinnamomi</i> , the root rot fungus, in areas where vegetation and soil is disturbed. As the swamps will not be directly impacted, the project will not introduce the root rot fungus to these swamps.
9: interfere with recovery	Dwarf Phyllota, Broad-leaved Sally and Littlejohns Tree Frog do not currently have recovery plans or actions. However, as no direct or indirect impacts are predicted to occur to these species, the project is unlikely to interfere with their recovery.
Conclusion	<p>The project is unlikely to result in significant impacts to vulnerable species associated with Temperate Highland Peat Swamps on Sandstone as:</p> <ul style="list-style-type: none"> <li>• there will be no direct impacts to their habitat as a result of the project; and</li> <li>• indirect habitat impacts such as drawdown-related impacts are not predicted at the swamps.</li> </ul>

## v Vulnerable mammals recorded in the project area: Koala and Large-eared Pied Bat

The Koala is listed as a vulnerable species under the EPBC Act. Six healthy individuals were recorded during surveys in the north-east of Belanglo State Forest between 2013 and 2015. A Koala scat was recorded in vegetation along Oldbury Creek in 2015. The north and north-western parts of the project area contain primary, secondary and supplementary Koala habitat, and are on the eastern edge of a Koala movement corridor which connects with several national parks and nature reserves. Koala habitat in the project area connects to larger tracts of habitat in adjoining national parks. This larger area of habitat (extending into the north-western parts of the project area) contains an important population of Koalas, and is considered to be of part of an area of habitat critical to the species survival in the area (see Appendix D.3). Koalas have also been recorded in terrestrial vegetation upstream of Long Swamp and near Black Bobs Creek in the terrestrial study area.

The Large-eared Pied Bat is listed as a vulnerable species under the EPBC Act. Three calls from this species (confidently identified) were recorded on an ultrasonic detector directly north of the project area on Longacre Creek in 2013. This creek flows into the north-eastern part of the project area. Three calls of this species were also recorded on an ultrasonic detector in vegetation associated with Oldbury Creek in the project area. Vegetation along drainage lines would provide foraging opportunities for the species and sandstone escarpments along Oldbury Creek, Longacre Creek and Red Arm Creek may provide shelter habitat, although no evidence was recorded during targeted roost searches.

The project area and surrounds is not considered critical to the survival of the Large-eared Pied Bat. Important habitat for the species includes fertile vegetated valleys (foraging habitat) adjacent to sandstone cliffs (shelter/breeding habitat) (DECC 2007). The majority of vegetation in fertile valleys of the project area has been cleared for agriculture in the past. Additionally, roost sites were not found during targeted roost searches.

An assessment of significance has been completed to assess potential impacts of the project on the Koala and Large-eared Pied Bat (Table G.5).

**Table G.5** Assessment of significance for vulnerable mammals recorded in the project area: Koala and Large-eared Pied Bat

Criteria	Discussion
1: long-term decrease of an important population	<p>The majority of the project area comprises cleared land that has little habitat value for the Koala. Preferred feed trees are generally absent from these areas and movement would be difficult through large open areas of land.</p> <p>However, vegetated areas and creeks in the north-western and central northern parts of the project area form part of an important population of Koalas that extends into adjoining national parks. The Koala habitat assessment tool from the EPBC Act Referral Guidelines for the vulnerable Koala (DoE 2014) was used to assess the quality of Koala habitat in these parts of the project area, and a score of 8 out of 10 was calculated (refer to Appendix E).</p> <p>The design of the surface infrastructure area has been optimised to avoid important areas of Koala habitat, including along Oldbury Creek, where evidence of an individual was recorded. Isolated paddock trees of poorer habitat value to the Koala than intact vegetation will be removed directly south of Oldbury Creek. The removal of these individual trees is not expected to cause a long-term decrease in the Koala population, as the vegetated corridor (where evidence of a Koala was recorded) has been avoided by the project design.</p> <p>Given its location adjacent to an area of known Koala habitat, there may be an increased risk of Koala road strike in the surface infrastructure area. Fauna-friendly fencing will be installed between Oldbury Creek and the surface infrastructure area to prevent Koalas from entering the surface infrastructure area.</p>

**Table G.5      Assessment of significance for vulnerable mammals recorded in the project area: Koala and Large-eared Pied Bat**

Criteria	Discussion
	<p>An action that results in changes to water quality or quantity that degrades habitat critical to the survival of the Koala is identified in the EPBC Act referral guidelines for the vulnerable Koala (DoE 2014) as having potential impacts on the species. Terrestrial vegetation that represents Koala habitat is located on the Wingecarribee River in Medway, Black Bobs Creek near Canyonleigh, Oldbury Creek and Long Swamp Creek and has a low to moderate risk of drawdown. As this terrestrial vegetation has a facultative (opportunistic) dependence on groundwater and the water table is predicted to stay within the tree root zone (ie less than 10 mbgl), these areas of Koala habitat are not expected to be impacted.</p> <p>Terrestrial vegetation that represents Koala habitat along Belanglo Creek has a higher risk of drawdown impact. As this terrestrial vegetation has a facultative (opportunistic) dependence on groundwater, it can respond to changes in the water table outside of prolonged drought periods. Should prolonged drought occur, monitoring and management measures will be implemented to manage Koala habitat in this area such that impacts do not occur.</p> <p>An important population of the Large-eared Pied Bat is not considered to occur in the project area, due to the absence of fertile foraging habitat and known roost sites.</p>
2: reduce area of occupancy of an important population	<p>Koala habitat constitutes 636 ha of the project area and they are known to be widely distributed in Belanglo State Forest, adjacent to the project area. The potential removal of paddock trees constituting poorer quality Koala habitat is not expected to reduce the important population's area of occupancy.</p> <p>As drawdown-related impacts are not predicted to occur throughout much of its habitat in the terrestrial study area, and impacts can be effectively managed during periods of prolonged drought, the project is not expected to reduce the important population's area of occupancy.</p> <p>An important population of the Large-eared Pied Bat is not considered to occur in the project area, due to the absence of fertile foraging habitat and known roost sites.</p>
3: fragment an important population	<p>Vegetated creeks within and adjacent to the project area would facilitate Koala movement. A conveyor will be constructed over Medway Rivulet, however this will be elevated such that connectivity along Medway Rivulet will be maintained.</p> <p>An important population of the Large-eared Pied Bat is not considered to occur in the project area, due to the absence of fertile foraging habitat and known roost sites.</p>
4: adversely affect critical habitat	<p>Vegetated creeks in the project area and open forest in Belanglo State Forest provide important Koala habitat and facilitate Koala movement. These Koala movement corridors will be retained.</p> <p>As drawdown-related impacts are not predicted to occur throughout much of the Koala habitat in the terrestrial study area, and impacts can be effectively managed during periods of prolonged drought, the project is not expected to affect critical habitat.</p> <p>The EPBC Act referral guidelines for the vulnerable Koala (DoE 2014) identifies the construction of new mines adjacent to areas of habitat critical to the survival of the Koala as having potential impacts, due to the increased fire risk. Given the location of the surface infrastructure adjacent to an area of known Koala habitat along Oldbury Creek, the fire risk to habitat in this area may be increased. Measures to minimise the fire risk have been documented in the Hazard and Risk Assessment, in Appendix P of the EIS.</p> <p>Critical habitat for the Large-eared Pied Bat is not considered to occur in the project area, due to the absence of fertile foraging habitat and known roost sites.</p>



**Table G.5      Assessment of significance for vulnerable mammals recorded in the project area: Koala and Large-eared Pied Bat**

Criteria	Discussion
5: disrupt the breeding cycle of an important population	<p>Koala breeding habitat will not be directly impacted as the design of the surface infrastructure has been optimised to avoid intact areas of native vegetation. The potential feed trees that may be removed for the project are not considered to contain suitable breeding habitat for the Koala given their isolation from the movement corridor along Oldbury Creek and a lack of vegetative cover.</p> <p>The elevated conveyor over Medway Rivulet will not impede dispersing Koalas searching for mates during the breeding season. Dispersing individuals looking for mates may also be subject to indirect impacts including light, dust and noise, particularly adjacent to the CHPP and MIA. The project includes light, dust and noise controls which will minimise the potential for indirect impacts to fauna, including the Koala.</p> <p>An important population of the Large-eared Pied Bat is not considered to occur in the project area, due to the absence of fertile foraging habitat and known roost sites.</p>
6: decrease availability or quality of habitat	<p>Direct impacts to Koala habitat areas are considered minor as the design of the surface infrastructure minimises impacts to such areas.</p> <p>As drawdown-related impacts are not predicted to occur throughout much of the Koala habitat in the terrestrial study area, and impacts can be effectively managed during periods of prolonged drought, the project is not expected to decrease the availability or quality of Koala habitat.</p> <p>Given the location of the surface infrastructure adjacent to an area of known Koala habitat along Oldbury Creek, the fire risk to habitat in this area may be increased. Measures to minimise bushfire risk have been proposed in the Hazard and Risk Assessment, in Appendix P of the EIS.</p> <p>No direct impacts will occur in Large-eared Pied Bat habitat. Additionally, subsidence impacts to cliffline habitats are predicted to be negligible. Therefore, the project is unlikely to decrease the availability or quality of habitat for the Large-eared Pied Bat.</p>
7: result in invasive species	<p>Domestic dogs (<i>Canis familiaris</i>) are known to prey on Koalas. As the project will not introduce domestic dogs to the area, the project will not result in invasive species that would adversely affect the Koala.</p> <p>Feral Goats (<i>Carpus hircus</i>) are known to degrade Large-eared Pied Bat roost sites. As no Feral Goats are present and will not be introduced to the area, invasive species that adversely affect the Large-eared Pied Bat will not result from the project.</p>
8: introduce disease	<p>Koalas are susceptible to Chlamydia, a sexually transmitted disease. All Koalas observed in the project area during surveys were in good health and free of the signs of Chlamydia. However, several records on the Atlas of NSW Wildlife state that Koalas in Canyonleigh, directly south of the project, have been observed with Chlamydia.</p> <p>In general, disease outbreaks occur when animals are stressed. As only paddock trees that represent poorer quality Koala foraging habitat will be removed, direct impacts to critical Koala habitats and movement corridors are not predicted and a disease outbreak is not predicted.</p> <p>Microbats species such as the Large-eared Pied Bat may be susceptible to Lyssavirus, a rabies-like virus. Lyssavirus outbreaks, like most diseases, generally occur as a result of stress in animal populations. As no direct impacts to habitat are expected, the project is not expected to cause stress to Large-eared Pied Bats such that a disease outbreak would occur.</p>
9: interfere with recovery	<p>The overall objective of the Recovery plan for the Koala (DECC 2008) is to reverse the decline of the Koala in NSW, to adequately protect, manage and restore Koala habitat and to maintain healthy breeding populations of Koalas throughout their current range. As the project has been optimised to minimise impacts to Koala habitat and potential indirect impacts (ie drawdown) can be effectively managed, the project is unlikely to interfere with recovery of the Koala.</p>

**Table G.5**      **Assessment of significance for vulnerable mammals recorded in the project area: Koala and Large-eared Pied Bat**

Criteria	Discussion
Conclusion	<p>The project is unlikely to result in significant impacts on the Koala as:</p> <ul style="list-style-type: none"> <li>the surface infrastructure design has been optimised to avoid direct impacts to critical Koala habitat;</li> <li>removal of up to 64 paddock trees is not expected to significantly impact the species;</li> <li>measures will be implemented to minimise bushfire risk to Koala habitat, and indirect impacts including light, noise and dust; and</li> <li>measures will be implemented to monitor and manage Koala habitat along Belanglo Creek in the event of prolonged drought.</li> </ul> <p>The project is unlikely to result in significant impacts to the Large-eared Pied Bat as:</p> <ul style="list-style-type: none"> <li>an important population of the species does not occur in the area;</li> <li>direct impacts will not occur in habitat areas;</li> <li>the project will use a non-caving mining method; and</li> <li>potential drawdown impacts in their habitat can be effectively managed during periods of prolonged drought.</li> </ul>

**vi**      **Migratory wetland birds with potential to occur in the project area and Temperate Highland Peat Swamps on Sandstone: Cattle Egret and Great Egret**

The Cattle Egret and Great Egret are listed as migratory terrestrial species under the EPBC Act. Neither species has been recorded in the project area, however potential foraging habitat exists in the agricultural areas following heavy rain. Cattle Egret breeding occurs outside the terrestrial study area from the central east coast to Bundaberg, and in inland wetlands including the Macquarie Marshes (DoE 2016b). Great Egret breeding occurs outside the project area, in the Northern Territory (DoE 2016b). Potential habitat also exists in the Temperate Highland Peat Swamps on Sandstone found in Long Swamp and Stingray Swamp in the study areas.

An assessment of significance has been completed to assess potential impacts on these migratory wetland birds (Table G.6).

