HUMECOAL
PROJECT

VOLUME 6

Hume Coal Project

Environmental Impact Statement

Appendix H

Prepared for Hume Coal Pty Limited
March 2017

EMM

VOLUME 1 **Main Report**

VOLUME 2 **Appendices A to C**
Appendix A Schedule of lands
Appendix B Secretary's Environmental Assessment Requirements
Appendix C Study team

VOLUME 3A **Appendix D**
Appendix D Berrima Rail Project Environmental Impact Statement
– Main report
– Appendices A to D

VOLUME 3B **Appendix D**
Appendix D Berrima Rail Project Environmental Impact Statement
– Appendices E to H

VOLUME 3C **Appendix D**
Appendix D Berrima Rail Project Environmental Impact Statement
– Appendices I to J

VOLUME 3D **Appendix D**
Appendix D Berrima Rail Project Environmental Impact Statement
– Appendices K to M

VOLUME 4A **Appendix E**
Appendix E Water Impact Assessment Report
– Main report
– Appendices A to E

VOLUME 4B **Appendix E**
Appendix E Water Impact Assessment Report
– Appendices F to O

VOLUME 5 **Appendices F and G**
Appendix F Soil and Land Assessment Report
Appendix G Agricultural Impact Statement

VOLUME 6 **Appendix H**
Appendix H Biodiversity Assessment Report

VOLUME 7 **Appendices I to L**
Appendix I Noise and Vibration Assessment Report
Appendix J Health Impact Assessment Report
Appendix K Air Quality and Greenhouse Gas Assessment Report
Appendix L Subsidence Assessment Report

VOLUME 8 **Appendices M to O**
Appendix M Traffic and Transport Assessment Report
Appendix N Visual Amenity Assessment Report
Appendix O Rehabilitation and Closure Strategy

VOLUME 9 **Appendices P to R**
Appendix P Hazard and Risk Assessment Report
Appendix Q Economic Impact Assessment Report
Appendix R Social Impact Assessment Report

VOLUME 10 **Appendices S to U**
Appendix S Aboriginal Cultural Heritage Assessment Report
Appendix T Statement of Heritage Impact
Appendix U Site Verification Certificate

Appendix H

Biodiversity Assessment Report

Hume Coal Project

Environmental Impact Statement | Appendix H | Biodiversity Assessment Report

Prepared for Hume Coal Pty Limited | 13 March 2017

Hume Coal Project

Environmental Impact Statement | Appendix H
| Biodiversity Assessment Report

Prepared for Hume Coal Pty Limited | 13 March 2017

Ground Floor, Suite 01, 20 Chandos Street
St Leonards, NSW, 2065

T +61 2 9493 9500
F +61 2 9493 9599
E info@emmconsulting.com.au

www.emmconsulting.com.au

Hume Coal Project

Final

Report J12055RP1 | Prepared for Hume Coal Pty Limited | 13 March 2017

Prepared by	**Katie Whiting**	Approved by	**Nicole Armit**
Position	Associate ecologist	Position	Associate environmental scientist
Signature		Signature	
Date	13 March 2017	Date	13 March 2017

Document Control

Version	Date	Prepared by	Reviewed by
1	4 November 2015	Katie Whiting	Jodi Kelehear Paul Mitchell
2	19 April 2016	Katie Whiting	Paul Mitchell
3	1 September 2016	Katie Whiting	Nicole Armit
4	11 October 2015	Katie Whiting	Luke Stewart
5	22 November 2016	Katie Whiting	Luke Stewart
6	25 November 2016	Katie Whiting	Luke Stewart
7	13 March 2017	Mark Roberts	Mark Roberts

EMM

T +61 (0)2 9493 9500 | F +61 (0)2 9493 9599

Ground Floor | Suite 01 | 20 Chandos Street | St Leonards | New South Wales | 2065 | Australia

www.emmconsulting.com.au

Executive Summary

Hume Coal Pty Limited is seeking State significant development consent to construct and operate an underground coal mine and associated mine infrastructure (the '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 will be developed within the northern part of A349 and associated surface facilities will be developed immediately north of A349.

This Biodiversity Assessment Report (BAR) has been prepared by EMM to support the Environmental Impact Statement prepared for the Hume Coal Project, and has been completed in accordance with the biodiversity-related Secretary's Environmental Assessment Requirements (SEARs), supplementary SEARs, and assessment recommendations from the NSW Office of Environment and Heritage (OEH),Department of Primary Industries (DPI) and Fisheries NSW. This BAR provides the methods and results of terrestrial field surveys completed by EMM Consulting Pty Ltd (EMM) and aquatic field surveys by JSA Environmental.

A desktop assessment and extensive field surveys were completed between 2012 and 2016 for the BAR to accurately define terrestrial and aquatic biodiversity in the project area (ie the extent of the underground and surface facilities), with a particular focus on threatened species, populations and communities listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act), *Fisheries Management Act 1994* (FM Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The terrestrial and aquatic study areas were expanded to the extent of potential indirect impacts relating to groundwater, in accordance with the DPI Water's assessment recommendations. A detailed desktop assessment was completed to identify threatened biodiversity and potential groundwater dependent ecosystems in this area. The survey effort employed between 2012 and 2015 was reviewed following receipt of the SEARs, agency requirements and the final surface infrastructure layout to determine if any additional surveys were required. Additional plot and transect flora surveys were completed in 2016 to provide sufficient coverage of the final surface infrastructure layout, accurately inform impact assessment and offset calculations, and satisfy the SEARs and agency requirements.

The extensive biodiversity knowledge gained during the biodiversity study has been used to inform the placement of surface facilities such that they avoid and minimise impacts to threatened biodiversity. This knowledge has also informed the selection of a mining method with negligible subsidence impacts on threatened biodiversity and minimised potential impacts on groundwater dependent ecosystems. Accordingly, the resulting mine design has minor impacts on threatened biodiversity.

The BAR has assessed the direct and indirect impacts of surface facilities in accordance with the *Framework for Biodiversity Assessment: NSW Offsets Policy for Major Projects* (the FBA) to inform an accurate assessment of the project's residual surface impacts on terrestrial biodiversity. This assessment has informed the calculation of the project's BioBanking credit requirements.

The BAR is an interdisciplinary assessment that considers the potential impacts of subsidence and changes to hydrology on the threatened terrestrial biodiversity identified and aquatic ecosystems. A groundwater dependent ecosystems assessment approach has been specifically developed for the project following the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NOW 2012). This approach combines depth to groundwater information, native vegetation mapping, groundwater dependent ecosystem characterisation and drawdown contours to inform an accurate assessment of potential impacts.

While threatened terrestrial species, populations and communities were recorded or are predicted to occur in the project and study area, many of these will not be directly impacted by the project. The project's residual direct impacts can be summarised as:

- the clearing of paddock trees, with an effective clearing area (according to the paddock tree calculator) of 8.3 ha of PCT 731 Broad-leaved Peppermint - Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion (low condition); and

- the clearing of paddock trees, with an effective clearing area of 8.3 ha, that represent habitat for the Koala, Southern Myotis and Squirrel Glider.

No threatened aquatic species were recorded or are predicted to occur, due to the absence of suitable habitat. No riparian vegetation will be cleared for the project, and waterway crossings will be designed such that fish passage will be maintained and appropriate scour protection measures implemented.

A total of 101 ecosystem credits and 582 species credits are required to offset the above impacts, in accordance with the FBA. A biodiversity offset strategy has been prepared to source and protect suitable offsets within 12 months of project approval that will compensate for these impacts.

One matter for further consideration was identified in the SEARs, namely the Black Gum (*Eucalyptus aggregata*), which is an endangered species and also an endangered population in the Wingecarribee local government area. The project will not directly or indirectly impact the Black Gum species or population.

Potential drawdown impacts have been predicted for terrestrial vegetation along Belanglo Creek and Wells Creek during periods of prolonged drought. The terrestrial vegetation along Belanglo Creek represents potential Koala habitat (listed as a vulnerable species under the TSC and EPBC Acts), and the terrestrial vegetation along Wells Creek represents Southern Highlands Shale Forest and Woodland (listed as an endangered ecological community under the TSC Act, and critically endangered under the EPBC Act). A monitoring and management procedure will be designed and implemented in accordance with the Biodiversity Management Plan (BMP) to be developed for the project.

Potential drawdown impacts were also assessed for Long Swamp and Stingray Swamp in the study area. These form part of Paddys River Swamps, which are listed as nationally important wetlands under the EPBC Act. These swamps are not predicted to be impacted by the project.

Stygofauna have potential to occur in groundwater systems in the area affected by drawdown, however none were recorded in the project area during surveys. However, should Stygofauna be present in the project area, it is unlikely that they would be restricted to the area affected by drawdown given the high level of groundwater connectivity to adjacent areas.

One individual of the family Bathynellidae was recorded in the south of the study area at Hanging Rock Swamp in Penrose State Forest. This known individual was recorded outside the area affected by drawdown and therefore will not be impacted by the project.

Minor reductions in base flow are expected in Medway Rivulet. While reduced low flow conditions have the potential to exacerbate existing disturbance conditions, they are unlikely to have an adverse long term impact on aquatic ecosystems given the minor base flow reduction expected. Changes to surface runoff as a result of site water management would be limited to the two watercourses in the surface infrastructure area, namely Medway Rivulet and Oldbury Creek. Flow regimes on these watercourses will be similar to pre-mining conditions during operation of the project, assuming that the constant low flow discharges from Moss Vale and Berrima sewage treatment plants continues. Should this continue, changes to surface runoff would not impact aquatic ecosystems. Platypus habitat was found to be absent from the project area and, therefore, they will not be impacted by any changes to streamflow or surface hydrology resulting from the project. The breeding population of Platypus on the Wingecarribee River will not be impacted by changes to base flow as a result of the project, as percentage loss of total stream flow as a result of baseflow reduction in the lower Wingecarribee River and their tributaries is assessed as negligible.

A number of other potential residual impacts were identified for the project associated with the construction and operation of the project, including fauna injury and mortality, erosion and sedimentation, introduced species and increased noise, dust and light. Strategies have been designed to minimise and mitigate these potential impacts, which will be implemented in accordance with the BMP to be developed for the project.

Assessments of significance were completed to assess the residual direct and indirect impacts of the project on Southern Highlands Shale Forest and Woodland, Paddys River Box, Koala and Large-eared Pied Bat, recorded adjacent to the surface facilities. Assessments of significance were also completed to assess indirect groundwater-related impacts on threatened species and communities associated with Long Swamp and Stingray Swamp in the study area, comprising:

- threatened ecological communities: Temperate Highland Peat Swamps on Sandstone and Robertson Basalt Tall Open Forest;
- threatened flora: Paddys River Box, Dwarf Phyllota and Broad-leaved Sally;
- threatened fauna: Australasian Bittern, Australian Painted Snipe, Koala and Giant Dragonfly; and
- migratory fauna: Cattle Egret and Great Egret.

The assessments concluded that the project is not expected to result in a significant impact on these threatened species and communities.