**Table G.6**      **Assessment of significance for Great Egret and Cattle Egret**

Assessment part	Discussion
1: substantially modify important habitat	<p>The project area, Long Swamp and Stingray Swamp do not constitute an area of important habitat for these species, as an ecologically significant proportion (as defined under the guidelines (DEH 2006)) of their populations do not reside in these areas, no breeding occurs in these areas, it is not at the limit of their range and they are not known to be declining.</p> <p>The project will result in a minor reduction of potential foraging habitat adjacent to Oldbury Creek for construction of the surface infrastructure. However, the potential habitat to be removed is not considered important to the species in the area as this cleared habitat is widely available in the locality.</p>
2: result in invasive species	<p>These migratory species are known to be subject to predation by the European Red Fox. The European Red Fox has been recorded in the project area. The project does not involve any activities such as creation of new access roads through native vegetation, which could result in the introduction or spread of invasive species such as the European Red Fox.</p>

**Table G.6      Assessment of significance for Great Egret and Cattle Egret**

Assessment part	Discussion
3: disrupt lifecycle of ecologically significant proportion of population	An ecologically significant proportion of the Cattle Egret and Great Egret populations do not reside in the project area. In addition, breeding activity has not been observed in the project area and the project would not disrupt their migration patterns as they are both highly mobile species. Therefore the project will not disrupt the lifecycle of an ecologically significant proportion of the Cattle Egret or Great Egret population.
Conclusion	<p>The project is not expected to result in significant impacts to the Cattle Egret or Great Egret as:</p> <ul style="list-style-type: none"> <li>• important habitat will not be substantially modified;</li> <li>• the project will not increase the spread of invasive species; and</li> <li>• their lifecycle of an ecologically significant proportion of the population will not be disrupted.</li> </ul>

## G.2      Significant impact criteria in accordance with the TSC Act

Section 5A of the EP&A Act provides the criteria that must be considered in the assessment of the significance of potential impacts on all threatened species listed under the TSC Act. Assessment of Significance (known as the seven-part test) is made up of the following seven questions:

1. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction;
2. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction;
3. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
  - a) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction;
  - b) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction;
4. In relation to the habitat of a threatened species, population or ecological community:
  - a) the extent to which habitat is likely to be removed or modified as a result of the action proposed;
  - b) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action;
  - c) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality;
5. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly);



6. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan; and
7. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Assessments of significance are undertaken in accordance with *Threatened Species Assessment Guidelines: The Assessment of Significance* (DECC 2007).

### G.2.1 Assessments of significance

Species requiring additional assessment as identified in Appendix D and which are listed as threatened under the TSC Act were assessed using the seven-part test. Seven-part tests have been prepared in accordance with the criteria presented in Section F.2.

#### i Giant Dragonfly

The Giant Dragonfly lives in permanent swamps and bogs and requires some areas of open water and vegetation. The Giant Dragonfly is known from Stingray Swamp in the study areas.

The project will not directly impact the species as its habitat occurs outside the surface infrastructure areas. Accordingly, an assessment of significance has been completed to assess indirect impacts on the species (Table G.7).

**Table G.7 Assessment of significance for Giant Dragonfly**

Criteria	Discussion
1: life cycle of threatened species	<p>Female Giant Dragonflies lay their eggs into moss or soft ground in swamps and bogs. The larval stage is long and can last for 10 to 30 years before emerging as an adult dragonfly. The larvae live in long burrows in swamps.</p> <p>The Giant Dragonfly is known to occur in Stingray Swamp. Its life cycle will not be directly impacted by the project as the species occurs outside the surface infrastructure areas. An area of Stingray Swamp has a low to moderate risk of water table drawdown. Stingray Swamp is likely to be a headwater swamp (following Commonwealth of Australia 2014) fed by perched groundwater systems that are not connected to the water table. Therefore, no drawdown-related impacts are expected to occur at Stingray Swamp.</p>
2: life cycle of endangered population	The Giant Dragonfly is a threatened species. Therefore, this question is not relevant to this assessment.
3: EEC extent and modification	The Giant Dragonfly is a threatened species. Therefore, this question is not relevant to this assessment.
4: habitat removal, fragmentation, isolation and importance	Stingray Swamp is located outside the surface infrastructure area, and therefore the project will not result in any habitat removal or fragmentation. Habitat at Stingray Swamp is considered to be important to the species given that they exclusively occur in swamps which are naturally restricted in the landscape.
5: critical habitat	Critical habitat has not been declared for the Giant Dragonfly.
6: consistency with recovery or threat abatement plans	The Giant Dragonfly does not have a recovery plan. Recovery actions focus on habitat protection and improvement. As no direct impacts will occur in their habitat and drawdown-related impacts are not predicted, the project does not interfere with the species recovery.

**Table G.7      Assessment of significance for Giant Dragonfly**

Criteria	Discussion
7: key threatening processes	Key threatening processes to the species include changes to groundwater regimes resulting from longwall mining subsidence. As no longwall mining will occur for the project, and no longwall mining will occur under these swamps, the project will not exacerbate this key threatening process to the Giant Dragonfly.
Conclusion	<p>The project is unlikely to result in significant impacts on the Giant Dragonfly as:</p> <ul style="list-style-type: none"> <li>• no direct impacts that would affect the species will occur; and</li> <li>• drawdown-related impacts to habitat are not predicted.</li> </ul>

### G.3 References;

Atlas of Living Australia (ALA) 2016, *The Atlas of Living Australia*, [www.ala.org.au](http://www.ala.org.au), viewed March 2016.

Commonwealth of Australia 2014, Temperate Highland Peat Swamps on Sandstone: ecological characteristics, sensitivities to change, and monitoring and reporting techniques, Department of the Environment, Canberra.

Department of Environment (DoE) 2013, EPBC Act Policy Statement 1.1 Significant Impact Guidelines: Matters of National Environmental Significance, [www.environment.gov.au](http://www.environment.gov.au), viewed July 2016.

- 2014, *EPBC Act referral guidelines for the vulnerable Koala*, [www.environment.gov.au](http://www.environment.gov.au), viewed March 2016.
- 2016a, *Species threat and profile database*, [www.environment.gov.au](http://www.environment.gov.au), viewed March 2016.
- 2016b, *Conservation Advice for Paddys River Box*, [www.environment.gov.au](http://www.environment.gov.au), viewed July 2016.

Department of Environment and Climate Change (DECC) 2007, *Threatened species assessment guideline: the assessment of significance*, NSW DECC, Hurstville.

- 2008, *Recovery plan for the Koala (Phascolarctos cinereus)*, Department of Environment and Climate Change NSW, Sydney.

Threatened Species Scientific Committee (TSSC) 2015, *Approved Conservation Advice (including listing advice) for Southern Highlands Shale Forest and Woodland of the Sydney Basin Bioregion*, [www.environment.gov.au](http://www.environment.gov.au), viewed August 2016.



## Appendix H

### Biodiversity Credit Report and BioBanking Credit Report for potential offsets

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# Biodiversity credit report



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This report identifies the number and type of biodiversity credits required for a major project.

Date of report: 24/11/2016

Time: 8:52:26AM

Calculator version: v4.0

## Major Project details

**Proposal ID:** 196/2016/2557MP

**Proposal name:** Hume Coal Project

**Proposal address:** Unit 7-8 Clarence House 9 Clarence St Moss Vale NSW 2577

**Proponent name:** Hume Coal Pty Ltd

**Proponent address:** Unit 7-8 Clarence House 9 Clarence St Moss Vale NSW 2577

**Proponent phone:** 02 4869 8200

**Assessor name:** Katie Whiting

**Assessor address:** SUITE 1 20 CHANDOS ST St Leonards NSW 2065

**Assessor phone:** 02 9493 9500

**Assessor accreditation:** 196



Summary of ecosystem credits required

Plant Community type	Area (ha)	Credits created
Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion	8.30	100.55
Total	8.30	101

Credit profiles

1. Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion, (HN570)

Number of ecosystem credits created	101
IBRA sub-region	Moss Vale - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Inland Scribbly Gum - Brittle Gum low woodland of the eastern tablelands, South Eastern Highlands Bioregion, (HN543)  Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion, (HN570)	Moss Vale - Hawkesbury/Nepean  and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

Summary of species credits required

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Koala	Phascolarctos cinereus	8.30	216
Squirrel Glider	Petaurus norfolcensis	8.30	183
Southern Myotis	Myotis macropus	8.30	183

# BioBanking credit report



Office of  
Environment  
& Heritage

This report identifies the number and type of credits required at a BIOBANK SITE

Date of report: 10/11/2016

Time: 10:39:25AM

Calculator version: v4.0

## Biobank details

**Proposal ID:** 196/2016/3984B

**Proposal name:** Hume Coal Project and Berrima Rail Project offsets

**Proposal address:** Unit 7-8 Clarence House 9 Clarence St Moss Vale NSW 2577

**Proponent name:** Hume Coal Pty Ltd

**Proponent address:** Unit 7-8 Clarence House 9 Clarence St Moss Vale NSW 2577

**Proponent phone:** 02 4869 8200

**Assessor name:** Katie Whiting

**Assessor address:** SUITE 1 20 CHANDOS ST St Leonards NSW 2065

**Assessor phone:** 02 9493 9500

**Assessor accreditation:** 196

## Additional information required for approval:

- ☐ Use of local benchmark
- ☐ Expert report...
- ☐ Request for additional gain in site value



Ecosystem credits summary

Plant Community type	Area (ha)	Credits created
Black Gum grassy woodland of damp flats and drainage lines of the eastern Southern Tablelands, South Eastern Highlands Bioregion	2.90	40.00
Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion	29.10	332.00
Total	32.00	372

Credit profiles

1. Black Gum grassy woodland of damp flats and drainage lines of the eastern Southern Tablelands, South Eastern Highlands Bioregion, (HN504)

Number of ecosystem credits created	40
IBRA sub-region	Moss Vale - Hawkesbury/Nepean

2. Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion, (HN570)

Number of ecosystem credits created	332
IBRA sub-region	Moss Vale - Hawkesbury/Nepean

## Species credits summary

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Paddys River Box, Camden Woollybutt	Eucalyptus macarthurii	2.00	14
Koala	Phascolarctos cinereus	32.00	227
Large-eared Pied Bat	Chalinolobus dwyeri	32.00	227
Southern Myotis	Myotis macropus	32.00	227
Squirrel Glider	Petaurus norfolcensis	32.00	227

## Additional management actions

Additional management actions are required for:

Vegetation type or threatened species	Management action details
Black Gum grassy woodland of damp flats and drainage lines of the eastern Southern Tablelands, South Eastern Highlands Bioregion	Feral and/or over-abundant native herbivore control
Black Gum grassy woodland of damp flats and drainage lines of the eastern Southern Tablelands, South Eastern Highlands Bioregion	Fox control
Koala	Exclude miscellaneous feral species
Koala	Slashing
Large-eared Pied Bat	Feral and/or over-abundant native herbivore control
Paddys River Box, Camden Woollybutt	Control of feral pigs
Paddys River Box, Camden Woollybutt	Feral and/or over-abundant native herbivore control
Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion	Exclude commercial apiaries
Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion	Exclude miscellaneous feral species
Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion	Feral and/or over-abundant native herbivore control
Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion	Fox control
Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion	Slashing
Southern Myotis	Maintain or re-introduce natural flow regimes
Squirrel Glider	Fox control
Squirrel Glider	Slashing

## Appendix I

### Qualifications of study team

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**Table I.1**      **Qualifications of study team**

Team member	Qualifications	Role
Katie Whiting (EMM)	BSc, MWldMgt (Habitat), accredited biobanking assessor	Lead terrestrial ecologist responsible for survey design and implementation, report author
Cassandra Thompson (EMM)	BSc, MAppSc, accredited biobanking assessor	Assistance with terrestrial field surveys, advice on survey design and implementation
Malith Weerakoon (EMM)	BSc, MSc	Assistance with terrestrial field surveys
Dr Alison Hunt (Alison Hunt and Associates)	BSc, PhD, accredited biobanking assessor	Advice on terrestrial survey design and implementation Assistance with aquatic surveys
Isobel Crawford (Australian Botanical Surveys)	BA, BAppSc	Specialist botanist responsible for plot surveys and plant identification
Steve Sass (Envirokey)	BAppSc, CEnvP, accredited biobanking assessor	Specialist herpetologist, assistance with targeted Broad-headed Snake surveys
Brendan Ryan (OMVI Ecological)	BSc, MSc, accredited biobanking assessor	Specialist frog, mammal and bird ecologist, assistance with field surveys
Dilys Zhang (EMM)	BSc (Marine Biology) (Hons)	Assistance with field terrestrial surveys
Jemma Sargent (JSA Environmental)	BSc, Postgraduate Diploma (Applied Information Systems), Postgraduate Diploma (Applied Statistics, Resource Survey and Habitat Evaluation)	Lead aquatic ecologist responsible for survey design and implementation, aquatic reporting





## Appendix J

### Supporting aquatic information

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# Stygofauna Sampling Methodology Plan

## Hume Coal Project

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26 October 2015



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# 1. Introduction

## 1.1 Background

Hume Coal Pty Limited (Hume Coal) proposes to develop and operate an underground coal mine and associated mine infrastructure (Hume Coal Project) in the Southern Coalfield of New South Wales (NSW). Hume Coal holds exploration Authorisation 349 (A349) to the west of Moss Vale, in the Wingecarribee local government area (LGA). The underground mine is proposed to be developed within part of A349 and associated surface facilities within and north of A349.

An environmental impact statement (EIS) is currently being prepared as part of the project's assessment and approval processes under Commonwealth and State legislation. The EIS includes numerous technical assessments, including, but not limited to, groundwater, surface water, terrestrial ecology and aquatic ecology assessments. One aspect being assessed in these inter-related studies is the potential for impacts to ecosystems which utilise groundwater, including consideration of stygofauna.

In order to accurately predict potential impacts on the local environment, it is first necessary to characterise and understand the existing environment. The project's baseline monitoring and surveys are near complete and provide a good understanding of the existing environment. The monitoring, surveys and assessments are being conducted generally in accordance with the relevant guidelines, standards and policies, and in consultation with government agencies and other stakeholders. There are, however, no guidelines for stygofauna surveys or assessment in NSW.

Hume Coal commenced baseline stygofauna surveys in and around the project area in Autumn 2013. The stygofauna sampling methodology was developed by an experienced aquatic ecologist, with consideration to contemporary industry practice and sampling guidance and protocols used elsewhere in Australia. This report documents outcomes of a review of these practices, guidelines and protocols, and compares the methods adopted for the Hume Coal Project to them. Contextual information on other stygofauna studies conducted in the vicinity of the project area and other studies undertaken for similar projects are also provided. The detailed assessment methodology and outcomes will be reported in the EIS. (EMM 2015)

## 1.2 Study Area

The project area is located in the Southern Highlands region of NSW, approximately 100 km south-west of Sydney and 3 km west of the township of Moss Vale, in the Wingecarribee LGA. It sits within the southern region of the sedimentary Sydney Basin. The project area and surrounds are shown in Figure 1. It covers approximately 5,043 hectares (ha) within and north of A349.

The study area for the stygofauna assessment comprises the entirety of the project area and bores located surrounding the study area to monitor potential impacts to groundwater outside of the direct impact area (Figure 2).

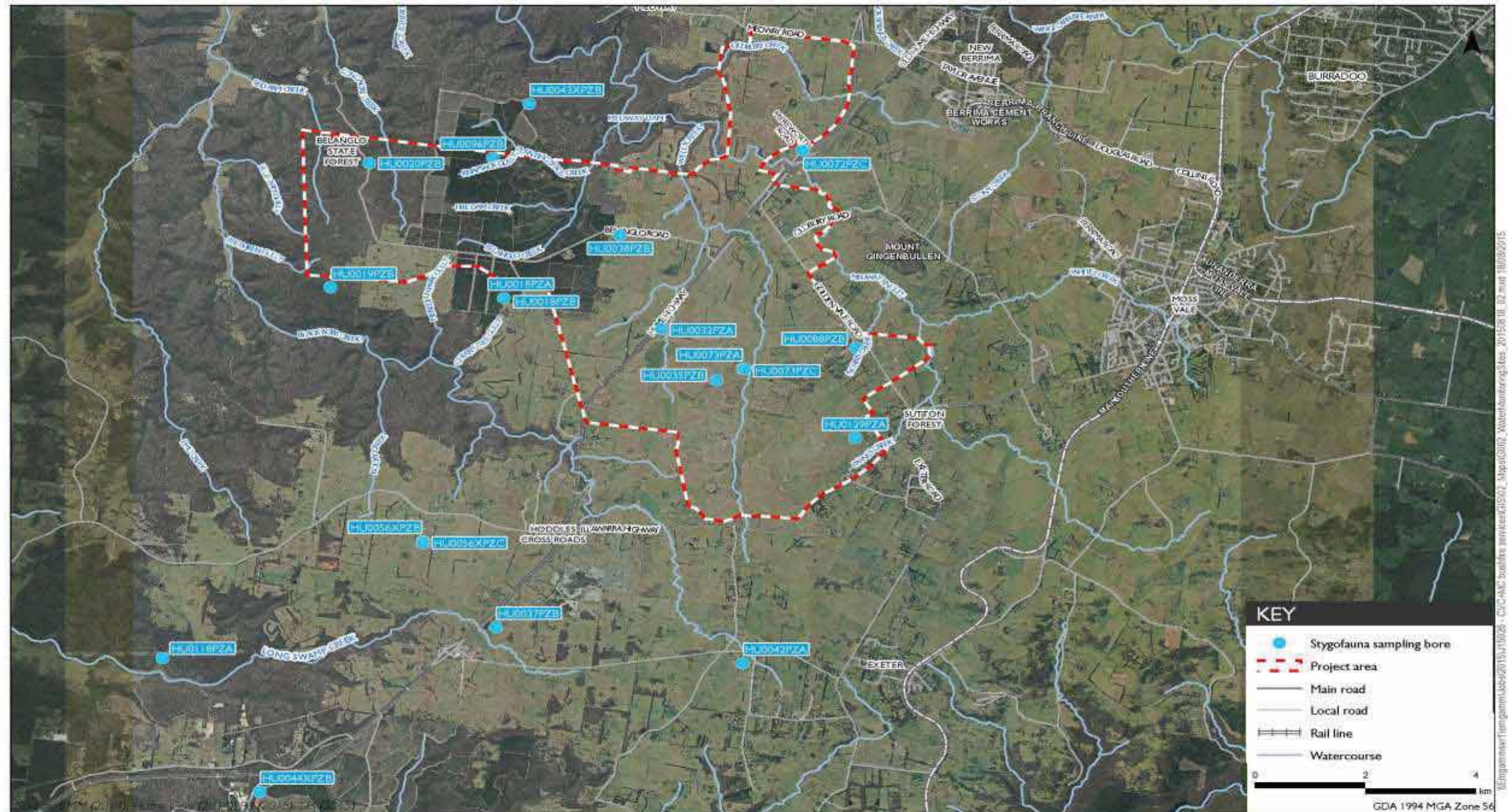


Figure 1 Hume Coal Project Location





Figure 2 Hume Coal Project Bore Locations







### 1.3 Aims of this Stygofauna Sampling Methodology Plan

This Stygofauna Sampling Methodology Plan (SSMP) provides a background to the stygofauna surveys undertaken for the Hume Coal Project and aims to:

- summarise existing standards, protocols and industry practices for stygofauna sampling, analysis and reporting and identify the most appropriate methods suitable for the Hume Coal Project to ensure the assessment is based on sound methodology, will accurately identify potential impacts and adequately informs mitigation measures;
- discuss suitability of groundwater borehole placement and sampling replication within and surrounding the project area for the stygofauna sampling program;
- identify stygofauna species previously identified within Southern NSW, based on the review of other stygofauna studies conducted in the vicinity of the project area; and
- discuss relevance of the Commonwealth Department of the Environment (DoE) Significant Impact Guidelines and NSW State Legislation and Policies.

The overarching aim of the SSMP is to ensure survey methodology and reporting will enable a well-informed, accurate assessment of the potential impacts of the Hume Coal Project on the stygofauna communities within the project area and surrounds. Due to the lack of relevant survey guidelines in NSW reliance has been made on guidelines from Western Australia (WA) and studies undertaken in NSW to ensure the survey and reporting will adequately address any potential impacts and mitigation measures. The SSMP has been developed to document the approach to the surveys to ensure they are rigorous and in accord with industry practice, which will in turn provide accurate and appropriately informed EIS reporting and prediction of impacts through a sound understanding of the project's groundwater systems.

The impact assessment will be made in conjunction with the surface and groundwater assessments, and form part of the EIS. It will consider potential impacts to stygofauna associated with any habitat disturbance, change to groundwater conditions such as water levels (drawdown or inundation), pressure or quality, or any change to surface water conditions which affect connected groundwater. The likely duration, extent and magnitude of potential impacts will be taken into account in making the assessment which can be determined from a series of characteristics including the proportion and extent of habitat removal, duration of impact, effects on water quality and hydrology, and degree of ecological isolation if contiguous habitat is interrupted (WA EPA 2007).

### 1.4 Groundwater Dependant Ecosystems

Groundwater Dependant Ecosystems (GDEs) represent a vital and significant component of the natural environment (ANZECC/ARMCANZ 2000) and can be simply defined as 'ecosystems that depend on groundwater for their existence and health'. Based on this definition, GDEs explicitly include any ecosystem that depends on groundwater at any time or for any duration in order to maintain its composition and condition.

GDEs include a broad range of ecosystems, from those that are highly specialised and possess unique biotic and abiotic characteristics that 'separate' them from other ecosystems that do not rely on groundwater to





survive, to more general terrestrial and aquatic ecosystems that have an opportunistic dependence on groundwater, or rely on it during times of drought.

The dependence on groundwater can be variable, ranging from partial and infrequent dependence (i.e. seasonal or episodic) to total continual dependence (entire/obligate). It is often difficult, however, to determine the nature of this dependence. A GDE's sensitivity to change is therefore dependent in part on its reliance on, or access to, groundwater, as well as its ability to disperse or relocate should the groundwater regime change.

## **1.5 Stygofauna**

Stygofauna are entirely groundwater dependent (obligate) and are restricted to locations of groundwater discharge or within aquifers and are considered shallow GDEs. Due to this dependence, stygofaunal communities are considered to be particularly sensitive to a range of factors that alter groundwater conditions such as groundwater levels, pressure, chemistry and aquifer structure.

Stygofauna communities in Australia consist almost entirely of invertebrates. The community composition is often dominated by crustaceans and oligochaetes, with smaller diversities of molluscs, insects and other invertebrate groups. The community composition is determined by a range of factors such as the type of aquifer, geological/geomorphic history, size of pore spaces, water chemistry and landscape context (i.e. position within the catchment and the association with river systems and the coast). Stygofauna can occur in any aquifer with sufficient pore space and connectivity within the substrate matrix, for example limestone karsts and caves, calcrete formations, lava tubes and fractured rock aquifers, but occur most commonly in alluvial aquifers. Within these environments they, in association with the microbial/bacterial community, take on the same roles as surface water aquatic invertebrates, by contributing to water quality through processes such as biochemical processing and filtration. Due to this intrinsic relationship with the physico-chemical parameters of the aquifer they are considered to be good indicators of groundwater health.

Scientifically, stygofauna are valuable as they have linkages to species with no or very few surface dwelling representatives. Examples of stygofauna orders include Bathynellacea, Thermosbaenacea, and Remipedia. Many stygofauna species are also representatives of ancient lineages and considered to be relictual taxa or 'living fossils', having evolved from surface-dwelling ancestors with Gondwanan and even Pangaeian connections. They are, therefore, critical to improving our understanding of the evolution of the Australian landscape. Stygofauna represent a vital and significant component of the natural environment and add to our knowledge of regional, national and global biodiversity (GHD 2012).

### **1.5.1 Ecological Requirements**

Stygofauna are intricately linked both ecologically and physiologically to the aquifer environment in which they live and are adapted to the relative stability of their surroundings. Compared to surface water environments, groundwater fluctuates less both in level and physico-chemical variables such as electrical conductivity, temperature and pH. Groundwater is also generally lower in dissolved oxygen and has less readily available organic matter than surface water environments.

As there is no direct photosynthesis in aquifers, stygofauna rely on connections to the land surface to provide them with food. These connections may be hydrological, with infiltrating water bringing dissolved or particulate organic matter to form the basis of subterranean food webs, or may be more direct, with tree roots that extend below the water table providing leachates, organic carbon or fine rootlets for food.



Generally, stygofauna biodiversity is highest near the water table and declines with depth. Stygofauna biodiversity is also higher in areas of recharge, where the water table is close (< 20 metres (m)) to the land surface. This is because the water table is likely to have the highest concentration of oxygen and organic matter. Stygofauna still also occur at considerable depth below the water table, but are fewer in number, have lower diversity, and may change in community composition. In some karstic (limestone terrane characterized by sinks, ravines, and underground streams) aquifers, where there is relatively high vertical exchange, or flow does not come into contact with large microbial surface areas (such as occurs in sedimentary aquifers), stygofaunal communities can occur at depths exceeding 100 m. They have been recorded as deep as 600 m to 800 m below the ground surface in the Edwards aquifer in Texas and near to 800 m deep within an aquifer in Mexico (GHD 2012).

In Australia, stygofauna are known from alluvial, limestone, fractured rock, and calcrete aquifers. As yet, few species are known from coal aquifers (although this is changing as further targeted sampling is undertaken in Queensland and NSW). As stygofauna require a space to live, the porosity of the sediments, degree of fracturing, or extent of cavity development must be sufficient, as must the connectivity between the living spaces (GHD 2012).

## **1.6 Ecosystems that potentially rely on groundwater within the Hume Coal Project area**

GDEs are most likely to occur in areas where groundwater is close to the surface. Depth to groundwater information from the NSW Office of Water (NOW) database indicates that shallow groundwater occurs in the northern part of the project area. The shallow groundwater in this area may be accessed by terrestrial and riparian vegetation, particularly deep rooted varieties, although it is noted that there is little undisturbed native vegetation over much of the area (PB 2012). The GDE Atlas identifies stygofauna and a number of potential GDEs such as terrestrial vegetation, swamps and base flow to streams that will be addressed in the terrestrial ecology section of the EIS.

In places, and at certain times, groundwater discharges to streams and at springs and seeps, such as along escarpments. Seepage along the escarpments is a major contributor to groundwater discharge, particularly along unit boundaries with contrasting vertical hydraulic conductivity (such as the Hawkesbury Sandstone to Illawarra Coal Measures). Ecosystems associated with these discharge areas may rely on groundwater for some of their water requirements. There is potential for groundwater to provide baseflow to Medway Rivulet at times, the deeply incised Black Bobs Creek and its tributaries south-west of the project area and some other streams in incised gullies in the north and west of the project area. However, stream baseflows within the project area are considered to be mainly rainfall dependent. Upstream of the above-mentioned areas, the watercourses are expected to be losing systems (PB 2012).