Table of contents

Executive Summary ES.1

Glossary of terms ix

Chapter 1 Introduction 1

1.1 Overview 1
1.2 Project area and study areas 1
1.3 Project description 8
1.4 General site description 9
1.5 Assessment requirements 13
1.6 Adoption of leading practices 19
1.7 Assessor accreditation and qualifications of study team 19

Chapter 2 Methods 21

2.1 Terrestrial assessment methods 21
2.2 Literature review 22
2.3 Database searches 22
2.4 Vegetation survey methods 23
2.4.1 Vegetation mapping review 23
2.4.2 Preliminary site assessment 24
2.4.3 Vegetation type mapping 24
2.4.4 Plot-based surveys 25
2.4.5 Rapid vegetation assessments 25
2.4.6 Threatened ecological community identification 25
2.5 Targeted species surveys 26
2.5.1 Target flora species 26
2.5.2 Targeted flora survey methods 27
2.5.3 Target fauna species 29
2.6 Fauna survey methods 32
2.6.1 Survey guidelines 32
2.6.2 Fauna habitat assessment 32
2.6.3 Active reptile searches 33
2.6.4 Bird surveys 33
2.6.5 Microbat surveys 33
2.6.6 Arboreal and ground-dwelling mammals 34
2.7 Survey effort summary 37
2.8 Limitations 37
2.9 Naming conventions 37
2.10 Identification of groundwater dependent ecosystems 38

Table of contents *(Cont'd)*

2.11	Aquatic assessment methods	40
	2.11.1 Database searches	40
	2.11.2 Survey locations and timing	41
	2.11.3 Survey methods	44
2.12	Stygofauna assessment methods	47
	2.12.1 Literature review	47
	2.12.2 Survey locations and timing	48
	2.12.3 Survey methods	50
Chapter 3	Landscape values	51
3.1	Overview	51
3.2	IBRA Bioregion	51
3.3	Mitchell landscapes	51
	3.3.1 Rivers and drainage lines	52
	3.3.2 Key fish habitats in the Wingecarribee Shire	54
	3.3.3 Wetlands	56
	3.3.4 Biodiversity links	56
	3.3.5 Other landscape values	56
3.4	Native vegetation	57
	3.4.1 Native vegetation within the assessment circles	57
Chapter 4	Biodiversity in the project area and study areas	59
4.1	Native vegetation	59
	4.1.1 The project area	59
	4.1.2 The terrestrial study area	65
4.2	Threatened flora species and populations	69
	4.2.1 The project area	69
	4.2.2 The terrestrial study area	69
4.3	Threatened ecological communities	69
	4.3.1 The project area	69
	4.3.2 The terrestrial study area	77
4.4	Threatened fauna species	81
	4.4.1 The project area	81
	4.4.2 Threatened fauna species listed under the TSC Act recorded or likely to occur in the project area	82
	4.4.3 Threatened fauna species listed under the EPBC Act recorded or likely to occur in the project area	82
	4.4.4 Threatened fauna predicted to occur in the study areas	86
4.5	Ecosystems potentially reliant on shallow groundwater	87
4.6	Aquatic species and habitats	90

Table of contents *(Cont'd)*

	4.6.1 Surface water quality	90
	4.6.2 Macroinvertebrates	91
	4.6.3 SIGNAL 2	92
	4.6.4 EPT index	94
	4.6.5 Fish and turtles	97
	4.6.6 Key fish habitat assessment	97
	4.6.7 Threatened and protected species	100
4.7	Stygofauna	101
	4.7.1 Groundwater quality	101
	4.7.2 Stygofauna	102
Chapter 5	Biodiversity in the surface infrastructure area	105
5.1	Terrestrial biodiversity in the surface infrastructure area	105
5.2	Vegetation zones in the surface infrastructure area	107
	5.2.1 Paddock tree calculations	107
5.3	Threatened species in the surface infrastructure area	108
	5.3.1 Ecosystem credit species predicted to occur in the surface infrastructure area	108
	5.3.2 Species credit species predicted to occur in the surface infrastructure area	109
5.4	Areas requiring offset	112
5.5	Areas not requiring offset	112
5.6	Aquatic biodiversity in the surface infrastructure area	115
Chapter 6	Impact avoidance and mitigation	117
6.1	Avoidance and minimisation	117
	6.1.1 Overview	117
	6.1.2 Surface infrastructure layout	118
	6.1.3 Mine design	118
	6.1.4 Groundwater management	119
	6.1.5 Surface water management	119
	6.1.6 Waterway crossings	120
6.2	Impact mitigation	120
	6.2.1 Construction and operational management plans	120
	6.2.2 Construction biodiversity mitigation measures	120
	6.2.3 Operational biodiversity mitigation measures	121
	6.2.4 Proposed mitigation measures	121
	6.2.5 Justification of avoidance and mitigation measures	124
	6.2.6 Effectiveness of avoidance and mitigation measures	125
Chapter 7	Impact assessment	127
7.1	Residual impacts on terrestrial biodiversity from construction of surface	127

Table of contents *(Cont'd)*

infrastructure

7.1.1 Direct impacts 127
7.1.2 Indirect impacts 130
7.2 Residual biodiversity impacts from underground mining 132
7.2.1 Groundwater dependent ecosystems in the study areas 132
7.3 Matters for further consideration 146
7.4 Impact assessment for threatened species and communities 148
7.4.1 Threatened and migratory species recorded outside the area of impact 148
7.4.2 Threatened species in the surface infrastructure area 148
7.4.3 Threatened and migratory species in the study areas 148
7.5 Key threatening processes 149
7.6 Critical habitat 150
7.7 Cumulative impacts 150
7.8 Matters of National Environmental Significance 152
7.8.1 Threatened ecological communities 152
7.8.2 Listed species 153
7.8.3 Nationally important wetlands 155

Chapter 8 Biodiversity credit report 157
8.1 Impacts requiring offsetting 157
8.2 Quantification of impacts 157
8.2.1 Ecosystem credits 157
8.2.2 Species credits 158

Chapter 9 Biodiversity offset strategy 159
9.1 Strategy 159
9.2 Offset security 160

Chapter 10 Conclusion 161

References 163

Appendices

A Compliance with FBA requirements
B Compliance of survey effort against guidelines
C Vegetation data
D Fauna species list
E Likelihood of occurrence for threatened species
F Koala habitat assessment
G Assessments of significance
H Biodiversity Credit Report and BioBanking Credit Report for potential offsets
I Qualifications of study team
J Supporting aquatic information

Tables

1.1	Biodiversity-related SEARs	13
1.2	OEH assessment recommendations	15
1.3	DPI Water assessment recommendations	15
1.4	Fisheries NSW assessment recommendations	17
1.5	Commonwealth Supplementary Biodiversity SEARs	18
2.1	Summary of survey dates	21
2.2	Database search details	23
2.3	Vegetation information reviewed and data obtained	24
2.4	Target threatened flora survey methods and timing	26
2.5	Target threatened fauna survey methods and timing	29
2.6	Summary of survey effort	37
2.7	Naming conventions by group	38
2.8	Database search details	40
2.9	Aquatic survey locations and timing	41
2.10	Habitat assessment locations and timing	43
2.11	Fish habitat classification	46
2.12	Data analysis summary	47
2.13	Stygofauna survey locations	48
3.1	Stream order in the aquatic study area	53
3.2	Native vegetation in the assessment circles before and after development	57
4.1	Plant community types in the project area	61
4.2	Vegetation communities in the terrestrial study area	65
4.3	Threatened ecological communities known to occur within the Burragorang and Moss Vale IBRA sub-regions and identified in the Protected Matters Search Tool	70

Tables

4.4	Assessment against condition categories, classes and thresholds for Southern Highlands Shale Forest and Woodland (TSSC 2015)	75
4.5	Threatened ecological communities in the terrestrial study area	78
4.6	Dependence of potential GDEs	88
4.7	Surface water quality results	91
4.8	EPT index	95
4.9	EPT results	96
4.10	Fish and turtles recorded	97
4.11	Key fish habitat assessment results	98
5.1	Vegetation zones in the surface infrastructure area and survey effort by zone	107
5.2	Assumptions informing paddock tree calculations	108
5.3	Ecosystem credit species	109
5.4	Species credit species	110
5.5	Fish habitat in the surface infrastructure area	115
6.1	Mitigation measures	121
7.1	Induced maximum baseflow reduction for surface water sources	144
7.2	Key threatening processes and significance of threat	149
8.1	Ecosystem credits required	158
8.2	Species credits required	158
9.1	Available species credits	159
9.2	Credits generated vs credits required	160
A.1	Assessment of compliance with FBA requirements for the site map	A.2
A.2	Assessment of compliance with FBA requirements for the location map	A.3
A.3	Assessment of compliance with other mapping and data requirements of the FBA	A.4
B.1	Comparison against survey effort guideilnes for threatened fauna species	B.1
E.1	Assessment criteria	E.1
E.2	Threatened species recorded or predicted to occur within 20 km radius of the project area	E.2
F.1	Koala Referral Guidelines Assessment for native vegetation in the project area	F.2
G.1	Assessment of significance for Southern Highlands Shale Forest and Woodland, Temperate Highland Peat Swamps on Sandstone and Robertson Basalt Tall Open Forest	G.3
G.2	Assessment of significance for endangered species associated with Temperate Highland Peat Swamps on Sandstone: Australasian Bittern and Australian Painted Snipe	G.6
G.3	Assessment of significance for Paddys River Box	G.7
G.4	Assessment of significance for vulnerable species associated with Temperate Highland Peat Swamps on Sandstone	G.9
G.5	Assessment of significance for vulnerable mammals recorded in the project area: Koala and Large-eared Pied Bat	G.11
G.6	Assessment of significance for Great Egret and Cattle Egret	G.14
G.7	Assessment of significance for Giant Dragonfly	G.16
I.1	Qualifications of study team	I.1

Figures

1.1	Regional context	3
1.2	Local context	4
1.3	Project area and study area	5
1.4	Site map – overview	6
1.5	Location map – overview	7
1.6	Indicative project layout	11
1.7	Indicative surface infrastructure layout	12
2.1	Flora survey locations	28
2.2	Targeted threatened species survey locations	36
2.3	Aquatic survey and habitat assessment locations	42
2.4	Stygofauna survey locations	49
3.1	Stream order in the project area and aquatic study area	55
4.1	Vegetation of the project area	64
4.2	Native vegetation in the project area and terrestrial study area	68
4.3	Threatened ecological communities in the project area	79
4.4	Threatened ecological communities in the project area and terrestrial study area	80
4.5	Threatened species locations	84
4.6	Vegetation types that represent potential Koala habitat in the project area	85
4.7	Ecosystems potentially reliant on groundwater	89
5.1	Plant community types and threatened species in the surface infrastructure area	106
5.2	Areas requiring offset – surface infrastructure area	113
5.3	Areas not requiring offset – surface infrastructure area	114
7.1	Potential ecosystem impacts - 17 years after start of mining	138
7.2	Potential ecosystem impacts - 30 years after start of mining	139
7.3	Project induced groundwater table drawdown at Year 17 of mining	140
7.4	Project induced groundwater table drawdown at Year 30 of mining	141
7.5	Black Gum records in the terrestrial study area	147

Plates

2.1	GDE categories	40
3.1	Key fish habitat in the Wingecarribee LGA (DPI 2007) (approximate aquatic study area shown in black square)	54
4.1	Macroinvertebrate abundance	92
4.2	The quadrant diagram for the Order-Class-Phyum version of SIGNAL2	93
4.3	SIGNAL2 results	94
7.1	Ecosystem drawdown risk assessment	133
7.2	Differential drawdown at the water table at virtual piezometer sites (source: Water Assessment, Appendix E of the EIS)	135