Groundwater ecosystems with potential for reliance on either the surface or subsurface expression of groundwater within or surrounding the project area are those associated with (EMM 2015):

- creeks where groundwater is connected and provides baseflows at times, for instance Medway Rivulet, Black Bobs Creek to the south-west, and some streams in incised gullies in the north and west of the project area (although stream baseflows are considered to be mainly rainfall dependent);
- springs, such as those associated with basalt hills south of the project area;
- upland swamps in the wider locality, namely Jumping Rock Swamp and the Paddys River Swamps located between approximately 7 and 15 km south-west of the project area;
- aquifers; and



- vegetation where groundwater is shallow (within the vegetation's root zone), for instance groundwater is 0 to 10 metres (m) below ground level along parts of Medway Rivulet and Wells, Belanglo, Longacre and Red Arm creeks, and could be accessed by native vegetation from time to time at these locations. However, vegetation in and around the project area is considered to be mainly rainfall dependent.





## 2. Relevance to the DoE Significant Impact Guidelines

The Commonwealth DoE's Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments—impacts on water resources (DoE 2013) will have relevance to the assessment of stygofauna communities for the Hume Coal Project.

The Guidelines will initially be used to determine whether or not the Hume Coal Project is considered likely to have a significant impact on a water resource. The Guidelines assist in determining whether or not a proponent should submit a referral to DoE for a decision by the Minister on whether assessment and approval is required under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

The Guidelines outline a 'self-assessment' process, including criteria, that are intended to provide general guidance on when actions will and will not require assessment and approval under the EPBC Act.

The Guidelines provide that a 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact is independent of the size of the water resource, and depends upon the sensitivity, value, and quality of the water resource which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts.

For a significant impact to be 'likely', it is not necessary for it to have a greater than 50 per cent chance of happening; it is sufficient if a significant impact on a water resource is a real or not remote chance or possibility. Under section 391 of the EPBC Act, the Minister must take into consideration the precautionary principle when deciding whether an action is a controlled action.

The Guidelines provide that "an action is likely to have a significant impact on a water resource if there is a real or not remote chance or possibility that it will directly or indirectly result in a change to:

- the hydrology of a water resource, or
- the water quality of a water resource,

that is of sufficient scale or intensity as to reduce the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes, or to create a material risk of such reduction in utility occurring."

The guidelines also state that "it is important to consider the value of the water resource in determining whether the impacts of a proposed action on a water resource are likely to be significant. The key factor that will be relevant in determining the value of a water resource will be its utility for all third party uses, including environmental and other public benefit outcomes". Environmental benefit outcomes would include, for instance, maintenance of ecosystem function.

The 'ecosystem function' of a water resource includes "the ecosystem components, processes and benefits or services that characterise the water resource, including support for the biological diversity or species composition of the water resource". Accordingly, consideration of potential impacts to ecosystems associated with a groundwater system, including stygofauna, are relevant in assessing the significance of the project's potential impacts to water resources under Commonwealth legislation.

An assessment of significance of the potential impact of the Hume Coal Project on stygofauna communities will be undertaken during the EIS, with consideration to the DoE (2013) guidelines, and in conjunction with the surface water and groundwater assessments and hydrological and hydrogeological modelling.



## 2.1 Relevant NSW State Legislation and Policies

### 2.1.1 NSW State Groundwater Dependent Ecosystems Policy

The NSW Groundwater Dependent Ecosystems Policy (DLWC 2002) is designed to protect valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of their dependent ecosystems are maintained or restored, for the benefit of present and future generations. The document provides guidance on the protection and management of GDEs and includes information on:

- The location of groundwater systems in NSW;
- Different types of GDEs;
- Value of and threats to GDEs;
- The principles that underpin the management of GDEs;
- Policies and legislation relating to management of GDEs, including how policy will be implemented and reviewed.

The species composition and natural ecological processes within some ecosystems (e.g. wetlands, redgum forests, limestone caves, springs, hanging valleys and swamps) are dependent on water that has filtered down below the surface of the earth and is held in rocks, gravel and sand. In NSW, groundwater often provides the base flows in rivers and streams after rainfall events that appears as springs or as diffuse flows from saturated sediments or rock underlying the watercourse or its banks (Cardno 2014).

### 2.1.2 NSW Aquifer Interference Policy

The Aquifer Interference Policy (Policy) explains the role and requirements of the Minister administering the Water Management Act 2000 (WM Act) in the water licensing and assessment processes for aquifer interference activities under the WM Act and other relevant legislative frameworks. The term aquifer interference as defined under the WM Act refers to the following:

- Penetration of an aquifer;
- Interference with water in an aquifer;
- Obstruction of the flow of water in an aquifer;
- Taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations; and
- Disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.

The Policy is applicable to all aquifer interference activities but has been specifically developed to address high risk activities. Mining operations such as open cut voids, underground mine workings and the disposal of water taken from an aquifer including water taken as part of coal seam gas extraction are considered high risk activities. The Policy outlines the requirements under NSW Legislation for obtaining water licences for aquifer interference activities, explains how development applications under Part 4, Division



4.1 and Part 5.1 of the EP&A Act will be assessed and specifies the factors that must be taken into consideration when assessing the potential effects of groundwater interference activities on an aquifer and its dependent assets, including ecosystems.

The framework for assessing the impacts of aquifer interference activities on water resources indicates the proponent will need to:

- Demonstrate their ability to obtain the necessary licences in order to account for the take of water from any relevant water source or that appropriate mitigation or avoidance strategies would be used to reduce the take of water to a point where it can be accounted for;
- Indicate adequate arrangements will be implemented to ensure that the minimal impact considerations specified in the policy can be met;
- Propose remedial actions for impacts greater than those that were predicted as part of the relevant approval.

Minimal impact considerations have been developed for impacts on each of the highly productive and less productive groundwater sources, connected water sources, and their dependent ecosystems, culturally significant sites and water users. Two levels of minimal impact considerations have been specified. Predicted impacts that are less than the Level 1 minimal impact considerations will be considered to be acceptable. Predicted impacts that exceed the Level 1 thresholds by no more than the accuracy of an otherwise robust model, will be considered within the range of acceptability, provided that extra monitoring and mitigation or remediation is undertaken if required. In this case, appropriate conditions may be imposed to ensure the impacts of the activity are acceptable. If the predicted impacts exceed the Level 1 minimal impact considerations by more than the accuracy of an otherwise robust model, additional studies will be required to fully assess the predicted impacts. If the subsequent assessment shows that the predicted impacts would not prevent the long-term viability of the relevant water-dependent asset, the impacts will be considered to be acceptable.

The policy also describes the information the proponent would need to supply to enable the aquifer interference activity to be assessed against the minimal impact considerations. This includes:

- Establishment of baseline groundwater conditions including depth, quality and flow based on sampling of all existing and future bores in the area potentially affected by the activity;
- Potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems;
- Potential for increased saline or contaminated water inflows to aquifers and highly connected river systems;
- Potential for river bank instability, or high wall instability or failure to occur (Cardno 2014).

### **2.1.3 NSW Office of Water's Risk Assessment Guidelines for GDEs**

NOW and OEH have developed comprehensive risk assessment guidelines to manage the effects of land and water use activities on GDEs. These guidelines are available in four volumes:

- Volume 1 - Risk assessment guidelines for groundwater dependent ecosystems – the conceptual framework;
- Volume 2 – Risk assessment guidelines for groundwater dependent ecosystems. Worked examples for seven pilot coastal aquifers;
- Volume 3 – Identification of high probability groundwater dependent ecosystems on the Coastal Plains of NSW and their ecological value;





- Volume 4 – The ecological value of groundwater sources on the Coastal Plains of NSW and the risk from groundwater extraction.

The conceptual framework provides the following:

- Definitions of groundwater, GDEs and high priority GDEs;
- A classification of different types of GDEs;
- An description of the relevant policy and legislative framework;
- Information on ecological valuation and risk assessment process and activities that threaten aquifers and/or their associated GDEs;
- A method for determining the ecological value of an aquifer and associated GDEs to assist in reporting against the state-wide Target for Groundwater;
- A method for assessing the risk of an activity to the ecological value of an aquifer and associated GDEs;
- A method for developing management strategies for aquifers and identified GDEs based on a Risk Matrix Approach;

The accompanying appendices contain background information, including:

- A method to identify the type and location of GDEs within an aquifer or defined area;
- A method for inferring the groundwater dependency of identified ecosystems;
- A description of surface and subsurface activities that threaten aquifers and associated GDEs.

This Volume 4 of the guidelines is the most relevant to the Project. The others show how the framework has been applied to groundwater resources and GDEs on the Coastal Plain (Cardno 2014).



### 3. Stygofauna Species of the Region

In NSW, large scale, targeted stygofauna studies have mainly been undertaken as a result of environmental assessment requirements for major projects, most commonly for large mining projects. The stygofauna information available in NSW is focussed on aquifers in the Hunter Valley, Gunnedah and Western Ranges regions, in karst formations. To date, only a very limited number of studies have been undertaken in the Southern Highlands region (these are described in the following section) most studies in the region have focused on large projects in the Western Coalfields. The applicability of the existing studies to Southern Highlands communities, in sandstone aquifers, based on geology and hydrogeology will be explored in detail in the Hume Coal Project EIS.

#### 3.1 Southern Highlands Stygofauna Studies

Of the studies undertaken in the Southern Highlands region, a number have identified stygofauna communities within the area. Thurgate *et al* (2001) identified that the Eastern Highlands region supports two-thirds of the stygofauna of New South Wales, and half of this total is concentrated at Wombeyan Caves. Surveys at sites at Wombeyan (40 sites), Jenolan (15 sites) Wee Jasper (6 sites), and Colong (3 sites) identified stygofauna in the following Orders:

- Neoniphargidae;
- Eusiridae;
- Psammaspididae;
- Phreatoicidae;
- Glacidorbiidae; and
- Hydrobiidae.

One study that has been undertaken of aquifers in the Kangaloon region of the Southern Highlands (Hose and Lategan 2009) identified a range of taxa from various aquifer sites, including both perched and main aquifers. The results indicated variability across the sampling sites for both richness and abundance. The results from this study also indicate that the stygofauna differ between the perched and main aquifer systems. Taxa identified in the study were:

- Copepoda: *Cyclopoida*, *Harpacticoida*;
- Syncarida: *Bathynellidae*, *Psammospidae*;
- Amphipoda: *Paramelitidae*;
- Acarina: Spp 1 and Spp2;
- Nematoda;
- Oligochaeta; and
- Tardigrada.

A study undertaken in the Berrima region (Bradbury and Williams 1997) identified stygofauna specimens from Wombeyan: *Wombeyanus botulosus*, *Neoniphargidae secus* and *N richardi* and *N simony* from Jenolan.



In the Kangaloon region, research by Hose (2009) identified widespread stygofauna assemblages in perched and main aquifers including:

- Copepoda *Cylcopoida* and *Harpacticoida*;
- Syncarinda Psammaspidae;
- Acarina spp 1 &2;
- Nematoda; and
- Oligochaeta.

Studies undertaken by SMEC in 2006 and 2007 for the Upper Nepean (Kangaloon) borefield project (KBR 2008) which is located in the same Catchment Management Area, collected three individuals from two species crustaceans (belonging to Order Crustacea). They were: Syncarida (one specimen *Psammaspides* n.sp) and Copepoda (two specimens *Diacyclops* sp.).

### 3.2 Hume Coal Project Stygofauna

The stygofauna surveys undertaken for the Hume Coal Project to date collected three taxa of aquatic fauna and one specimen of the Syncarida *Bathynellidae* spp in bore HU0018PZA .

Bathynellidae belong to the crustacean Super-Order Syncarida and are relatively poorly known in Australia. The Syncarida includes 200 described species divided between two orders, the Anaspidacea and the Bathynellacea. Bathynellaceans occur worldwide in interstitial (spaces between sand grains) or groundwater habitats. According to Serov (2002), there is currently only one species of Bathynellidae described from Australia: *Bathynella primaustaliensis* from the Murray-Darling basin. However, the family occurs more widely and, in Western Australia, species have been collected from the Pilbara and Yilgarn as well as Eneabba. Bathynellidae typically inhabit freshwater interstitial species in alluvium (Bennelongia 2008).

The taxa have very small ranges with two-thirds of species having known ranges of less than 10 km. However, two species had ranges extending across several hundred kilometres and studies have recently pointed out in their review of global diversity of syncarids that, when intensive sampling occurs, many species previously thought to be restricted are shown to have wide distributions (Bennelongia 2008). Bathynellidae have previously been recorded in the region in the Kangaloon studies.

Figure 3 Syncarida Bathynellidae







## 4. The Hume Coal Project Area

### 4.1 Topography and Land Use

The project area is situated on the elevated, relatively flat Woronora-Nattai Plateau. Elevations typically range from approximately 550 to 735 m above Australian Height Datum (AHD). Most of the central and eastern parts of the project area have very low rolling hills with occasional elevated ridge lines. There are, however, steeper slopes and deep gorges in the west of the project area, in Belanglo State Forest.

The region has some peaks of igneous origin, including Mount Gingenbullen to the east of the project area, which has a maximum elevation of approximately 800 m AHD.

The project area is in a semi-rural setting, characterised by grazing properties, small-scale farm businesses, hobby farms, natural areas, forestry, scattered rural residences, villages and towns and some industries and major infrastructure.

The villages of Sutton Forest and Exeter are within A349, but both have been excluded from the project area. Medway, New Berrima and Berrima villages are also nearby, while Moss Vale, Bowral and Mittagong, located between approximately 3 and 15 km east and north-east of the project area, are the LGA's main regional centres.

Industrial and manufacturing facilities in the locality include the substantial Berrima Cement Works and Berrima Feed Mill on the fringe of New Berrima, as well as brickworks, metal fabrication, mining equipment manufacture and quarries. Berrima Colliery's mining lease (CCL 748) adjoins the project area's northern boundary. Berrima Colliery closed in 2013 after almost one hundred years of operation and is currently in care and maintenance.

Surface infrastructure is proposed to be developed on predominately cleared land owned by Hume Coal, or for which there are appropriate access agreements in place with the landowner. Over half of the remaining sections of the project area (principally land above the proposed underground mining area) comprise cleared land that is, and will continue to be, used for livestock grazing, small-scale farm businesses and hobby farms. There are a small number of vineyards present, principally Cherry Tree Hill Wines, and Eling Forest, both adjacent to the Hume Highway. Belanglo State Forest covers the north-western portion of the project area and contains introduced pine forest plantations, areas of native vegetation and several creeks that flow through deep sandstone gorges. Native vegetation and threatened species habitat within the project area is largely restricted to Belanglo State Forest and some relatively undisturbed riparian corridors along watercourses such as parts of Oldbury Creek and Medway Rivulet.

The project area is traversed by several watercourses including Oldbury Creek, Medway Rivulet, Wells Creek, Wells Creek Tributary, Belanglo Creek and Longacre Creek, all of which ultimately discharge to the Wingecarribee River, located around 2 km north of the project area. Surface water interacts with (recharges and/or is recharged by) the underlying groundwater systems in places and at certain times. The main groundwater bearing unit in the area is the Hawkesbury Sandstone, which overlies the Wongawilli coal seam (EMM 2015).



## 4.2 Geology

The project area is in the Southern Coalfield, on the south-western edge of the Permo-Triassic Sydney Basin. The Southern Coalfield is one of the Sydney-Gunnedah Basin's five major coalfields and is the only source of premium quality hard metallurgical coal for steel production in NSW (Department of Planning 2008). The project area's sedimentary rocks were deposited during the Permian and Triassic periods. The lower Permian sequences comprise the:

- basal Shoalhaven Group, which are sandstones of marine origin interbedded with latite, which are remnant igneous extrusions; and
- overlying Illawarra Coal Measures, which are a strata of freshwater origin approximately 50 m thick, composed of conglomerates, quartz, quartz-lithic sandstone, grey shales, carbonaceous shales and coal. The coal seam of economic significance in the locality is the Wongawilli Seam.

The overlying Triassic sequence comprises:

- Hawkesbury Sandstone, which is the main landform influence and generally comprises flat lying massive quartzose sandstone. It varies in thickness from approximately 50 to 120 m and is the main cliff forming sequence; and
- the overlying Wianamatta Group, which is a sequence of shales with minor interbedded sandstones, and reaches a maximum thickness of about 50 m in this area.

During the late Triassic to early Jurassic period, the region experienced episodes of volcanic activity. Accordingly, there are also igneous necks, sills, basalt flows, diatremes, dykes and faults in the project area.

It is noted that the normal sequence of Illawarra Coal Measures has, throughout the area, been eroded prior to deposition of the Hawkesbury Sandstone. In addition, the Narrabeen Group, which underlies the Hawkesbury Sandstone in places, has been removed by erosion over much of the project area. Hawkesbury Sandstone is the dominant surface geology across the western side of the project area, while the Wianamatta Group dominates the eastern side.

## 4.3 Groundwater Environment

Hume Coal has undertaken extensive groundwater investigations to characterise the existing hydrogeology of the project area and surrounds, including groundwater depth, quality, flow and uses. Investigations are ongoing, though approximately 65 groundwater monitoring points have been established to date, comprising mainly purpose-built groundwater monitoring bores, as well as vibrating wire piezometers. Data from NOW monitoring bores in the locality have also been obtained.

The Hawkesbury Sandstone is the main groundwater bearing unit in the region, though groundwater is also present in other units. Where the Narrabeen Group is not present, and this is at a majority of the site, the Hawkesbury Sandstone directly overlies the Wongawilli Seam.

Water bearing zones within the Hawkesbury Sandstone are often associated with bedding plane joints, sub-vertical joints and faults, and thus groundwater flow is largely via secondary porosity. The water bearing zones are often separated by lower permeability zones of siltstone, claystone, fine grained sandstone and shale found within the Hawkesbury Sandstone. Investigations to date indicate that groundwater yields are typically in the range of 0.1 to 1 litres per second (L/s) in the north-west of the project area to 5 L/s in its south-east, which is typical for that type of geology. The Hawkesbury Sandstone in the project areas north-west is partially unsaturated, but in the east the strata dips to the east and this results in an increased



saturated thickness. In the east of the project area the Hawkesbury Sandstone is overlain by the Wianamatta Group. In the west there is no overlying shale, and so this is where the unsaturated Hawkesbury Sandstone occurs.

The regional groundwater flow direction is generally from south to north, reflecting the topography (Ross 2014). On a more localised scale, groundwater flow within the project area is generally from areas of high elevation to the southeast, towards the north. The exceptions are in the west of the project area, where it flows towards Black Bobs Creek and associated tributaries, and, in the north-west, where it flows north towards either Berrima Colliery or Medway Rivulet.

Sandstone outcrops in the north-west of the project area and these ridgelines are zones of groundwater recharge. The primary recharge mechanism is rainfall. Ross (2014) reports that recharge is relatively rapid in areas where fractured Hawkesbury Sandstone is exposed at the surface, such as at the nearby Kangaloon site. Groundwater recharge in areas where shale is exposed occurs but at a lower rate. The primary discharge mechanisms are evapotranspiration, surface water discharge, and at seeps and springs along escarpments. Landholder extraction through existing bores is also considered to be a discharge mechanism.

Groundwater quality is similar within the Hawkesbury Sandstone and Wongawilli Seam, and is typically fresh. Salinity is higher in some areas due to infiltration of more saline water from the overlying Wianamatta Group shales, which are of marine origin.

Hydraulic connection between surface water and groundwater exists in places at certain times. This is generally where rivers or creeks are in direct contact with the underlying aquifer via a zone of saturated material, or where the river is separated from the aquifer by a narrow unsaturated zone, generally less than twice the stream width (Bouwer and Maddock 1997). Where the groundwater level is much deeper than the base of the river, fluctuations in the water table typically have little or no effect on the stream.

Groundwater uses within and adjacent to the project area include:

- landholder bores (for stock, domestic, irrigation and other purposes), most of which access groundwater in the Hawkesbury Sandstone, though some have screened intervals in (and therefore access) water bearing zones in the overlying Wianamatta Group shales, and some in the underlying Wongawilli Seam; and
- potential use by flora and indirectly by fauna in certain places and at certain times (EMM 2015).





## 5. Standards and Protocols for Stygofauna Sampling, Analysis and Reporting

There are currently no guidelines for stygofauna sampling or assessment in NSW. Similarly, most other states within Australia do not have established or published protocols for sampling of stygofauna. The only exception is Western Australia (WA). As such, most states, including NSW, adopt the Western Australian EPA Environmental Assessment Guideline No. 12 June 2013 Consideration of Subterranean Fauna in Environmental Impact Assessment in WA (2003) and Western Australian EPA Guidance Statements No. 54a "Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia" (2007).

In eastern Australia however, a number of stygofauna studies have been undertaken on communities with two in particular relating to the evaluation of methods and optimal sample sizes for sampling groundwater fauna to identify standardised sampling methodologies:

- Sampling groundwater fauna: efficiency of rapid assessment methods tested in bores in eastern Australia (Hancock and Boulton 2009); and
- Sampling Strategies for Biological Assessment of Groundwater Systems: Technical Report 21 (Hose and Lategan 2012).

A number of EISs have been undertaken for similar projects throughout NSW in recent years. These studies assessed GDEs and stygofauna surveys to varying levels of investigation, a number of these are detailed in Table 1.



**Table 1 Recent Similar NSW Major Projects Investigation of Stygofauna**

<b>Project Name</b>	<b>Report Name and Author</b>	<b>Date</b>	<b>Resource Type</b>	<b>Stygofauna Assessment Methods</b>
<b>Sunnyside Coal Mine Modification : Whitehaven Coal</b>	Resource Strategies	July 2015	Coal	Groundwater only assessed, GDEs not assessed.
<b>Moolarben Coal Complex: UG1 Optimisation Modification</b>	Appendix E: Flora and Fauna Impact Assessment: Ecological	May 2015	Coal	GDEs not assessed
<b>Balranald Mineral Sands Project: Open Cut: Iluka Resources Limited</b>	Appendix J Groundwater Dependant Ecosystems Assessment Report CDM Smith	June 2015	Mineral Sands	General overview of GDEs, shallow GDEs including stygofauna not specifically discussed
<b>Sly's Quarry Environmental Impact Assessment: Newman Quarrying Pty Ltd</b>	Appendix F Ecology Assessment: GHD	May 2015	Sandstone	Groundwater only assessed,
<b>Drayton South Coal Project: Anglo American Pty Limited</b>	Appendix W Stygofauna Assessment : Eco Logical	February 2015	Coal	Followed WA EPA Guidelines 2003, 2007, sampled 24 bores, collected 2 stygofauna species
<b>New Berrima Shale Quarry Project: Austral Bricks</b>	RW Corkery & Co Pty Limited	2015	Clay/Shale	Ecology not assessed
<b>Mount Owen Continued Operations Project: Glencore</b>	Ecological Assessment Umwelt	October 2014	Coal	General desktop overview of GDEs, stygofauna not specifically discussed
<b>Airly Coal Mine Underground Extension Project</b>	Appendix F: Aquatic Ecology and Stygofauna: Cardno	August 2014	Coal	Samples collected from 6 sites once, variety of pump and net hauls used to sample. No stygofauna collected
<b>Springvale Coal Mine: Underground Mine Project</b>	Appendix G: Aquatic Ecology and Stygofauna: Cardno	January 2014	Coal	Samples collected from 16 boreholes using a bailer over one season. 411 stygofauna collected.
<b>Watermark Coal Project</b>	Appendix U Stygofauna Impact Assessment: Eco Logical	February 2013	Coal	Sampled 20 bores using a combination of net and pump methods. No stygofauna were collected.

The WA Guidance Statements, methods identified in the two NSW studies (Hancock and Boulton 2009 and Hose and Lategan 2012) and recent similar EIS surveys were considered in developing and undertaking the stygofauna survey for the Hume Coal Project. The Secretary's Environmental Assessment Requirements issued by DPI and NSW Office of Environment and Heritage for the Hume Coal Project both require assessment of GDEs. The following sections summarise key elements from the Guidance Statements and studies and compare the methods adopted for the current sampling program to them to identify alignment with best practice survey methodology for the Hume Coal Project.



## 5.1 Comparison against Guidance Statements and Studies Summary

Comparison of the Hume Coal Project stygofauna survey methods against the Guidance Statements and relevant study methods are detailed in Tables 2-6 and summarised in the following sections.

### 5.1.1 Sampling Design

The WA EPA (2003) Guidance Statement 54a recommends that the most efficient sampling design will include collection of 40 samples taken from at least 10 bores within the impact zone. This typically equates to 20 bores within the project area potentially impacted by the project (termed 'impact bores') in two seasons spaced at least three months apart. An equal sampling effort using comparable methods should be expended on control bores located outside the potential impact area. Therefore, it is recommended that at least as many samples are taken from beyond the impact zone as within it and that the habitats sampled beyond the impact zone should be similar to those within the zone. The Guidance Statement does recognise that the results of a species accumulation analysis may be taken into account when determining the adequacy of the sampling design. Hose and Lategan (2012) identify that multiple bores per aquifer/region are needed to assess the richness of that aquifer/region and Hancock and Boulton (2009) identify more than five bores are required to provide adequate information on stygofauna communities.

The Hume Coal Project undertook sampling at 19 bores (8 bores within the project area and 11 bores outside the project area) (refer to **Error! Reference source not found.** for sampling locations). A total of 14 of the 20 bores were sampled over two seasons six months apart, as per the Guidance Statement, with the remaining six sampled once to date. The bores sampled and survey timing for each are identified in Table 2.

Recent stygofauna surveys undertaken as part of coal mine EISs in NSW have varied in the number of sampling bores surveyed including:

- Springvale Coal Mine: Underground Mine Project (Cardno 2014): Total of 16 bores within project area, no bores outside the project area;
- Drayton South Coal Project (Eco Logical 2015): Total of 24 bores, 19 bores within the project area, 5 bores outside the project area;
- Airly Coal Mine Underground Extension Project (Cardno 2014): Total of 6 bores within the project area, no bores outside the project area; and
- Watermark Coal Project (Eco Logical 2013): Total of 20 bores, 12 bores within the project area, 6 bores outside the project area.