Glossary of terms

Approved conservation advice: Legal definition of a threatened ecological community listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*	**Biodiversity credit report:** Output of the NSW Office of Environment and Heritage's BioBanking Calculator, which determines the credits required to offset the impacts of a development.
Groundwater system: An underground layer of water-bearing permeable rock, rock fractures, or unconsolidated material (ie gravel, sand or silt).	**Terrestrial vegetation:** Native vegetation on land.
Assessment circles: Two circles (the inner and outer assessment circle) in which the percentage of native vegetation cover in the landscape is assessed, taking into account both the cover and condition of the vegetation.	**Subsidence:** An assessment of the likely conventional and non conventional subsidence effects and impacts of the development, and the potential consequences of these effects and impacts on the natural and built environment.
Biodiversity links: Vegetation corridors important for faunal movement.	**Groundwater model:** A computer model of groundwater flow systems, used to simulate the changes in an groundwater system during and after mining.
Ecosystem credit species: A species that can be reliably predicted to occur within a plant community type.	**Cumulative impact:** Impacts caused by the combined results of current and future development activities.
Ecosystem credit: Ecosystem credits measure the loss in biodiversity values at a development site and the gain in biodiversity values at an offset site.	**Critical habitat:** Habitat for threatened species or populations listed under Section 53-55 of the *Threatened Species Conservation Act 1995.*
Final determination: The legal definition of a threatened ecological community listed under the NSW *Threatened Species Conservation Act 1995.*	**Biodiversity offset strategy:** A strategy that outlines how biodiversity offset sites will be found that meet the credit requirements of the project.
Groundwater dependent ecosystem: An ecosystem in which the species composition and natural ecological processes are detemined by groundwater.	**Water table drawdown:** A decrease in water table height as a result of underground mining.
IBRA Bioregion: A bioregion identified under the Interim Biogeographic Regionalisation for Australia (IBRA) system, which divides Australia into bioregions on the basis of their dominant landscape-scale attributes.	**Pre-mining water table height:** The height of the water table in metres below ground level (mbgl) prior to mining.
Landscape values: The value given to landscape attributes of a development site or offset site after an assessment undertaken in accordance with Section 4.2 of the Framework for Biodiversity Assessment: NSW Offsets Policy for Major Projects.	**Virtual piezometer:** A virtual bore built into the groundwater model to predict water table drawdown at a specific point.
Mitchell landscape: Landscapes with relatively homogenous geomorphology, soils and broad vegetation types, mapped at a scale of 1: 250,000.	**Key threatening process:** Processes including habitat loss, weed invasion, disease and climate change, that impact biodiversity and are listed under the NSW *Threatened Species Conservation Act 1995* and the Commonwelath *Environment Protection and Biodiversity Conservation Act 1999.*
Paddock tree calculator: A calculator that converts the loss of paddock trees in exotic grassland to an effective clearing area in hectares, that can be entered into the BioBanking Calculator to calculate the credits required to offset their loss.	**Residual impact:** An impact on biodiversity values after all resasonable measures have been taken to avoid and minimise the impacts of development. Under the Framework for Biodiversity Assessment: NSW Offsets Policy for Major Projects, offsets are calculated for residual impacts on biodiversity values.

Plant community type: A NSW plant community type identified using the NSW Vegetation Information System (VIS) classification database.	**Habitat critical to the survival of a threatened species or community:** Habitat that is necessary for activites such as foraging, breeding, roosting or dispersal; for the long-term maintenance of the species or ecological community; to maintain genetic diversity and long-term evolutionary development; or for the reintroduction of populations or recovery of the sepcies or ecological community.
Plot: An area within a vegetation zone in which site attributes including native plant species and their structure are assessed.	**Assessment of significance:** An assessment of the significance of a development on a threatened species or community, in accordance with the criteria prescribed in *Matters of National Environmental Significance: Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999.*
Project area: As defined in Figure 1.3 of this report.	**Species polygon:** The area of habitat in a development site for a species credit species.
Species credit species: Threatened species that cannot be reliably predicted by habitat.	**Nationally important wetlands:** Wetlands identified to be of national importance, and defined by the Directory of Important Wetlands in Australia.
Species credit: The class of biodiversity credits created or required for the impact on threatened species.	**Matters of National Environmental Significance:** These include world heritage properties, national heritage places, wetlands of international importance, nationally threatened species and ecological communities, migratory species, Commonwealth marine areas, the Great Barrier Reef, nuclear actions and water resources.
Spring: Water flowing from an groundwater system to earth's surface.	**Tg value:** The ability of a threatened species to respond to improvements in site value or other habitat improvement at an offset site through the implementation of management measures. Tg is based on an assessment of the effectiveness of management actions, life history characteristics, naturally very rare species and poorly known species.
Study area: As defined on Figure 1.3 of this report.	**Avoidance and/ or minimiation measure:** Measures implemented during the development planning process to avoid or minimise impacts on biodiversity.
Surface infrastructure area: The area where surface infrastructure facilities will be placed.	**Mitigiation measure:** Measures that reduce residual impacts, after avoidance and minisation measures have been implemented.
Swamp: An area of low-lying ground where water collects, and is characterised by aquatic vegetation.	**Direct impact:** An impact on biodiversity values that is a direct result of vegetation clearance from a development.
Threatened ecological community: Ecological communities that are listed as vulnerable, endangered or critically endangered under the NSW *Threatened Species Conservation Act 1995* and/or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*	**Indirect impact:** An impact on biodiversity values that occurs as an indirect consequence of development, eg weed invasion, predation, fertiliser drift.
Threatened species: Species that are listed as vulnerable, endangered or critically endangered under the NSW *Threatened Species Conservation Act 1995* and/or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*	**Significant impact:** An impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an impact is significant depends upon the sensitivity, value and quality of the environment which is impacted.
Transect: A line or narrow belt along which environmental data is collected.	**Biodiversity offsets:** The management actions that are undertaken to achieve a gain in biodiversity values at an offset site that compensates for losses to biodivesity values at a development site.

Vegetation type: An assemblage of plant species that are often found growing under the same environmental conditions and are characterised by the presence of one or more dominant species.	**Baseflow:** The portion of streamflow that is not runoff, and results from the seepage of water from the ground into a channel over time.
Vegetation zone: A relatively homogenous area of native vegetation on a development site that is the same plant community type and broad condition state.	**Site value:** The condition of native vegetation assessed for each vegetation zone against the benchmark values for a plant community type.
Stygofauna: the animals that live in groundwater. The taxa predominantly comprise many kinds of crustaceans but includes worms, snails, insects, other invertebrate groups, and, in Australia, two species of blind fish	**Macroinvertebrate:** aquatic invertebrate fauna that can be captured by a 500--µm net or sieve. This includes arthropods (insects, mites, scuds and crayfish), molluscs (snails, limpets, mussels and clams), annelids (segmented worms), nematodes (roundworms), and platyhelminthes (flatworms).

1 Introduction

1.1 Overview

Hume Coal Pty Limited (Hume Coal) is seeking State significant development consent to construct and operate an underground coal mine and associated mine infrastructure (the '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 Shire local government area (LGA). The underground mine and associated surface facililities will be developed within A349, with the majority of associated surface facilities to be constructed to the north of this area.. The project area and its regional and local setting are shown in Figure 1.1 and Figure 1.2.

The project has been developed following several years of technical investigations to define the mineable resource and identify and address environmental and other constraints. Low impact mining methods will be used which will have negligible subsidence impacts and thereby protect the overlying groundwater system and surface features and allow existing land uses to continue at the surface. Post-mining, the mine infrastructure will be decommissioned and the areas rehabilitated to a state where they can support land uses similar to the current land uses.

Approval for the Hume Coal Project is being sought under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). An environmental impact statement (EIS) is a requirement of the approval processes. This Biodiversity Assessment Report (BAR) forms part of the EIS. It documents the methodology and results of the biodiversity assessment, the measures taken to avoid and minimise impacts, and the additional mitigation, management and proposed offset strategy. This report focuses on terrestrial and aquatic biodiversity. All terrestrial surveys were completed by EMM, while aquatic surveys were completed by JSA Environmental. The methods, results and conclusions of the aquatic assessment form part of this BAR.

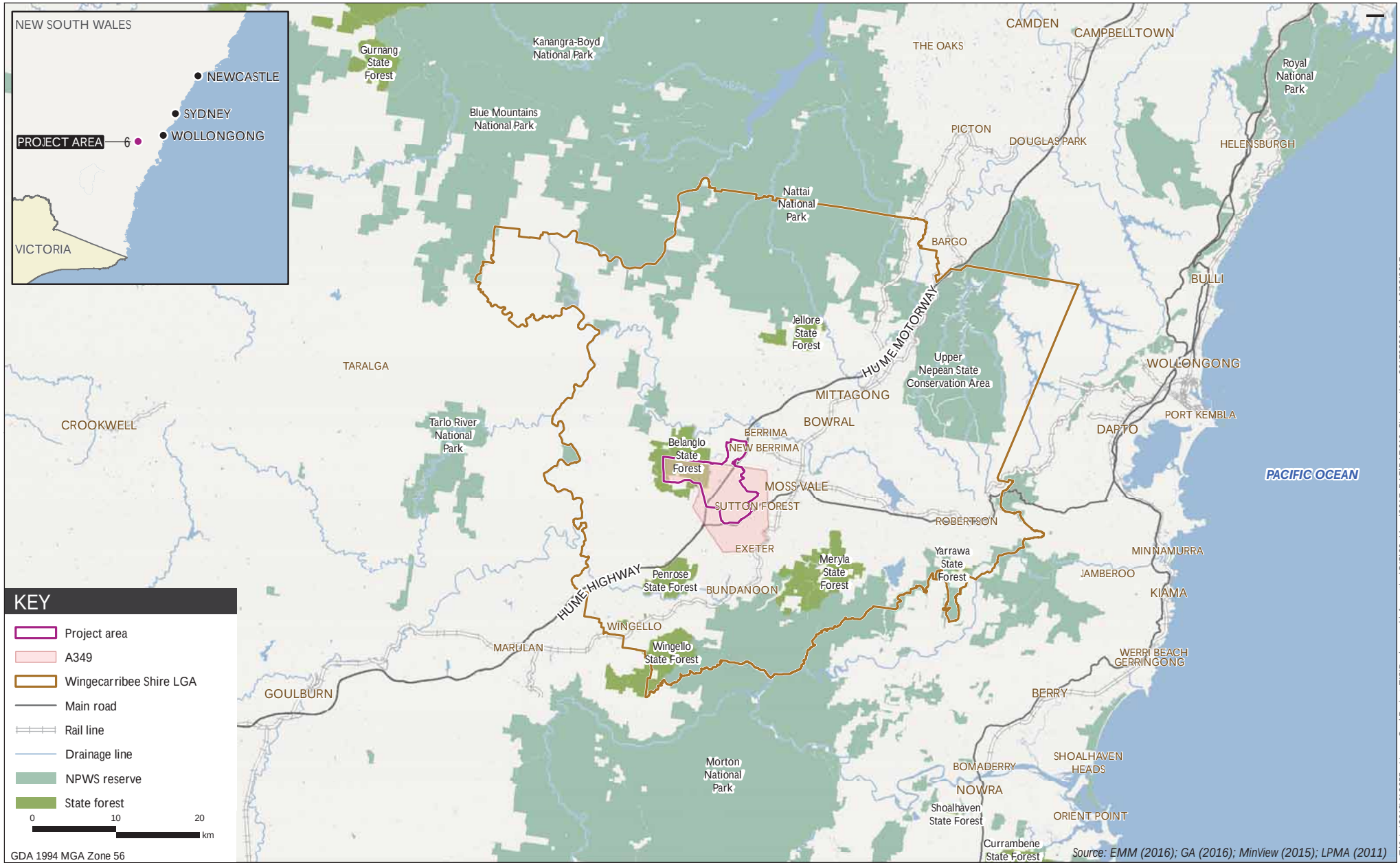
1.2 Project area and study areas

The project area is defined in Figure 1.3. In accordance with the SEARs and other agency requirements, this biodiversity assessment considers surface impacts on terrestrial biodiversity in accordance with the FBA, surface impacts on aquatic biodiversity and also impacts on terrestrial and aquatic biodiversity relating to changes in surface water and groundwater regimes, that may result from the project.

Accordingly, two study areas (ie terrestrial and aquatic) were defined for the BAR, which expanded beyond the project area to the area indicated on Figure 1.3, to consider surface water and groundwater-related impacts (collectively referred to as the study areas) and encompass all aquatic and surface water sampling sites. The study areas also include the proposed downcast shaft in Belanglo State Forest and the shaft east of the Hume Highway (Figure 1.3).