Table 2 Hume Coal Project Bore and Sampling Details

Site Name	Easting (UTM)	Northing (UTM)	Site Type	Surveyed Autumn 2013	Surveyed Spring 2013	Surveyed Autumn 2014
HU0018PZA	246696	6174166	Outside Project Area	✓	✓	
HU0018PZB	246695	6174158	Outside Project Area	✓	✓	
HU0019PZB	243562	6174378	Outside Project Area	✓	✓	
HU0020PZB	244257	6176920	Inside Project Area	✓	✓	
HU0032PZA	249530	6173532	Inside Project Area	✓	✓	
HU0035PZB	250523	6172485	Inside Project Area	✓	✓	
HU0037PZB	246546	6167438	Outside Project Area	✓	✓	
HU0038PZB	248792	6175451	Inside Project Area	✓	✓	
HU0042PZA	251007	6166705	Inside Project Area	✓	✓	
HU0043XPZB	247151	6178133	Outside Project Area	✓	✓	
HU0044XPZB	242281	6164075	Outside Project Area	✓	✓	
HU0056XPZB	245228	6169197	Outside Project Area		✓	
HU0056XPZC	245228	6169169	Outside Project Area		✓	
HU0072PZC	252090	6177179	Outside Project Area	✓	✓	
HU0073PZA	251015	6172717	Inside Project Area	✓	✓	
HU0073PZC	251035	6172716	Inside Project Area	✓	✓	
HU0088PZB	246966	6175811	Inside Project Area			✓
HU0096PZB	246966	6177040	Inside Project Area			✓
HU0118PZA	240529	6166810	Outside Project Area			✓
HU0129PZA	253041	6171301	Outside Project Area			✓



### 5.1.2 Survey Timing

The WA Guidance Statement 54a provides recommendations with regard to timing for stygofauna surveys, that being, that the sampling is undertaken twice in different seasons. As discussed in Section 3.1.1, a total of 14 of the 20 bores were sampled over two seasons six months apart, as per the Guidance Statement, with the remaining six sampled once to date. Table 3 summarises Hume Coal's compliance with the WA Guidance Statement 54a.

The Hancock and Boulton (2009) study identified that increased replication of surveys increases sampling strength and greater than four samples (over consecutive seasons) is required to capture the full taxonomic richness of most bores in alluvial aquifers of NSW. Hose and Lategan (2012) identified that one sampling event is inadequate and suggest up to five surveys may be required. Increasing taxonomic richness coincided with seasonal sampling, so it is unclear how much of the variability in composition of repeat samples is related to sampling error or seasonal changes. At a similar scale, but with more frequent sampling, Hose and Lategan (in preparation) found large variation in the trends of richness with sampling effort in the alluvium of Wollombi Brook, NSW.

Recent stygofauna surveys undertaken as part of coal mine EISs in NSW have varied in the replication of sampling, from two seasons (Drayton South Coal Project) and one season (Watermark Coal Project. Springvale Coal Mine: Underground Mine Project and Airly Coal Mine Underground Extension Project).

**Table 3 Guideline 54a Survey Timing Compliance**

Guideline 54a Reference	Item	Summary	Hume Coal Project Compliance
Table 3.2 Timeframes associated with subterranean fauna studies	Colonisation of bores	Allow 6 months following bore development	All sampling bores (except HU0018PZB first sampling event)
	Sampling rounds	Ideally two in different seasons (2 <sup>nd</sup> round >3 months after 1 <sup>st</sup> round)	All sampling bores, except six which have only been sampled once to date

### 5.1.3 Sampling Method: Haul Net

There are a variety of methods suitable for sampling stygofauna, grouped loosely as pump, bailer, net or trapping methods. The WA Guidance Statement 54a provides direction on how to sample stygofauna from bores using net, pumping or trapping methods. It does not specify the use of any particular method. The use of traps and bailers is not widely used for larger projects.

Trapping involves the deployment of baited or unbaited traps in bore holes where they are left for varying periods of time, and are later retrieved. The fauna collected appears taxonomically similar to that collected by other means, but traps provided greater richness and abundances of fauna compared to pumped samples. Traps also allow for depth stratified sampling, a task not easily achieved with other approaches.



However, traps do require repeat visits for deployment and collection (Hose and Lategan 2012). The use of traps is more time consuming than other methods and the potential taxonomic bias of the sampling meant this method was not considered suitable for the Hume Coal Project.

Bailers are frequently used to collect groundwater samples, but can also be used for stygofauna collection. Bailers are best suited to shallow, small volume bores where nets and pumps can be difficult. Bailers are particularly useful for sampling perched aquifers and swamps. An advantage of using bailers is that they can disturb and collect fauna directly from the sediment at the bottom, a task which is difficult with pumps and nets. Bailers are also effective at sampling the entire bore contents. Bailers are best suited to shallow, small volume bores where nets and pumps can be difficult (Hose and Lategan 2012). Due to the habitat location of the bores and their depth (average depth 106m) this method was not considered for the Hume Coal Project.

Netting, pumping or a combination of both methods were considered suitable for the sampling of stygofauna for the Hume Coal Project. The WA Guidance Statement 54a while not providing recommendations for the choice of sampling methodologies, does identify that collecting animals by pumping water out of a bore and through a net often recovers more species than net hauling but is unsuitable for deep bores, and can damage many of the animals collected. The use of pumps is suitable for vertical cased bores where the water table is > 50m below ground. As the average water table level at the boreholes associated with the Hume Coal Project is 46m depth and the average depth of the bores is 106m and to ensure data could be compared between bores during analysis, net sampling alone was used to sample the boreholes for the Hume Coal Project. Pump sampling is not considered suitable for slow replenishing bores (Hose and Lategan 2012). Due to the depth of the bores, water table level and in order to maintain consistency between data collection methods to enable comparisons between bores and seasons it was determined that net sampling would be undertaken for the Hume Coal Project.

The study undertaken by Hancock and Boulton (2009) identified that although nets collected most of the animals taken in the pump samples, the community composition differed in the relative abundances of animals. However, most other studies show few differences in the richness of stygofauna in samples collected using the various methods (Hose and Lategan (2012). Comparative analysis of the sampling efficiency between nets and pumps indicates that while pumping of bores collects higher taxa numbers and abundance than nets however when seasonal samples are undertaken the community composition are similar (Hose and Lategan (2012).

Recent stygofauna surveys undertaken as part of coal mine EISs in NSW have varied in their methods of sampling, Springvale Coal Mine: Underground Mine Project used bailers, Drayton South Coal Project, Airly Coal Mine Underground Extension Project, Watermark Coal Project used a combined net and pumps depending on bore characteristics.

Table 4 summarises Hume Coal's compliance with the WA Guidance Statement 54a.

**Table 4 Guideline 54a Haul Net Sampling Methodology Compliance**

Guideline 54a Reference	Item	Summary	Hume Coal Project Compliance
Section 3.7.1.2	Use in vertical bores	Can only be used in vertical bore holes.	All sampling bores
	Number of haul net samples	Net is to be lowered and retrieved six times (yield will increase if the sediments are vigorously agitated).	All sampling bores





	Net mesh size	Many stygofauna are <0.5 mm in length and are elongate in bodyform. A small mesh size (about 50 µm) is required for reliable collection of the smaller species of stygofauna. However, small mesh sizes tend to become clogged with sediment and also create a pressure wave in front of the net as it is retrieved, which may cause animals to be pushed clear of the net. Use of a larger meshed net (about 150 µm) on some hauls is likely to improve capture rates of larger animals.	All sampling bores sampled using 50 and 150 µm mesh size
	Removal of samples	The contents of the net should be emptied after each haul because any animals present are likely to swim free as the net is dropped back down the bore.	All sampling bores
		Emptying the contents into a sample jar is easier if the bottom of the net consists of a removable vial that can be unscrewed and tipped straight into the sample jar.	All sampling bores
		Animals that may be adhering to the mesh of the net should be washed into the vial before it is removed from the net.	All sampling bores

#### 5.1.4 Sample Preservation

The WA Guidance Statement 54a provides requirements for the preservation of samples. Table 5 summarises Hume Coal's compliance with the WA Guidance Statement.

Table 5 Guideline 54a Sample Preservation Compliance

Guideline 54a Reference	Item	Summary	Hume Coal Project Compliance
Section 3.7.1.5	Field preservation	Samples should be preserved in the field and returned to a laboratory for sorting under a dissecting microscope	All samples
		The best all-round preservative is 70% ethanol but 100% analytical grade ethanol should be used if DNA is likely to be required from animals.	All samples were preserved with 70% ethanol.



### 5.1.5 Sample Sorting

The WA Guidance Statement 54a describes appropriate methods for sorting of samples. Table 6 summarises Hume Coal's compliance with the WA Guidance Statement 54a.

Table 6 Guideline 54a Sample Sorting Compliance

Guideline 54a Reference	Item	Summary	Hume Coal Project Compliance
Section 3.7.1.6	Filtering	Elutriating (sieving) a sample to get rid of as much sediment as possible and sieving the sample into size fractions assists this process. A common strategy is to use three sieves (250, 90 and 53 $\mu\text{m}$ mesh size) to separate the sample into > 250, 250-90, and 9-53 $\mu\text{m}$ categories.	All samples
	Sorting	Even after elutriation and sieving, the volume of sample added to a sorting tray should be small enough that sediment is not more than one particle thick across the bottom of the tray.	All samples



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# Site SWQ01

Site Location	Black Bobs Creek			Site Location	Black Bobs Creek		
Survey Date	16.5.13			Survey Date	6.11.13		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	Oil film on water, patches of brown floating matter on water surface	2	Moderate disturbance	Water Quality	Shallow under bridge with deeper pools either side,	3	High disturbance
Intream Habitat	Large deep pools, shallow flowing riffles, rubbish, filamentous algae	3	High disturbance	Intream Habitat	Disturbed by bridge, two large pools either, some filamentous algae	3	High disturbance
Riparian Zone	Cumbungi ( <i>Typha latifolia</i> ) on water edges, large amounts of introduced weeds including Stinging nettle	3	High disturbance	Riparian Zone	Lots of blackberry, pools ringed by dense beds of Cumbungi reeds	3	High disturbance



Site Description			Comments	Site Description			Comments
Topography	Steep gully			Topography	Steep gully		

# Site SWQ01

Average Depth (m)	1.5			Average Depth (m)	1.5		
Water Level	Low			Water Level	Low (deep pools)		
Shading of River	Low/moderate			Shading of River	Low/moderate		
Riparian Vegetation %	Trees <10m (%)	15	<i>Acacia</i> spp, <i>Eucalyptus viminalis</i>	Riparian Vegetation %	Trees >10m (%)	15	<i>Acacia</i> spp, <i>Eucalyptus viminalis</i>
	Shrubs/vines/rushes (%)	60	<i>Lomandia longifolia</i> , gorse, blackberry		Shrubs/vines/rushes (%)	60	<i>Lomandia longifolia</i> , gorse, blackberry
	Grasses/herbs/ferns (%)	20	Most commonly occurring weed species		Grasses/herbs/ferns (%)	20	Most commonly occurring weed species
Stream Width	Mode (m)	5		Stream Width	Mode (m)	5	
Land Use	Some upstream grazing			Land Use	Recreation and grazing		
Substrate (%)	Boulder	5		Substrate (%)	Boulder	20	
	Cobble	90			Cobble	30	
	Silt	5			Silt	30	
					Clay	20	
Habitat	Detritus cover/ bank overhang/ trailing bank vegetation %	5/20/10		Habitat	Detritus cover/ trailing bank vegetation %	10/0	
	Total Macrophytes %	3	<i>Ceratophyllum demersum</i>		Total Macrophytes %	20	<i>Potamogeton ochreatus</i>

# Site SWQ02

<b>Site Location</b>	246270/6167390			<b>Site Location</b>	246270/6167390		
<b>Survey Date</b>	15.5.13			<b>Survey Date</b>	4.11.13		
<b>Site Summary</b>	Black Bob's Creek	<b>Ranking</b>	Summary	<b>Site Summary</b>	Black Bob's Creek	<b>Ranking</b>	Summary
<b>Water Quality</b>	Odour, oil, disruption of natural hydrology from causeway	3	High disturbance	<b>Water Quality</b>	disruption of natural hydrology from causeway, suspended red silt	3	High disturbance
<b>Instream Habitat</b>	Change in hydrology eg. rock piles and sedimentation, red algae blooms present	3	High disturbance	<b>Instream Habitat</b>	Change in hydrology eg. sand deposition, red algae blooms present	3	High disturbance
<b>Riparian Zone</b>	Devegetated, bank degradation, some good riparian cover to the west but largely cleared	3	High disturbance	<b>Riparian Zone</b>	Cleared grazed banks, some steep bank, good grassy bank cover and stable		High disturbance



# Site SWQ02

Site Description	15.5.13		Comments	Site Description			Comments
Topography	Broad Valley			Topography	Broad Valley		
Average depth (m)	0.4			Average depth	0.5		
Water Level	Low			Water Level	Low		
Shading of River	Low			Shading of River	None		
Riparian Vegetation %	Trees <10m (%)	10	<i>Eucalyptus viminalis</i> and assorted Eucalypt spp	Riparian Vegetation %	Trees >10m (%)	10	<i>Eucalyptus viminalis</i> and assorted Eucalypt spp
	Shrubs/vines/rushes (%)	25	Blackberry		Shrubs/vines/rushes (%)	25	Blackberry
	Grasses/herbs/ferns (%)	85	<i>Lomanded longifolia</i> , common reed, open reed		Grasses/herbs/ferns (%)	85	<i>Lomanded longifolia</i> , common reed, open reed
Stream Width	Mode (m)	1.5		Stream Width	Mode (m)	1.2	
Land Use	Grazing		Bank disturbance from cattle	Land Use	Grazing		Cattle access present
Substrate (%)	Sand	95		Substrate (%)	Cobble	95	
	Silt	15			Silt	5	
Habitat	Detritus cover/bank overhang/trailing bank vegetation (%)	10/10/25		Habitat	Detritus cover	5	
	Total macrophytes	40%	Hornwort <i>Ceratophyllum demersum</i>		Total macrophytes		Hornwort <i>Ceratophyllum demersum</i>



# Site SWQ03

Site Location	Medway Rivulet	Site Location	Medway Rivulet
Survey Date	16.5.13	Survey Date	5.11.13
Site Summary		Site Summary	
Water Quality	Bridge, disruption of natural hydrology, turbid	Ranking	3
Intream Habitat	Change in substrate eg. rock piles and sedimentation, filamentous green algae, rubbish	Summary	High disturbance
Riparian Zone	Devegetated, banks heavily modified surrounding bridge, exotic species, bank degradation, point source from bridge	Ranking	3
		Summary	High disturbance



# Site SWQ03



Site Description			Comments	Site Description			Comments
Slope				Slope	5m		
Topography	Broad Valley			Topography	Broad Valley		
Water Level	Low			Water Level	Low		
Shading of River	Low/moderate			Shading of River	None		
Riparian Vegetation %	Trees <10m (%)	20	Willows	Riparian Vegetation %	Trees >10m (%)	20	
	Shrubs/vines/rushes (%)	40	Blackberry		Shrubs/vines/rushes (%)	40	Blackberry
	Grasses/herbs/ferns (%)	20	Most commonly occurring weed species		Grasses/herbs/ferns (%)	20	Most commonly occurring weed species
Stream Width	Mode (m)	2		Stream Width	Mode (m)	1.5	
Land Use	Grazing		Bank disturbance from cattle	Land Use	Grazing		
Substrate (%)	Bedrock (%)	80		Substrate (%)	Cobble	40	
	Silt	20			Sand	40	

# Site SWQ03

					Silt	20	
Habitat	Detritus cover/ trailing bank vegetation %	10/10		Habitat	Detritus cover	10	
	Total Macrophytes	10	<i>Potamogeton perfoliatus</i> , Hornwort <i>Ceratophyllum demersum</i>		Total Macrophytes		Hornwort <i>Ceratophyllum demersum</i>

# Site SWQ04

<b>Site Location</b>	Medway Rivulet			<b>Site Location</b>	Medway Rivulet		
<b>Survey Date</b>	16.5.13			<b>Survey Date</b>	5.11.13		
<b>Site Summary</b>		<b>Ranking</b>	<b>Summary</b>	<b>Site Summary</b>		<b>Ranking</b>	<b>Summary</b>
<b>Water Quality</b>	Bridge, disruption of natural hydrology, turbid	3	High disturbance	<b>Water Quality</b>	Lower turbidity, deeper scoured holes around pylons	3	High disturbance
<b>Intream Habitat</b>	Change in substrate eg. rock piles and sedimentation, filamentous green algae, rubbish	3	High disturbance	<b>Intream Habitat</b>	Large woody debris, mix of microhabitats (riffle, pool, deep pool), changes in depth profile, evidence of high flows, filamentous green algae	3	High disturbance
<b>Riparian Zone</b>	Devegetated, banks heavily modified surrounding bridge, exotic species, bank degradation, point source from bridge	3	High disturbance	<b>Riparian Zone</b>	Banks heavily modified and steep, downstream steeper banks, good bank cover	3	High disturbance





# Site SWQ04

Site Description			Comments	Site Description			Comments
Topography	Broad Valley			Topography	Broad Valley		
Water depth (m)	1			Water depth (m)	1		
Water Level	Low			Water Level	Low		
Shading of River	Low/moderate			Shading of River	None		
Riparian Vegetation %	Trees <10m (%)	20	Willows	Riparian Vegetation %	Trees >10m (%)	20	Willows
	Shrubs/vines/rushes (%)	40	Blackberry		Shrubs/vines/rushes (%)	40	Blackberry
	Grasses/herbs/ferns (%)	20	Most commonly occurring weed species		Grasses/herbs/ferns (%)	20	Most commonly occurring weed species
Stream Width	Mode (m)	2		Stream Width	Mode (m)	1.5	
Land Use	Grazing		Bank disturbance from cattle	Land Use	Grazing		
Substrate (%)	Bedrock (%)	80		Substrate (%)	Cobble	40	
	Silt	20			Sand	40	
					Silt	20	
Habitat	Detritus cover/ trailing bank vegetation %	10/10		Habitat	Detritus cover	10	
	Total Macrophytes	10	<i>Potamogeton perfoliatus</i> , Hornwort <i>Ceratophyllum demersum</i>		Total Macrophytes		Hornwort <i>Ceratophyllum demersum</i>

# Site SWQ05

Site Location	Wells Creek			Site Location	Wells Creek		
Survey Date	15.5.13			Survey Date	6.11.13		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	Turbid, no flow, downstream from bridge crossing	3	High disturbance	Water Quality	Turbid, impacts from grazing runoff	3	High disturbance
Intream Habitat	Deep straight channel, bank overhang and limited trailing bank vegetation	3	High disturbance	Intream Habitat	Little available habitat, thick mud silt benthic substrate, downstream waterway enclosed by weeds	3	High disturbance
Riparian Zone	Heavily cleared for grazing, no riparian vegetation	3	High disturbance	Riparian Zone	Cleared, downstream blackberry and introduced weeds	3	High disturbance



# Site SWQ05

Site Description			Comments	Site Description			Comments
Topography	Broad Valley			Topography	Broad Valley		
Water depth (m)	1			Water depth (m)	1		
Water Level	Low			Water Level	Moderate		
Shading of River	Low/moderate			Shading of River	None		
Riparian Vegetation %	Trees <10m (%)			Riparian Vegetation %	Trees >10m (%)	0	
	Shrubs/vines/rushes (%)				Shrubs/vines/rushes (%)	5	Blackberry
	Grasses/herbs/ferns (%)				Grasses/herbs/ferns (%)	10	Most commonly occurring weed species
Stream Width	Mode (m)			Stream Width	Mode (m)	1.5	
Land Use	Grazing			Land Use	Grazing		
Substrate (%)	Bedrock (%)			Substrate (%)	Mud/silt	100	
Habitat	Detritus cover/ trailing bank vegetation %			Habitat	Detritus cover	0	
	Total Macrophytes				Total Macrophytes		

# Site SWQ08

Site Location	Long Swamp Creek			Site Location	Log Swamp Creek		
Survey Date	15.5.13			Survey Date	6.11.13		
Site Summary		Ranking	Summary	Site Summary	NO FLOW	Ranking	Summary
Water Quality	Odour, oil, disruption of natural hydrology	3	High disturbance	Water Quality			
Intream Habitat	Change in hydrology eg. rock piles and sedimentation, invasion of exotic aquatic plants	3	High disturbance	Intream Habitat			
Riparian Zone	Devegetated, exotic plant invasion, bank degradation, point sources	3	High disturbance	Riparian Zone			





# Site SWQ08

Site Description	15.5.13		Comments	Site Description			Comments
Elevation	690m			Elevation	690m		
Slope	5m			Slope	5m		
Topography	Broad Valley			Topography	Broad Valley		
Water Level	No flow			Water Level	No flow		
Shading of River	None			Shading of River	None		
Riparian Vegetation %	Trees >10m (%)	0		Riparian Vegetation %	Trees >10m (%)		
	Shrubs/vines/rushes (%)	25	Melaleuca regrowth, blackberry		Shrubs/vines/rushes (%)		
	Grasses/herbs/ferns (%)	95	Couch, <i>Paspalum dilatatus</i> , <i>Juncus usitatus</i> , kangaroo grass		Grasses/herbs/ferns (%)		
Stream Width	Mode (m)	7		Stream Width	Mode (m)		
Land Use	Grazing		Extensive bank disturbance from cattle	Land Use	Grazing		
Substrate	Cobble	5%		Substrate	Cobble		
	Silt	15%			Silt		
	Clay	80%			Clay		
Habitat	Detritus cover	50%		Habitat	Detritus cover		
	Total Macrophytes	85%	<i>Eleocharis acuta</i> , <i>Potamogeton ochreatus</i> , <i>Potamogeton perfoliatus</i> , <i>Myriophyllum spicatum</i>		Total Macrophytes		

# Site SWQ10

<b>Site Location</b>	Long Swamp Creek			<b>Site Location</b>	Log Swamp Creek		
<b>Survey Date</b>	15.5.13			<b>Survey Date</b>	6.11.13		
<b>Site Summary</b>		<b>Ranking</b>	Summary	<b>Site Summary</b>	NO FLOW	<b>Ranking</b>	Summary
<b>Water Quality</b>	Odour, oil, disruption of natural hydrology	3	High disturbance	<b>Water Quality</b>			
<b>Intream Habitat</b>	Change in hydrology eg. rock piles and sedimentation, invasion of exotic aquatic plants	3	High disturbance	<b>Intream Habitat</b>			
<b>Riparian Zone</b>	Devegetated, exotic plant invasion, bank degradation, point sources	3	High disturbance	<b>Riparian Zone</b>			



# Site SWQ10

Site Description	15.5.13		Comments	Site Description			Comments
Elevation	690m			Elevation	690m		
Slope	5m			Slope	5m		
Topography	Broad Valley			Topography	Broad Valley		
Water Level	No flow			Water Level	No flow		
Shading of River	None			Shading of River	None		
Riparian Vegetation %	Trees >10m (%)	0		Riparian Vegetation %	Trees >10m (%)		
	Shrubs/vines/rushes (%)	25	Melaleuca regrowth, blackberry		Shrubs/vines/rushes (%)		
	Grasses/herbs/ferns (%)	95	Couch, <i>Paspalum dilatatus</i> , <i>Juncus usitatus</i> , kangaroo grass		Grasses/herbs/ferns (%)		
Stream Width	Mode (m)	7		Stream Width	Mode (m)		
Land Use	Grazing		Extensive bank disturbance from cattle	Land Use	Grazing		
Substrate	Cobble	5%		Substrate	Cobble		
	Silt	15%			Silt		
	Clay	80%			Clay		
Habitat	Detritus cover	50%		Habitat	Detritus cover		
	Total Macrophytes	85%	<i>Eleocharis acuta</i> , <i>Potamogeton ochreatus</i> , <i>Potamogeton perfoliatus</i> , <i>Myriophyllum spicatum</i>		Total Macrophytes		

# Site SWQ11

Site Location	Longacre Creek		
Survey Date	15.5.13		
Site Summary		Ranking	Summary
Water Quality	Small stagnant pool of standing water in one section	3	High disturbance
Instream Habitat	Largely dry drainage line, vegetated by grasses	3	High disturbance
Riparian Zone	Cleared for grazing on western side of road, eastern forestry with dense riparian cover	3	High disturbance





# Site SWQ12

Site Location	Wells Creek			Site Location	Wells Creek		
Survey Date	19.5.14			Survey Date	4.11.13		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow conditions	3	High disturbance	Water Quality	No flow, shallow water in channel	3	High disturbance
Instream Habitat	Shallow, muddy benthic substrate with cattle access	3	High disturbance	Instream Habitat	Algal bloom	3	High disturbance
Riparian Zone	Cleared for grazing and some weeds, no riparian shrubs or trees	4	Extreme disturbance	Riparian Zone	Cleared for grazing and some weeds, no riparian shrubs or trees	4	Extreme disturbance



# Site SWQ12

Site Description			Comments	Site Description			Comments
Topography	Broad Valley			Topography	Broad Valley		
Average Water Depth (m)	>1m			Water Depth (m)	0.3		
Water Level	Low flow			Water Level	Low flow		
Shading of River	None			Shading of River	High		
Riparian Vegetation	Trees >10m (%)	1		Riparian Vegetation %	Trees >10m (%)	1	
	Shrubs/vines/rushes (%)	0			Shrubs/vines/rushes (%)	0	
	Grasses/herbs/ferns (%)	40			Grasses/herbs/ferns (%)	10	
Stream Width	Mode (m)	2		Stream Width	Mode (m)	1.5	
Land Use	Grazing			Land Use	Grazing		
Substrate	Silt	10		Substrate	Silt	10	
	Clay	90			Clay	90	
Habitat	Detritus cover/Bank overhang/Trailing bank vegetation	0/20/20		Habitat	Detritus cover/Bank overhang/Trailing bank vegetation	0/0/10	
	Total Macrophytes	0			Total Macrophytes	0	

Site SWQ06				Site SWQ07			
Site Location	Belangelo Creek			Site Location	Black Bob's Creek (upstream)		
Survey Date	15.5.13			Survey Date	15.5.13		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow, at roadway	3	High disturbance	Water Quality	At roadway culvert	2	Moderate disturbance
Instream Habitat	No Flow	1	Little disturbance	Instream Habitat	Open water	2	Moderate disturbance
Riparian Zone	Intact riparian, near roadway	2	Moderate disturbance	Riparian Zone	Cleared riparian vegetation	3	High disturbance



Site SWQ11				Site SWQ13			
Site Location	Longacre Creek			Site Location	Indigo Creek		
Survey Date	15.5.13			Survey Date	16.5.13		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	Low flow	2	Moderate disturbance	Water Quality	No flow		
Instream Habitat	Isolated pooling below culvert	2	Moderate disturbance	Instream Habitat	No flow	2	Moderate disturbance
Riparian Zone	Cleared	3	High disturbance	Riparian Zone	Cleared and disturbed	3	High disturbance3