A conservative approach was taken when identifying the terrestrial and aquatic study areas. Surveys commenced in 2012 when three different mining methods (ie longwall, miniwalls and Wongawilli and low impact) and four different surface infrastructure area locations were being considered (see Chapter 6 of the EIS). Therefore, the scale of impacts could not be predicted. Accordingly, the project team assessed broad study areas.

An overview site map (Figure 1.4) and overview location map (Figure 1.5) have been prepared in accordance with the mapping requirements prescribed in Section 3.2 of the FBA (OEH 2014), with the exception of the mapping scale requirements (ie 1:1,000 scale for the site map and 1:10,000 scale for the location map). Individual site maps and location map have been prepared at the required scales and are provided in Appendix A.

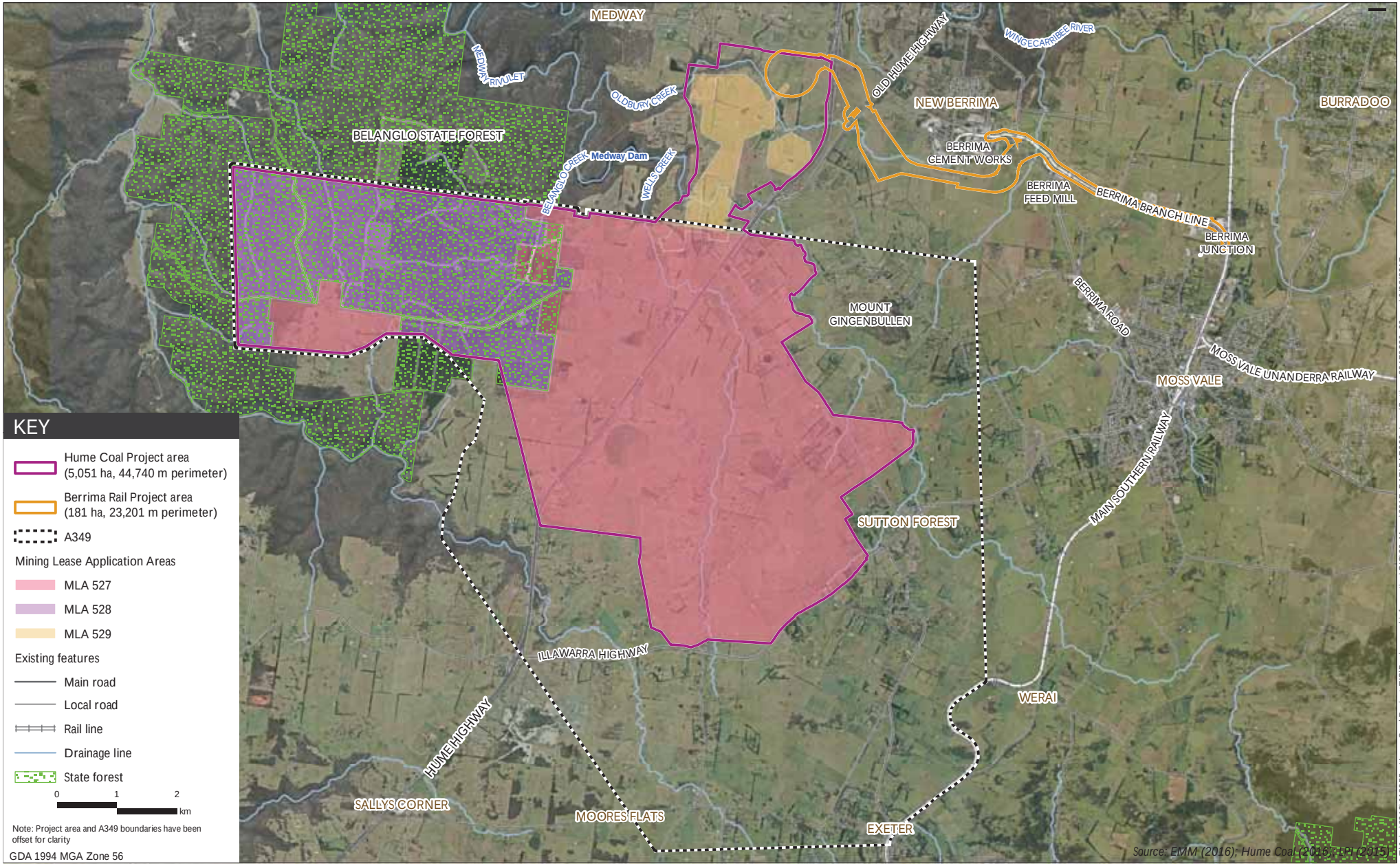


Regional context

Hume Coal Project

Biodiversity Assessment Report

Figure 1.1

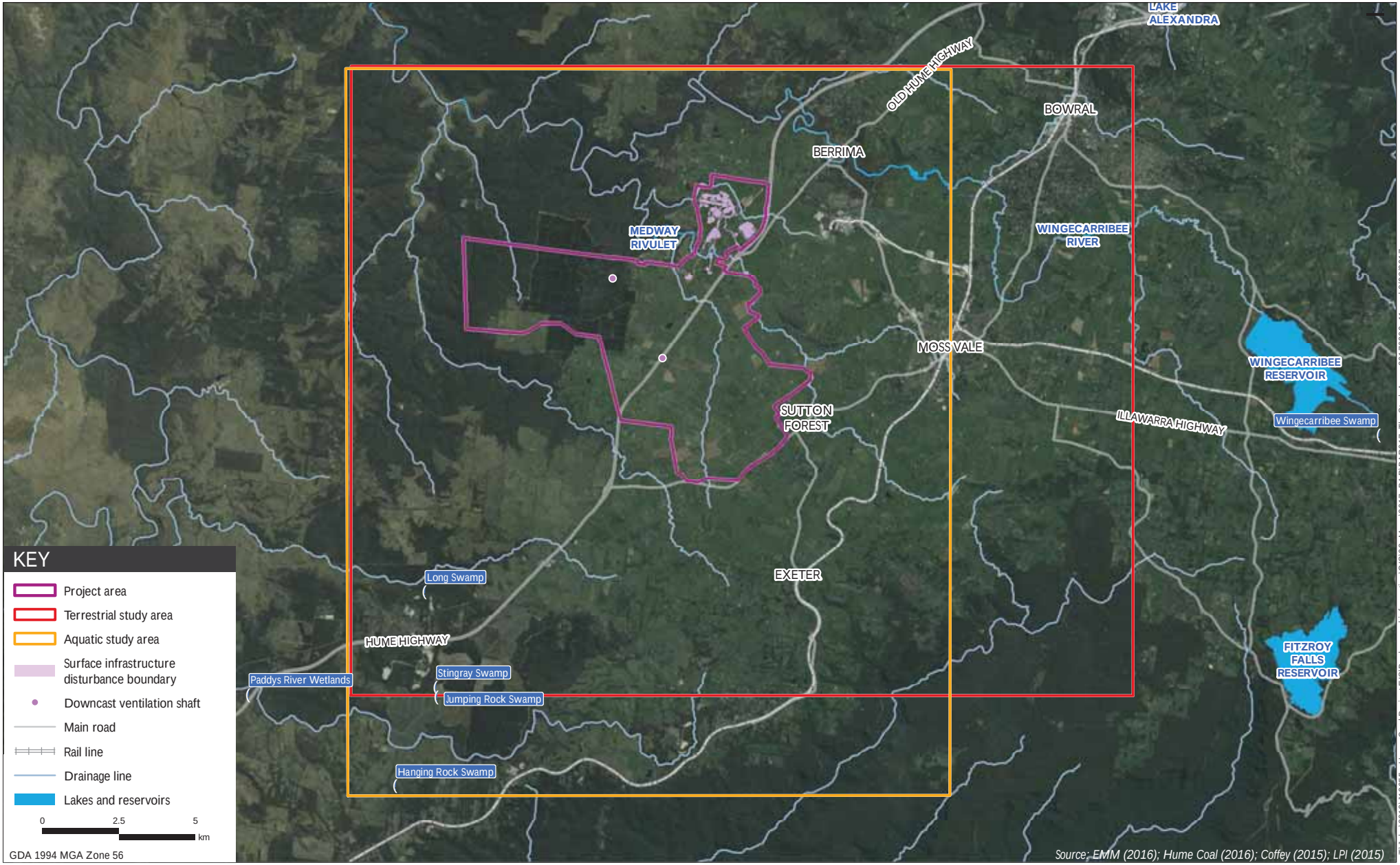


Local context

Hume Coal Project

Biodiversity Assessment Report

Figure 1.2



Project area and terrestrial and aquatic study areas

Hume Coal Project

Biodiversity Assessment Report

Figure 1.3

Biodiversity assessment site map - overview

Hume Coal Project
Biodiversity Assessment Report

Figure 1.4

Biodiversity assessment location map - overview

Hume Coal Project
Biodiversity Assessment Report

Figure 1.5

1.3 Project description

The project involves developing and operating an underground coal mine and associated infrastructure over a total estimated project life of 23 years. Indicative mine and surface infrastructure plans are provided in Figure 1.3 and Figure 1.4. A full description of the project, as assessed in this report, is provided in Chapter 2 of the main EIS report (EMM 2017a).

In summary it involves:

- Ongoing resource definition activities, along with geotechnical and engineering testing, and other fieldwork to facilitate detailed design.
- Establishment of a temporary construction accommodation village.
- Development and operation of an underground coal mine, comprising of approximately two years of construction and 19 years of mining, followed by a closure and rehabilitation phase of up to two years, leading to a total project life of 23 years. Some coal extraction will commence during the second year of construction and hence there will be some overlap between the construction and operational phases.
- Extraction of approximately 50 million tonnes (Mt) of run-of-mine (ROM) coal from the Wongawilli Seam, at a rate of up to 3.5 million tonnes per annum (Mtpa). Low impact mining methods will be used, which will have negligible subsidence impacts.
- Following processing of ROM coal in the coal preparation plant (CPP), production of up to 3 Mtpa of metallurgical and thermal coal for sale to international and domestic markets.
- Construction and operation of associated mine infrastructure, mostly on cleared land, including:
    - one personnel and materials drift access and one conveyor drift access from the surface to the coal seam;
    - ventilation shafts, comprising one upcast ventilation shaft and fans, and up to two downcast shafts installed over the life of the mine, depending on ventilation requirements as the mine progresses;
    - a surface infrastructure area, including administration, bathhouse, washdown and workshop facilities, fuel and lubrication storage, warehouses, laydown areas, and other facilities. The surface infrastructure area will also comprise the CPP and ROM coal, product coal and emergency reject stockpiles;
    - surface and groundwater management and treatment facilities, including storages, pipelines, pumps and associated infrastructure;
    - overland conveyors;
    - rail load-out facilities;
    - a small explosives magazine;
    - ancillary facilities, including fences, access roads, car parking areas, helipad and communications infrastructure; and

- environmental management and monitoring equipment.

- Establishment of site access from Mereworth Road, and construction of minor internal roads.
- Coal reject emplacement underground, in the mined-out voids.
- Peak workforces of approximately 414 full-time equivalent employees during construction and approximately 300 full-time equivalent employees during operations.
- Decommissioning of mine infrastructure and rehabilitating the area once mining is complete, so that it can support land uses similar to current land uses.

The project area, shown in Figure 1.2 is approximately 5,051 hectares (ha). Surface disturbance will mainly be restricted to the surface infrastructure areas shown indicatively on Figure 1.4 though will include some other areas above the underground mine, such as drill pads and access tracks. The project area generally comprises direct surface disturbance areas of up to approximately 117 ha, and an underground mining area of approximately 3,472 ha, where negligible subsidence impacts are anticipated.

A construction buffer zone will be provided around the direct disturbance areas. The buffer zone will provide an area for construction vehicle and equipment movements, minor stockpiling and equipment laydown, as well as allowing for minor realignments of surface infrastructure. Ground disturbance will generally be minor and associated with temporary vehicle tracks and sediment controls as well as minor works such as backfilled trenches associated with realignment of existing services. Notwithstanding, environmental features identified in the relevant technical assessments will be marked as avoidance zones so that activities in this area do not have an environmental impact.

Product coal will be transported by rail, primarily to Port Kembla terminal for the international market, and possibly to the domestic market depending on market demand. Rail works and use are the subject of a separate EIS and State significant development application for the Berrima Rail Project.

1.4 General site description

The project area is approximately 100 kilometres (km) south-west of Sydney and 4.5 km west of Moss Vale town centre in the Wingecarribee LGA (refer to Figure 1.1 and Figure 1.2). The nearest area of surface disturbance will be associated with the surface infrastructure area, which will be 7.2 km north-west of Moss Vale town centre.It is in the Southern Highlands region of NSW and the Sydney Basin Biogeographic Region.

The project area is in a semi-rural setting, with the wider region characterised by grazing properties, small-scale farm businesses, natural areas, forestry, scattered rural residences, villages and towns, industrial activities such as the Berrima Cement work and Berrima Feed Mill, and some extractive industry and major transport infrastructure such as the Hume Highway.

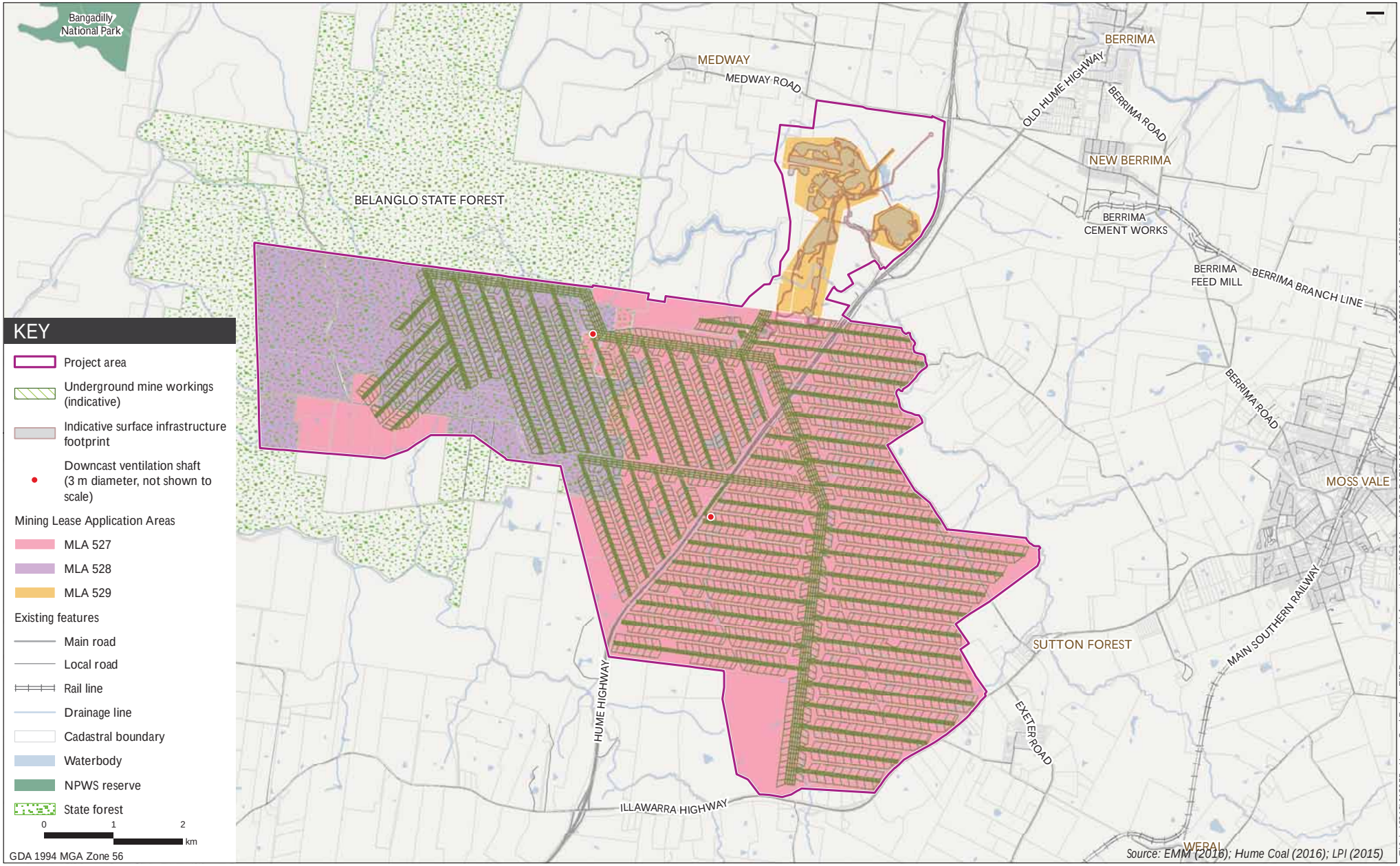
Surface infrastructure is proposed to be developed on predominately cleared land owned by Hume Coal or affiliated entities, or for which there are appropriate access agreements in place with the landowner. Over half of the remainder of the project area (principally land above the underground mining area) comprises cleared land that is, and will continue to be, used for livestock grazing and small-scale farm businesses. 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 within the project area is largely restricted to parts of Belanglo State Forest and riparian corridors along some watercourses.

The project area is traversed by several drainage lines 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 5 km downstream of the project area (Figure 1.2). The Wingecarribee River's catchment forms part of the broader Warragamba Dam and Hawkesbury-Nepean catchments. Medway Dam is also adjacent to the northern portion of the project area (Figure 1.2).

Most of the central and eastern parts of the project area have very low rolling hills with occasional elevated ridge lines. However, there are steeper slopes and deep gorges in the west in Belanglo State Forest.

Existing built features across the project area include scattered rural residences and farm improvements such as outbuildings, dams, access tracks, fences, yards and gardens, as well as infrastructure and utilities including roads, electricity lines, communications cables and water and gas pipelines. Key roads that traverse the project area are the Hume Highway and Golden Vale Road. The Illawarra Highway borders the south-east section of the project area.

Industrial and manufacturing facilities adjacent to the project area include the Berrima Cement Works and Berrima Feed Mill on the fringe of New Berrima. Berrima Colliery's mining lease (CCL 748) also adjoins the project area's northern boundary. Berrima colliery is currently not operating with production having ceased in 2013 after almost 100 years of operation. The mine is currently undergoing closure.



Indicative project layout

Hume Coal Project

Biodiversity Assessment Report

Figure 1.6

Indicative surface infrastructure layout

Hume Coal Project
Biodiversity Assessment Report

Figure 1.7

1.5 Assessment requirements

This assessment has been prepared in accordance with the relevant governmental assessment requirements, guidelines and policies, and in consultation with the relevant government agencies. Guidelines and policies considered are as follows:

- *Framework for Biodiversity Assessment: NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014);
- *Threatened species assessment guideline: the assessment of significance* (DECC 2007);
- *NSW State Groundwater Dependent Ecosystems Policy* (DLWC 2002);
- *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NOW 2012);
- *State Environmental Planning Policy No. 44 – Koala Habitat Protection* (SEPP 44);
- *Matters of National Environmental Significance*: *Significant impact guidelines 1.1* (DoE 2013);
- *EPBC Act referral guidelines for the vulnerable Koala* (DoE 2014);
- *Referral guideline for 14 birds listed as migratory species under the EPBC Act* (DoE 2015);
- *Policy and Guidelines for fish habitat conservation and management* (DPI 2013);
- *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings'* (Fairfull and Witheridge 2003); and
- *Guidelines for watercourse crossings on waterfront land* (NOW 2012).

This BAR has been prepared in accordance with the requirements of the Commonwealth Department of the Environment and Energy (DoEE) and NSW Department of Planning and Environment (DP&E). These were set out in the Secretary's Environmental Assessment Requirements (SEARs) for the Hume Coal Project, issued on 20 August 2015, and supplementary SEARs issued on 1 December 2015. The SEARs identify matters which must be addressed in the EIS and essentially form its terms of reference. A copy of the SEARs is attached to the EIS as Appendix B, while Table 1.1 lists the individual requirements relevant to this biodiversity assessment and where they have been addressed in this report.

Table 1.1 Biodiversity-related SEARs

Requirement	Section addressed
An assessment of the likely impacts of the development on the environment including: • a description of the existing environment likely to be affected by the development, using sufficient baseline data;	Chapters 3, 4 and 5
• an assessment of the likely impacts of all stages of the development, including any cumulative impacts, taking into consideration any relevant legislation, environmental planning instruments, guidelines, policies, plans and industry codes of practice;	Chapter 7

Table 1.1 Biodiversity-related SEARs

Requirement	Section addressed
• a description of the measures that would be implemented to mitigate and/or offset the likely impacts of the development, and an assessment of: - whether these measures are consistent with industry best practice, and represent the full range of reasonable and feasible mitigation measures that could be implemented; - the likely effectiveness of these measures, including performance measures where relevant; and - whether contingency plans would be necessary to manage any residual risks.	Chapters 6 and 9
• a description of the measures that would be implemented to monitor and report on the environmental performance of the development if it is approved.	Chapter 6
An assessment of the likely biodiversity impacts of the development, in accordance with the Framework for Biodiversity Assessment, by a person accredited in accordance with s142(B)(1)(c) of the *Threatened Species Conservation Act 1995*, and having regard to OEH's and DPI's requirements and recommendations (see Attachment 2).	Section 1.7 Chapter 6 Appendix A
A strategy to offset any residual impacts of the development in accordance with the NSW Biodiversity Offsets Policy for Major Projects.	Chapter 9
An assessment of the likely impacts on aquifers, watercourses, riparian land, water related infrastructure and other water users.	This BAR addresses the following requirements: • Section 7.2.1iii (aquifers, referred to as groundwater systems in this report); • Section 7.1.1 iv (watercourses); and • Section 7.1.1i, (riparian land). Impacts on water related infrastructure and other water users are addressed in the Water Assessment (Appendix E of the EIS).

To inform the preparation of the SEARs, DP&E invited other government agencies to recommend matters for addressing in the EIS. These matters were then taken into account by the Secretary for DP&E when preparing the SEARs. Copies of the government agencies' advice to DP&E were attached to the SEARs.

Three agencies, the NSW Office of Environment and Heritage (OEH), NSW Department of Primary Industries - Water (DPI Water) and Fisheries NSW, raised matters relevant to the biodiversity assessment. These were mainly their standard requirements for projects of this nature, though included some project-specific requirements for aquatic biodiversity assessment. These matters are listed in Table 1.2 ,Table 1.3 and Table 1.4 respectively, and have been taken into account in preparing this BAR, as indicated in the tables.

Table 1.2 OEH assessment recommendations

Requirement	Section addressed
The EIS should include an appropriate assessment of the potential impact on biodiversity, including threatened species, populations, ecological communities, or their habitats likely to occur within or near the subject site.	Chapter 7
Biodiversity impacts related to the proposed development are to be assessed and documented in accordance with the Framework for Biodiversity Assessment, unless otherwise agreed by OEH, by a person accredited in accordance with s142B(1)(c) of the *Threatened Species Conservation Act 1995*.	Section 1.7 Chapter 6 Appendix A
The offset strategy will be required to meet the minimum requirements outlined in the FBA.	Chapter 9
Impacts on the following populations will require further consideration and provision of the information specified in s9.2 of the Framework for Biodiversity Assessment: • Black Gum (*Eucalyptus aggregata*).	Section 7.3
The EIS must assess the impact of the development on hydrology, including: a. Water balance including quantity, quality and source. b. Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas. c. Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems. d. Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (eg river benches). e. Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water. f. Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options. g. Identification of proposed monitoring of hydrological attributes.	Items a, b, e and g are addressed in the Water Assessment (Appendix E of the EIS. This BAR addresses the following items: • c (Section 7.1.1iv); • d (Section 7.1.1vi); and • f (Table 6.1).