Site SWQ14				Habitat C			
Site Location	Whites Creek			Site Location	Medway Rivulet		
Survey Date	17.5.13			Survey Date			
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	Below culvert, turbid and odorous	3	High disturbance	Water Quality	Clear, flowing, some larger pools	2	Moderate disturbance
Instream Habitat	Detritus, rubbish	3	High disturbance	Instream Habitat	Variety of habitat, emergent vegetation, cobble and sand benthos, near road crossing	2	Moderate disturbance
Riparian Zone		2	Moderate disturbance	Riparian Zone	Cleared and grazed	3	High disturbance



Habitat D				Habitat E			
Site Location	Unnamed Creek			Site Location	Black Bob's Creek		
Survey Date	17.5.13			Survey Date	16.5.13		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow			Water Quality	Permanent water flow	2	Moderate disturbance
Instream Habitat	Little evidence of recent flows	2	Moderate disturbance	Instream Habitat	Good habitat variety	2	Moderate disturbance
Riparian Zone	Cleared	4	Extreme disturbance	Riparian Zone	Cleared and grazed	3	High disturbance



Habitat F				Habitat G			
Site Location	Black Bob's Creek			Site Location	Wells Creek		
Survey Date				Survey Date			
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow			Water Quality	Low flow	2	Moderate disturbance
Instream Habitat	Vegetated, below culvert	3	High disturbance	Instream Habitat	Low habitat variability	2	Moderate disturbance
Riparian Zone	Heavily cleared	4	Extreme disturbance	Riparian Zone	Cleared	3	High disturbance



Habitat H				Habitat I			
Site Location	Medway Rivulet			Site Location	Long Acre Creek		
Survey Date	17.5.13			Survey Date	15.5.13		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow			Water Quality	No flow, some pooling stagnant water	2	Moderate disturbance
Instream Habitat	Some large woody debris	1	Little disturbance	Instream Habitat	Some variability in stream habitat, some instream erosion sediment control works	2	Moderate disturbance
Riparian Zone	Riparian zone intact	1	Little disturbance	Riparian Zone	Riparian zone intact, cleared near road crossing	2	Moderate disturbance





Habitat J				Habitat K			
Site Location	Longacre Creek			Site Location	Wells Creek		
Survey Date	17.5.13			Survey Date	18.3.14		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow conditions			Water Quality	No flow conditions		
Instream Habitat	Heavily vegetated, large woody debris instream	2	Moderate disturbance	Instream Habitat	Open shallow channel	2	Moderate disturbance
Riparian Zone	Some clearing near roadway	2	Moderate disturbance	Riparian Zone	Cleared for grazing	4	Extreme disturbance



Habitat L				Habitat M			
Site Location	Wells Creek			Site Location	Stony Creek		
Survey Date	18.3.15			Survey Date	18.3.14		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow conditions	2	Moderate disturbance	Water Quality	No flow conditions	2	Moderate disturbance
Instream Habitat	Dry creek bed	2	Moderate disturbance	Instream Habitat	Dry Creek bed with various reeds	2	Moderate disturbance
Riparian Zone	Cleared for grazing	4	Extreme disturbance	Riparian Zone	Cleared for grazing	4	Extreme disturbance



Habitat N and P				Habitat O			
Site Location	Stony Creek			Site Location	Bundanoon Creek		
Survey Date	18.3.14			Survey Date	17.3.14		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow conditions			Water Quality	No flow conditions		
Instream Habitat	Established weeds	3	High disturbance	Instream Habitat	Vegetated by grasses and weeds	3	High disturbance
Riparian Zone	Semi cleared and dominated by weed species	3	High disturbance	Riparian Zone	Large tree species	3	High disturbance



Habitat Q				Habitat R			
Site Location	Medway Rivulet			Site Location	Oldbury Creek		
Survey Date	19.3.14			Survey Date	17.3.14		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow conditions			Water Quality	No flow conditions		
Instream Habitat	Emergent vegetation and clear channel	2	Moderate disturbance	Instream Habitat	Vegetated by grasses and weeds	3	High disturbance
Riparian Zone	Cleared for grazing	3	High disturbance	Riparian Zone	Some large tree species	3	High disturbance





Habitat S				Habitat T			
Site Location	Belangelo Creek			Site Location	Firedam Creek		
Survey Date	13.11.15			Survey Date	14.11.15		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow conditions			Water Quality	No flow conditions		
Instream Habitat	Emergent vegetation, thickly vegetated	2	Moderate disturbance	Instream Habitat	Vegetated by grasses and weeds	2	Moderate disturbance
Riparian Zone	forestry	1	Low disturbance	Riparian Zone	Native vegetation and forestry trees	2	Moderate disturbance



Habitat U				Habitat V			
Site Location	Long Acre Creek			Site Location	Belangelo Creek		
Survey Date	15.11.15			Survey Date	14.11.15		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow conditions			Water Quality	No flow conditions		
Instream Habitat	Emergent vegetation, thickly vegetated	2	Moderate disturbance	Instream Habitat	Vegetated by grasses and small shrubs	2	Moderate disturbance
Riparian Zone	Forestry	1	Low disturbance	Riparian Zone	Forestry	2	Moderate disturbance



Habitat W				Habitat X			
Site Location	Planting Spade Creek			Site Location	Long Acre Creek		
Survey Date	14.11.15			Survey Date	14.11.15		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow conditions			Water Quality	No flow conditions		
Instream Habitat	Eroded channel	2	Moderate disturbance	Instream Habitat	Degraded channel, cattle access	3	High disturbance
Riparian Zone	Forestry, cleared	3	High disturbance	Riparian Zone	Cleared for grazing	3	High disturbance



Habitat Y				Habitat Z			
Site Location	Stony Creek			Site Location	Stony Creek		
Survey Date	14.11.15			Survey Date	14.11.15		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow conditions			Water Quality	No flow conditions		
Instream Habitat	Shallow water, high amounts of detritus	2	Moderate disturbance	Instream Habitat	Vegetated by grass	3	High disturbance
Riparian Zone	Cleared for grazing, willows	3	High disturbance	Riparian Zone	Cleared for grazing	3	High disturbance





Habitat AA				Habitat AB			
Site Location	Red Arm Creek			Site Location	Red Arm Creek		
Survey Date	15.11.15			Survey Date	15.11.15		
Site Summary		Ranking	Summary	Site Summary		Ranking	Summary
Water Quality	No flow conditions			Water Quality	No flow conditions		
Instream Habitat	Shallow standing water in some areas	2	Moderate disturbance	Instream Habitat	Vegetated by shrubs and trees	1	Low disturbance
Riparian Zone	Native forest	1	Low disturbance	Riparian Zone	Native forest	1	Low disturbance



# Habitat AC

Site Location	Oldbury Creek		
Survey Date	15.11.15		
Site Summary		Ranking	Summary
Water Quality	No flow conditions		
Instream Habitat	Vegetated by grasses	1	Low disturbance
Riparian Zone	Native forest	1	Low disturbance



# Belangelo and Long Acre Creeks

<b>Site Location</b>	Belangelo Creek			<b>Site Location</b>	Long Acre		
<b>Survey Date</b>	14.10.15			<b>Survey Date</b>	14.10.15		
<b>Site Summary</b>		<b>Ranking</b>	<b>Summary</b>	<b>Site Summary</b>		<b>Ranking</b>	<b>Summary</b>
<b>Water Quality</b>	Low flow conditions	1	Low disturbance	<b>Water Quality</b>	No flow, shallow water with pools	1	Low disturbance
<b>Instream Habitat</b>	Thickly vegetated by Lomandra with flow through	1	Low disturbance	<b>Instream Habitat</b>	Thickly vegetated with Lomandra and larger separate pools	1	Low disturbance
<b>Riparian Zone</b>	Native forest	1	Low disturbance	<b>Riparian Zone</b>	Native Forest	1	Low disturbance



# Belangelo and Long Acre Creeks

Site Description			Comments	Site Description			Comments
Topography	Broad Valley			Topography	Broad Valley		
Average Water Depth (m)	>50cm			Water Depth (m)	0.3		
Water Level	Low flow			Water Level	Low flow		
Shading of River	Moderate			Shading of River	High		
Riparian Vegetation	Trees >10m (%)	50		Riparian Vegetation %	Trees >10m (%)	1	
	Shrubs/vines/rushes (%)	0			Shrubs/vines/rushes (%)	0	
	Grasses/herbs/ferns (%)	40			Grasses/herbs/ferns (%)	10	
Stream Width	Mode (m)	2		Stream Width	Mode (m)	1.5	
Land Use	Native forest			Land Use	Grazing		
Substrate	Gravel	20		Substrate	Silt	10	
	Clay	80			Clay	90	
Habitat	Detritus cover/Bank overhang/Trailing bank vegetation	0/0/0		Habitat	Detritus cover/Bank overhang/Trailing bank vegetation	0/0/10	
	Total Macrophytes	0			Total Macrophytes	0	



# Knapsack Creek

Site Location	Knapsack Creek		
Survey Date	15.10.15		
Site Summary		Ranking	Summary
Water Quality	Low flow conditions	1	Low disturbance
Instream Habitat	Bedrock with detritus, isolated pools in bedrock	1	Low disturbance
Riparian Zone	Native forest	1	Low disturbance



Site Description			Comments
Topography	Broad Valley		
Average Water Depth (m)	>50cm		
Water Level	Low flow		
Shading of River	Moderate		

# Knapsack Creek

Riparian Vegetation	Trees >10m (%)	60	
	Shrubs/vines/rushes (%)	10	
	Grasses/herbs/ferns (%)	30	
Stream Width	Mode (m)	1.5	
Land Use	Native forest		
Substrate	Bedrock	100	
Habitat	Detritus cover/Bank overhang/Trailing bank vegetation	30/0/10	
	Total Macrophytes	5	Small individuals of <i>Chara</i>

# Site Medway Dam

Site Location	Medway Dam		
Survey Date	18.3.14		
Site Summary		Ranking	Summary
Water Quality	Clear deep dam	0	No evidence of disturbance
Instream Habitat	Gravelly stable sediment with sloping banks	0	No evidence of disturbance
Riparian Zone	Well established and not disturbed	0	No evidence of disturbance



Site Description			Comments
Topography	Broad/Steep Valley		
Average Water Depth (m)	>1.5 m		
Water Level	High		
Shading of River	Moderate/High		

# Site Medway Dam

<b>Riparian Vegetation</b>	Trees >10m (%)	70	
	Shrubs/vines/rushes (%)	20	Juncus sp
	Grasses/herbs/ferns (%)	10	
<b>Stream Width</b>	Mode (m)	10m	
<b>Land Use</b>	Native forest		
<b>Substrate</b>	Silt	10	
	Gravel	90	
<b>Habitat</b>	Detritus cover/Bank overhang/Trailing bank vegetation	0/10/20	
	Total Macrophytes	80	<i>Potamogeton crispus</i> <i>and ochreatus</i> <i>Nymphoides indica</i>



# Sites SIA7 and SIA9

<b>Site Location</b>	Oldbury Creek			<b>Site Location</b>	Medway Rivulet		
<b>Survey Date</b>	19.5.14			<b>Survey Date</b>	17.5.14		
<b>Site Summary</b>		<b>Ranking</b>	<b>Summary</b>	<b>Site Summary</b>		<b>Ranking</b>	<b>Summary</b>
<b>Water Quality</b>	No flow conditions	3	High disturbance	<b>Water Quality</b>	Flowing over cobble	3	High disturbance
<b>Instream Habitat</b>	Emergent vegetation within channel and deeper channel without emergent vegetation	3	High disturbance	<b>Instream Habitat</b>	Bridge at site	3	High disturbance
<b>Riparian Zone</b>	Cleared for grazing and some weeds, no riparian shrubs or trees	4	Extreme disturbance	<b>Riparian Zone</b>	Uncleared, high creek shading	4	Extreme disturbance



<b>Site Description</b>			<b>Comments</b>	<b>Site Description</b>			<b>Comments</b>
<b>Topography</b>	Broad Valley			<b>Topography</b>	Broad Valley		
<b>Average Water Depth (m)</b>	>1m			<b>Water Depth (m)</b>	0.3		
<b>Water Level</b>	Low flow			<b>Water Level</b>	Low flow		

# Sites SIA7 and SIA9

Shading of River	None			Shading of River	High		
Riparian Vegetation	Trees >10m (%)	1		Riparian Vegetation %	Trees >10m (%)	30	
	Shrubs/vines/rushes (%)	0			Shrubs/vines/rushes (%)	30	Gorse and weed species
	Grasses/herbs/ferns (%)	40	Juncus spp		Grasses/herbs/ferns (%)	10	
Stream Width	Mode (m)	2		Stream Width	Mode (m)	1.5	
Land Use	Grazing			Land Use	Grazing		
Substrate	Silt	10		Substrate	Silt	10	
	Clay	90			Cobble	90	
Habitat	Detritus cover/Bank overhang/Trailing bank vegetation	0/20/20		Habitat	Detritus cover/Bank overhang/Trailing bank vegetation	0/0/10	
	Total Macrophytes	0			Total Macrophytes	0	<i>Azolla pinnata</i>









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