Table 1.3 DPI Water assessment recommendations

Requirement	Section addressed
Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, wetlands, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	An assessment of surface and ground water sources, adjacent licensed water users and basic landholders rights is provided in the Water Assessment (Appendix E of the EIS). This BAR contains an assessment of the impacts on watercourses (Section 7.1.1iv, and 7.1.1vi), wetlands (Section 7.8.3), groundwater dependent ecosystems (Section 7.2.1) and measures proposed to reduce and mitigate these impacts (Table 6.1).
A detailed assessment of riparian and watercourse impacts, particularly with respect to watercourse crossings. The project should be designed to minimise impacts on watercourses and riparian land, and must have regard to the Department of Primary Industries' Guidelines for Controlled Activities on Waterfront Land – in particular the guideline on watercourse crossings.	Riparian impacts are addressed in Section 7.1.1i. Watercourse impacts are addressed in Section 7.1.1iv and 7.1.1vi. Watercourse crossings are specifically addressed in Section 6.1.6, with regard to '*Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*' (Fairfull and Witheridge 2003), *Policy and Guidelines for fish habitat conservation and management* (DPI 2013) and *Guidelines for watercourse crossings on waterfront land* (NOW 2012).

Table 1.3 DPI Water assessment recommendations

Requirement	Section addressed
Detailed description of dependent ecosystems and existing surface water users within the area, including basic landholder rights to water and adjacent/downstream licensed water users.	Existing surface water users, basic landholder rights to water and adjacent/downstream licensed water users are addressed in the Water Assessment (Appendix E of the EIS). A detailed description of groundwater dependent ecosystems is provided in Section 4.5, while potential impacts on these ecosystems are addressed in Section 7.2.1.
Assessment of predicted impacts on the following: • flow of surface water (including floodwater), sediment movement, channel stability, and hydraulic regime, • water quality, • flood regime, • dependent ecosystems, • existing surface water users, and • planned environmental water and water sharing arrangements prescribed in the relevant water sharing plans.	Existing surface water users and planned environmental water and water sharing arrangements are addressed in the Water Assessment (Appendix E of the EIS). This BAR addresses the impacts on surface water, water quality and flooding (Section 7.1.1iv and Section 7.1.1vi), and groundwater dependent ecosystems (Section 7.2.1) with respect to aquatic ecology.
The EIS must consider the potential impacts on any Groundwater Dependent Ecosystems (GDEs) at the site and in the vicinity of the site and: • identify any potential impacts on GDEs as a result of the proposal including: - the effect of the proposal on the recharge to groundwater systems; - the potential to adversely affect the water quality of the underlying groundwater system and adjoining groundwater systems in hydraulic connections; and - the effect on the function of GDEs (habitat, groundwater levels, connectivity).	These requirements are addressed in detail in the Groundwater Assessment (EMM 2017b). This BAR specifically addresses the habitat-related impacts to terrestrial GDEs, with the focus being habitat of threatened species, populations and communities in Sections 4.5 and 7.2.1.
• provide safeguard measures for any GDEs.	Sections 6.1.4 and 6.2.2
Scaled plans showing the location of: • wetlands/swamps, watercourses and top of bank; • riparian corridor widths to be established along the creeks; • existing riparian vegetation surrounding the watercourses (identify any areas to be protected and any riparian vegetation proposed to be removed); • the site boundary, the footprint of the proposal in relation to the watercourses and riparian areas; and • proposed location of any asset protection zones.	There are no wetlands or swamps in the project area. Important wetlands in the south of the study area are identified on Figure 7.1 and 7.2. Existing riparian vegetation is shown on Figure 4.1. None of this riparian vegetation is proposed to be removed. The site boundary, proposal footprint, watercourses and riparian areas is shown on Figure 1.6 and 1.7. Asset protection zones are not required for the project.
A detailed description of all potential impacts on the wetlands, including potential impacts to the wetlands hydrologic regime; groundwater recharge; habitat and any species that depend on the wetlands.	Section 7.8.3

Table 1.4 Fisheries NSW assessment recommendations

Requirement	Section addressed
Identification of Key Fish Habitat within the proposal area.	Section 3.3.2 Section 4.6.6
Description of aquatic and riparian environments in the vicinity of the development, particularly extent and condition of riparian vegetation and instream aquatic vegetation, water depth, and permanence of water flow and snags (large woody debris) within the footprint of the proposal area.	Section 4.6 Appendix J
Analysis of any interactions of the proposed development with water quality and aquatic and riparian environments (including fish and aquatic and riparian vegetation) and predictions of any impacts upon those environments.	Section 7.14.1vi Section 7.2.1iv
Analysis of impacts of groundwater interference and drawdown on water quality, water flow and aquatic and riparian environments within and downstream of all waterways within the proposal area.	Section 7.2.1
Plan of proposed underground mine design overlaid with waterways.	Figure 2.3
Safeguards to mitigate any impacts upon water quality, water flow and aquatic and riparian environments within and downstream of all waterways within the proposal area during construction and ongoing operation of the proposed coal mine. In particular, provide details on proposals for erosion and sediment control (to be incorporated into a Construction Environmental Management Plan - CEMP) and proposed stormwater and ongoing drainage management measures. Water quality management for the project should be designed to achieve no net increase in pollutant run-off to receiving waters within the proposal site.	Table 6.1 Section 6.1.5 and 6.1.6
Details of ongoing monitoring programs to assess any impacts upon water quality, water flow and aquatic and riparian environments within and downstream of all waterways within the proposal area.	Table 6.1 states that these will be implemented. Details are provided in Section 7.1 and 7.2 of the Hume Coal Project Surface Water Flow and Geomorphology Assessment (Appendix E of the EIS)
Fisheries NSW recommend the use of best practice sediment and erosion control, and water quality and stormwater management provisions to safeguard and mitigate impacts on water quality at the site and downstream. They also recommend inclusion of appropriate riparian corridors to provide a buffer between the development areas and adjacent waterways or natural drainage lines to provide protection to riparian and aquatic habitats.	Table 6.1 Section 6.1.5 and 6.1.6
Design and construction of any watercourse crossings on the site should be undertaken in accordance with the Departments Policy and Guidelines for Fish Friendly Waterway Crossings (2004) and Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (2004)	Table 6.1 Section 6.1.5 and 6.1.6

The Hume Coal Project was declared as a controlled action on 1 December 2015 by the DoEE. The project will be assessed under the Bilateral Agreement between the NSW Government and the Commonwealth Government. Accordingly, the DoEE has issued supplementary SEARs to address matters of national environmental significance relevant to the project. These matters are provided in Table 1.5, and have been taken into account in preparing this BAR, as indicated in the table.

Table 1.5 Commonwealth Supplementary Biodiversity SEARs

Requirement	Section addressed
The EIS must address the following issues in relation to biodiversity in accordance with the Matters of National Environmental Significance - Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999 (Significant Impact Guidelines), and include:	
• identification of each EPBC Act listed threatened species and community likely to be significantly impacted by the development; and	Section 7.4
• evidence why other EPBC Act listed threatened species and communities likely to be located in the project area or in the vicinity will not be significantly impacted.	Section 7.4
For each of the relevant EPBC Act listed threatened species and communities likely to be significantly impacted by the development the EIS must:	
• describe the habitat and habits (including identification and mapping of suitable breeding habitat, suitable foraging habitat, important populations and habitat critical for survival) with consideration of, and reference to, any relevant Commonwealth guidelines and policy statement including listing advice, conservation advice and recovery plans, threat abatement plans and wildlife conservation plans;	Section 7.4
• detail the scope, timing and methodology for studies or surveys used and how they are consistent with (or justification for divergence from) published Australian Government guidelines and policy statement; and	Chapter 2, Appendix B
• describe the impacts of the action having regard to the full national extent of the species or community's range.	Section 7.4, Appendix G
Note: The relevant guidelines and policy statements for each species and community are available from the Department of the Environment Species Profiles and Threats Database http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl	
For each of the relevant EPBC Act listed threatened species and communities likely to be significantly impacted by the development the EIS must:	
• identify significant residual adverse impacts likely to occur after the proposed activities to avoid and mitigate all impacts are taken into account;	Section 7.4
• detail how the current published NSW Framework for Biodiversity Assessment (FBA) has been applied in accordance with the objects of the EPBC Act to offset significant residual adverse impacts; and	Chapters 8 and 9
• detail the offsets to compensate for significant residual impacts, including details of the credit profiles required to offset the development in accordance with the FBA and/or mapping and descriptions of the extent and condition of the relevant habitat and/or threatened communities occurring on proposed offset sites.	Chapters 8 and 9
Note: For the purposes of approval under the EPBC Act, it is a requirement that offsets directly contribute to the ongoing viability of the specific protected matter impacted by a proposed action, ie 'like for like'. In applying the FBA, residual impacts on EPBC Act listed threatened ecological communities must be offsets with Plant Community Types (PCTs) that are ascribed to the specific EPBC Act listed ecological community. PCTs from a different vegetation class will not generally be acceptable as offsets for EPBC Act listed communities.	
Any significant residual impacts not addressed by the FBA may need to be addressed in accordance with the Environment Protection and Biodiversity Conservation Act 1999 Environmental Offset Policy, http://www.environment.gov.au/epbc/publications/epbc-act-environmental-offsets-policy.	All significant residual impacts will be offset in accordance with the FBA.
Note: If the EPBC Act Environmental Offset Policy is used to calculate proposed offsets for a threatened species or community you may wish to seek further advice from the Department of Planning and Environment.	

1.6 Adoption of leading practices

Hume Coal has adopted a number of leading practices resulting in a mine design that avoids and minimises impacts to terrestrial biodiversity. Extensive technical investigations have taken place over several years to develop and refine the project, and arrive at the current mine design. These investigations, which began in 2012, have included ecology studies.

The results have been considered in a number of workshops with mining and infrastructure engineers and geologists. This iterative process enabled numerous alternative conceptual mine designs to be prepared and evaluated. This included various mining methods and extents, and surface infrastructure locations and designs.

Ecologists have employed a large survey effort across the majority of the project area, including the proposed surface infrastructure areas to inform the final mine design. They identified areas of potential sensitivity such as threatened species habitat and riparian vegetationas well as areas of 'low constraint', which represented opportunities for positioning surface infrastructure.

The resultant mine design avoids most native vegetation and fauna habitats. The leading practices adopted by Hume Coal are consistent with the requirements of the *Framework for Biodiversity Assessment: NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014) (FBA), in demonstrating the design measures taken to avoid and minimise most biodiversity impacts and the offsets proposed to compensate for minor residual impacts.

1.7 Assessor accreditation and qualifications of study team

This biodiversity assessment report has been prepared by Katie Whiting, following the FBA (OEH 2014) *Framework for Biodiversity Assessment*. Katie is the Ecology Services Manager at EMM, and an accredited assessor in accordance with Section 142B(1)(c) of the NSW *Threatened Species Conservation Act 1995* (TSC Act).

This report incorporates the methods, results and conclusions of the aquatic assessment completed by Jemma Sargent, Principal Scientist and Director of JSA Environmental. Qualifications of all ecologists who have assisted with this study are provided in Appendix I.

2 Methods

This chapter describes the desktop review, field survey and impact assessment methods used to prepare this BAR.

2.1 Terrestrial assessment methods

A combination of desktop and field-based techniques were used to identify biodiversity values associated with the terrestrial study area, and in particular any threatened species, populations or ecological communities listed under the EPBC Act and/or TSC Act, or their habitats present or likely to occur. Key steps were as follows:

- review of existing ecological and other (eg geological, topographic and soil) information available for the terrestrial study area and surrounds, including relevant databases, regional vegetation mapping, survey data, environmental assessment reports and scientific literature.
- aerial photograph interpretation.
- based on outcomes of the above, design of a field survey program to fully characterise the area's biodiversity values, following the appropriate scientific guidelines. The program was designed to be commensurate with the expected environmental variation, ecological requirements of target species and the extent of potentially suitable habitat identified. Vegetation survey sites were selected using random stratified techniques.
- field survey, including fauna habitat assessment, flora and fauna surveys, characterising and mapping vegetation communities and targeted searches for threatened species previously recorded in or near the terrestrial study area or considered likely to occur there.

Detailed field surveys were completed in all accessible parts of the project area (Figure 1.3) to identify threatened biodiversity and inform the mine planning process. Targeted surveys were completed when the surface infrastructure area was more clearly defined, in accordance with the FBA (OEH 2014). Regional vegetation mapping was used to inform the assessment of groundwater dependent ecosystems between the project area and edge of the terrestrial study area (Figure 1.3).

A summary of the survey dates is provided in Table 2.1. Qualifications of the study team are provided in Appendix I.

Table 2.1 Summary of survey dates

Date	Field methods
5 February 2013	Preliminary field visit to broadly characterise native vegetation types across the project area
8 to 12 April 2013	Vegetation plots, transects and rapid assessments, targeted threatened flora searches, targeted Broad-headed Snake, threatened microbat, mammal, diurnal bird and owl surveys across the project area
9 to 10 July 2013	Targeted surveys for Regent Honeyeater and Swift Parrot, targeted threatened flora surveys, rapid vegetation assessments across the project area
25 to 29 November 2013	Targeted threatened mammal, microbat, diurnal bird, owl and frog surveys across the project area

Table 2.1 Summary of survey dates

Date	Field methods
3 to 7 February 2014	Targeted threatened mammal, microbat, diurnal bird, owl and frog surveys across the project area
11 to 14 March 2014	Vegetation plots, transects and rapid assessments, targeted threatened flora searches across the project area and surface infrastructure area
14 to 16 April 2014	Vegetation plots, transects and rapid assessments, targeted threatened flora searches in surface infrastructure area
5 to 7 November 2014	Vegetation plots, transects and rapid assessments, targeted threatened flora searches in surface infrastructure area, identification of springs
7 January 2015	Vegetation plots, transects and rapid assessments, targeted threatened flora searches in surface infrastructure area, identification of springs
10 to 13 February 2015	Vegetation plots, transects and rapid assessments, targeted threatened flora searches, targeted threatened diurnal bird, owl, frog, microbat, mammal and reptile surveys in surface infrastructure area, identification of springs
9 August 2016	Vegetation plots

A summary of the main documents and databases reviewed, outcomes of the review and the survey methods is provided in the following sections.

2.2 Literature review

Relevant scientific literature and biodiversity studies previously undertaken within the terrestrial study area and surrounding region were reviewed to compile a list of threatened species, populations, communities and migratory species likely to occur in the terrestrial study area. Material reviewed comprised: *Ecology inspections and assessment for exploration drill sites in Belanglo State Forest* (Hayes Environmental 2011);

- *Flora and fauna assessment: surface exploration of additional boreholes in Belanglo State Forest* (Niche 2013);
- *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region* (DECC 2007);
- *The Native Vegetation of the Nattai and Bargo Reserves* (DECC 2004a);
- *Vertebrate Fauna of Kanangra-Boyd National Park* (DECC 2004b); and
- *Wingecarribee Biodiversity Strategy* (EcoLogical 2003).

2.3 Database searches

Table 2.2 summarises the database searches performed to identify any threatened terrestrial flora and fauna species, important habitat for migratory species and/or critical habitats recorded in and surrounding the terrestrial study area. Recent searches were completed in 2016 to determine if any new species, populations or communities had been listed since commencement of the biodiversity assessment in 2013. Threatened species, populations and communities listed under the TSC Act and/or EPBC Act previously recorded or predicted to occur within an approximate 20 km radius around the project area are provided in Appendix E.

Preliminary listing advices were also consulted under the TSC and EPBC Acts to determine any species, populations or communities that may be listed in the future, or existing species that may increase in conservation status (ie existing vulnerable species that is proposed to be uplisted to endangered).

Table 2.2 Database search details

Source	Search date(s)	Search extent
PlantNET spatial database search for rare and threatened Australian Plants http://plantnet.rbgsyd.nsw.gov.au/search/spatial.htm	23 May 2013 22 June 2016	Wingecarribee LGA
Atlas of NSW Wildlife www.environment.nsw.gov.au/atlasapp/	7 July 2013 2 November 2015 22 June 2016	20 km radius around approximate terrestrial study area
Protected Matters Search Tool www.environment.gov.au/webgis-framework-apps/pmst/pmst.jsf/	9 April 2014 2 November 2015 22 June 2016	20 km radius around approximate terrestrial study area
NSW Vegetation Information System (VIS) Classification Database, Vegetation Benchmarks Database and Over-cleared Landscapes Database www.environment.nsw.gov.au/	21 August 2014 2 November 2015 22 June 2016	Hawkesbury-Nepean Major Catchment Area (MCA)
Threatened species profile database www.environment.nsw.gov.au/atlasapp/	2 November 2015 22 June 2016	Relevant species within Hawkesbury-Nepean MCA
Critical habitat register www.environment.nsw.gov.au/criticalhabitat/CriticalHabitatProtectionByDoctype.htm	7 July 2013 2 November 2015 22 June 2016	All registered sites were searched. No areas of declared critical habitat within or adjacent to terrestrial study area
Australian Wetlands Database http://www.environment.gov.au/topics/water/water-our-environment/wetlands/australian-wetlands-database	2 November 2015 22 June 2016	Search by name for each wetland within approximately 20 km radius of the terrestrial study area
Preliminary determinations by date (TSC Act) http://www.environment.nsw.gov.au/committee/PreliminaryDeterminationsByDate.htm	22 June 2016	Search of all preliminary determinations
Listing assessments for public comment (EPBC Act) http://www.environment.gov.au/biodiversity/threatened/nominations/comment	22 June 2016	Search of all preliminary determinations

2.4 Vegetation survey methods

2.4.1 Vegetation mapping review

Existing vegetation mapping and databases were reviewed to provide information on the vegetation communities previously recorded or likely to occur in the terrestrial study area. Table 2.3 provides a summary of information reviewed and data obtained for the terrestrial study area.

Table 2.3 Vegetation information reviewed and data obtained

Source	Data obtained	Relevance to the assessment
Wingecarribee Biodiversity Strategy	Vegetation types for the Wingecarribee LGA	Indicative of vegetation types in the terrestrial study area
Vegetation Moss Vale – 8928 1: 100,000 map sheet	Regional vegetation types	Indicative of vegetation formations in the terrestrial study area
Biometric Vegetation Types (DECC 2008a)	Vegetation types for the Hawkesbury-Nepean MCA	Used to assign vegetation of the terrestrial study area to a biometric type
Vegetation Information System (VIS) database (OEH 2016)	Plant community types for the Hawkesbury Nepean MCA	Used to determine the plant community types present in the region

2.4.2 Preliminary site assessment

A preliminary site survey was completed on 5 February 2013 to gain an appreciation of the vegetation and habitats present within the terrestrial study area and surrounds. The survey involved driving around the terrestrial study area and characterising dominant species and habitat features. The results informed the threatened species likelihood of occurrence assessment (Appendix E) and determination of targeted survey requirements for the terrestrial study area (refer to Section 2.5). Identification of broad vegetation types also helped determine the number of plots to complete (refer to Section 2.4.4). The potential for the terrestrial study area to provide habitat for threatened species and communities was re-assessed following the completion of detailed field surveys.

2.4.3 Vegetation type mapping

Vegetation types in the surface infrastructure area and terrestrial study area were assessed in the field using a combination of plot-based surveys (see Section 2.4.4) and rapid assessment surveys (see Section 2.4.5). These surveys were completed in April 2013, March 2014, April 2014, November 2014, January 2015, February 2015 and August 2016. Sufficient rainfall was received during this time to enable detection of most flora species expected to occur in the area. The survey locations are shown in Figure 2.1.

Vegetation type boundaries were mapped in the field, either on foot or from a vehicle, using a global positioning satellite (GPS) receiver, whilst referencing aerial photographs and topographic maps. Field-based assessments were followed by aerial photograph interpretation and analysis using a geographic information system (GIS) to create a comprehensive vegetation map of the entire terrestrial study area.

Once vegetation types within the study area had been identified, the NSW Biometric Vegetation Types Database (DECC 2008a) was used to provide an appreciation of the extent and distribution of these vegetation types within the locality and region more broadly.

2.4.4 Plot-based surveys

A total of 64 (20 x 20 m) plot and transect (50 m) flora surveys were undertaken across the terrestrial study area in accordance with Section 5.3.2 of the *Framework for Biodiversity Assessment* (OEH 2014), hereafter referred to as the FBA. The framework provides guidance on how many plots and transects are needed for each 'vegetation zone', to provide adequate survey coverage across a study area. Accordingly, the number of quadrats to be completed was determined through stratification using regional vegetation mapping for the area, and then calculating the requisite number of plots and transects for each 'strata' or 'vegetation zone' in the terrestrial study area. Consistent with the practice of random stratified sampling, plots and transects were then sited within accessible areas within each vegetation zone. Table 5.1 benchmarks the survey effort against OEH (2014) requirements.

In accordance with Section 5.3.2 of the FBA, site attributes recorded in the plots and transects included:

- native plant species richness;
- native plant cover (percentage cover) within the canopy, mid-storey and groundcover, respectively;
- exotic plant cover (percentage cover within each vegetation stratum/percentage of the total mid-storey and ground cover;
- the number of trees with hollows;
- proportion of canopy species occurring as regeneration; and
- the total length of fallen logs.

The locations of plots and transects are shown on Figure 2.1.

2.4.5 Rapid vegetation assessments

Rapid assessments were undertaken at 45 locations across the terrestrial study area (Figure 2.1). These were generally made at areas of interest which were unable to be accessed for plot-based surveys, as well as several locations in the Belanglo State Forest to provide greater accuracy in the mapping of vegetation community boundaries. At each rapid assessment location, the dominant flora species within each stratum were recorded, photographs taken and any other points of interest noted. Vegetation type at rapid assessment points was classified by the dominant over-storey species, and then by the other component species. Position in the landscape (for example 'slope' or 'alluvial plain') was also recorded and used to assist in determining vegetation type.

2.4.6 Threatened ecological community identification

Vegetation plot data and rapid assessment data were reviewed against the Commonwealth and NSW Government descriptions of threatened ecological communities (TECs) known from the region, to determine their presence (or otherwise) in the terrestrial study area. A comparison was also undertaken with published TEC species lists, habitat descriptions and distributions, and published identification guidelines.

2.5 Targeted species surveys

2.5.1 Target flora species

The results of the desktop study and preliminary site inspection identified threatened flora species (listed under the EPBC Act and/or TSC Act) previously recorded, or predicted to occur (based on known distributions and the potential presence of suitable habitat), in or near the terrestrial study area.

The results of the desktop study and preliminary site inspection were used to identify threatened flora species (listed under the EPBC Act and/or TSC Act) to target during the surveys. These were generally those species previously recorded, or predicted to have a moderate or high likelihood of occurring (based on known distributions and the potential presence of suitable habitat), in or near the project area, and those predicted by the BioBanking Calculator.

It is noted that the likelihood of occurrence of all threatened species predicted by the data sources and listed in Table 2.4 and/or other relevant literature as potentially occurring within a 20 km radius of the project area was assessed, considering their known distributions and the potential suitability of habitat in the terrestrial study area. The results are provided in full in Appendix E. Those species with a moderate or high likelihood of occurrence in the project area were subject to targeted surveys and further assessment, as detailed in this report. Those species with little to no likelihood of occurrence were not assessed further. Flora searches were timed so as to maximise the potential for identification of the threatened species being targeted.

Table 2.4 lists the species targeted and the survey detection methods and timing. It also identifies if suitable habitat is present in the terrestrial study area for each species. The likelihood of occurrence for all threatened flora species previously recorded or predicted to occur was assessed, and is provided in Appendix E.

Table 2.4 Target threatened flora survey methods and timing

Species	TSC Act status	EPBC Act status	Survey methods	Suitable survey timing	Habitat present in surface infrastructure area?	Habitat present in terrestrial study area?
Dense Cord Rush *Baloskion longipes*	V	V	Targeted search	Year round	None	High likelihood
Dwarf Kerrawang *Commersonia prostrata*	E	E	Targeted search	Year round	None	Moderate likelihood
Paddys River Box *Eucalyptus macarthurii*	V	-	Targeted search	Year round	Recorded	High likelihood
Black Gum *Eucalyptus aggregata*	V	-	Targeted search	Year round	None	High likelihood
Cambage Kunzea *Kunzea cambagei*	V	V	Targeted search	Year round	None	Moderate likelihood
Dwarf Phyllota *Phyllota humifusa*	V	V	Targeted search	Year round	None	High likelihood
Cotoneaster Pomaderris *Pomaderris cotoneaster*	E	E	Targeted search	Year round	None	Moderate likelihood
Velvet Zieria *Zieria murphyi*	V	V	Targeted search	Year round	None	Moderate likelihood

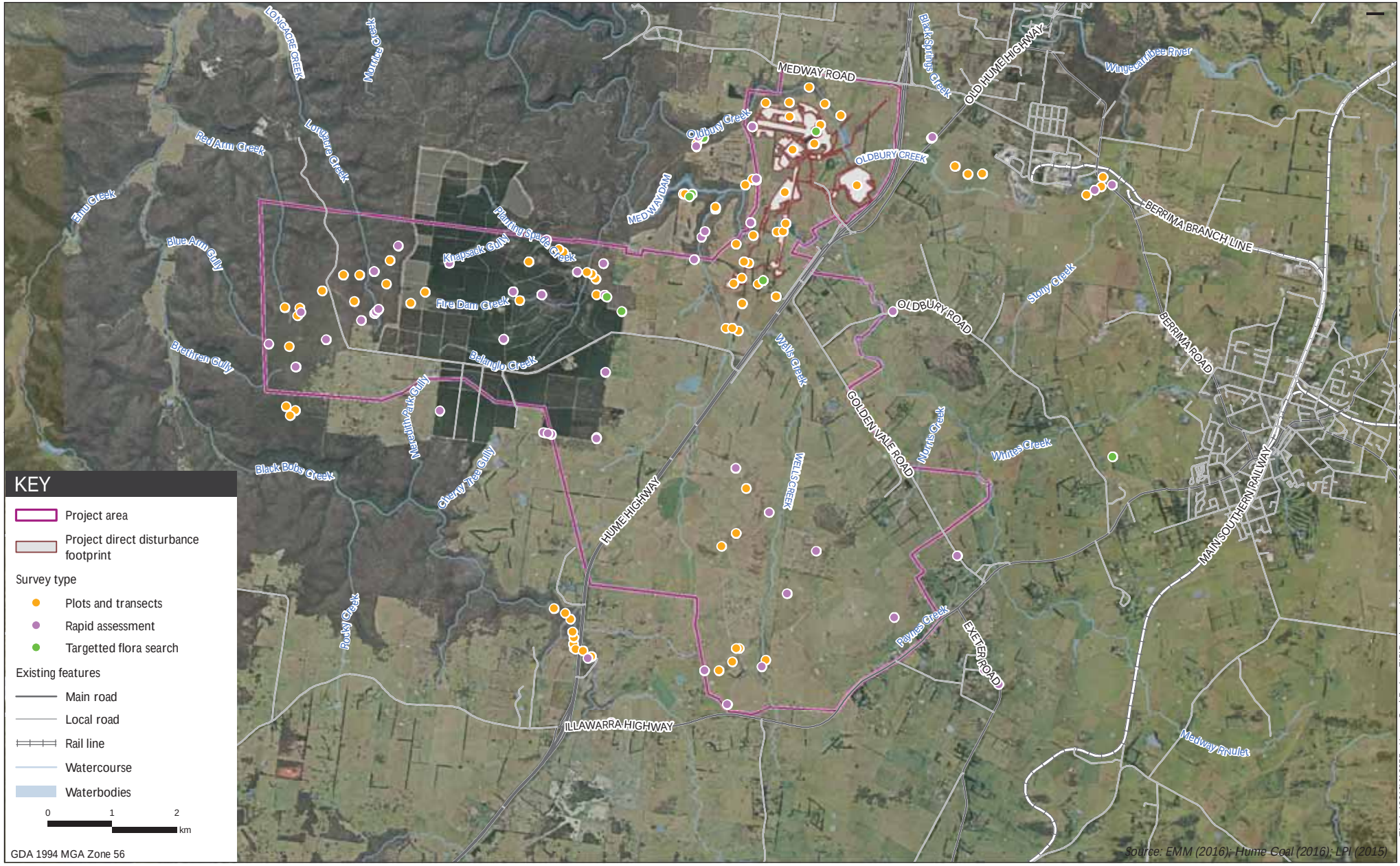
Notes: 1. TSC Act - Threatened Species Conservation Act 1995, EPBC Act - Environment Protection and Biodiversity Conservation Act 1999, V - vulnerable, E - endangered.

2.5.2 Targeted flora survey methods

Targeted searches for threatened flora were undertaken over 206 person hours within suitable or potentially suitable habitats of the terrestrial study area, using the random meander method. Targeted searches were undertaken at all flora survey locations shown in Figure 2.1. Survey effort was based on the vegetation type and the likely presence of suitable habitats. Random meanders were generally undertaken while mapping the vegetation types of the terrestrial study area. Where a rare or threatened species was recorded, the following data was collected:

- number of individuals;
- reproductive status of the population (eg flowering/fruiting);
- the location(s) of each individual, recorded using a GPS (where individuals were less than one metre apart, a single point was recorded and the number of plants at that point noted);
- habitat features present (eg rocky outcrops and associated flora species);
- aspect and/or degree of slope;
- vegetation type; and
- threats (if any) and/or previous disturbances.

The locations of targeted flora surveys are shown in Figure 2.1.



Flora survey locations

Hume Coal Project

Biodiversity Assessment Report

Figure 2.1

2.5.3 Target fauna species

All TSC Act threatened species recorded within a 20 km radius of the project area were targeted during surveys. Records for the listed species predicted by the Protected Matters Search Tool (DoE 2016) were interrogated on the Atlas of NSW Wildlife (OEH 2016) and Atlas of Living Australia (ALA 2016) to determine if they had been recorded within a 20 km radius of the project area. Species on this list greater than 20 km from the project area and not likely to occur (ie coastal species) were excluded from targeted surveys. The exception to this rule was the completion of targeted winter surveys for the Regent Honeyeater and Swift Parrot, given the nomadic habits of these species. The remaining species were targeted during surveys.

Survey methods for threatened fauna were determined following the results of the desktop study, preliminary site visit and assessment of the presence of suitable habitat (see Appendix E). This was done following the same general process as for threatened flora, described in Section 2.5.1. Table 2.5 provides a list of threatened and migratory fauna species (listed under the EPBC Act and/or TSC Act) which were identified as having a moderate to high potential to occur prior to surveys. Their likelihood of occurrence was revised, following the completion of field surveys. The table also summarises survey methods and optimal survey timing for detection. Surveys were completed for all threatened fauna in the optimal survey timing recommended by the guidelines listed in Section 2.6.1.

Table 2.5 Target threatened fauna survey methods and timing

Species	Status		Survey methods	Optimal survey timing	Habitat present in surface infrastructure area?	Habitat present in terrestrial study area?
	TSC Act	EPBC Act				
Reptiles						
Broad-headed Snake *Hoplocephalus bungaroides*	E	V	Spotlighting hollow trees (summer) and searches under rocks (winter)	Summer and Winter	None	Moderate likelihood
Rosenbergs Goanna *Varanus rosenbergi*	V	-	Targeted searches on rock platforms and near termite mounds	September to May	None	Moderate likelihood
Frogs						
Giant Burrowing Frog *Helioporus australiacus*	V	V	Call playback and spotlighting	September to March	None	Low likelihood
Birds						
Australasian Bittern *Botaurus poiciloptilus*	E	E	Wetland/waterbody search in morning/evening	Year round	None	Moderate likelihood
Australian Painted Snipe *Rostratula australis*	E	E	Searches in wetlands	Year round	Low likelihood	Moderate likelihood
Black-faced Monarch *Monarcha melanopsis*	-	Mi	Timed area search, targeted search	Year round	None	Low likelihood.
Brown Treecreeper (eastern subspecies) *Climacteris picumnus victoriae*	V	-	Timed area search, targeted search	Year round	Low likelihood	**Recorded**
Cattle Egret *Ardea ibis*	-	Mi	Timed area search, targeted search	Year round	Low likelihood	Moderate likelihood

Table 2.5 Target threatened fauna survey methods and timing

Species	Status		Survey methods	Optimal survey timing	Habitat present in surface infrastructure area?	Habitat present in terrestrial study area?
	TSC Act	EPBC Act				
Diamond Firetail *Stagonopleura guttata*	V	-	Timed area search, targeted search	Year round	High likelihood	High likelihood
Flame Robin *Petroica phoenicea*	V	-	Timed area search, targeted search	Year round	Low likelihood	High likelihood
Freckled Duck *Stictonetta naevosa*	V	-	Timed area search, targeted search	Year round	Low likelihood	Moderate likelihood
Gang-gang Cockatoo *Callocephalon fimbriatum*	V	-	Timed area search, targeted search	Year round	High likelihood	Recorded
Glossy Black-Cockatoo *Calyptorhynchus lathami*	V	-	Timed area search, targeted search	Year round	None	Recorded
Great Egret *Ardea alba*	-	Mi	Timed area search, targeted search	Year round	Low likelihood	Moderate likelihood
Hooded Robin (south-eastern form) *Melanodryas cucullata cucullata*	V	-	Timed area search, targeted search	Year round	Moderate likelihood	Moderate likelihood
Little Eagle *Hieraaetus morphnoides*	V	-	Timed area search, targeted search	Year round	High likelihood	Recorded.
Little Lorikeet *Glossopsitta pusilla*	V	-	Timed area search, targeted search	Year round	High likelihood	Recorded
Masked Owl *Tyto novaehollandiae*	V	-	Call playback, spotlighting, stag watching, searches for pellets and owl wash	Year round	High likelihood	Recorded
Powerful Owl *Ninox strenua*	V	-	Spotlighting and call playback	Year round	Moderate likelihood	Recorded
Rainbow Bee-eater *Merops ornatus*	-	Mi	Timed area search, targeted search	Year round	Low likelihood	Moderate likelihood
Regent Honeyeater *Anthochaera phrygia*	-	E	Timed area search, targeted search	Year round	None	None.
Rufous Fantail *Rhipidura rufifrons*	-	Mi	Timed area search, targeted search	Year round	Low likelihood	Moderate likelihood
Satin Flycatcher *Myiagra cyanoleuca*	-	Mi	Timed area search, targeted search	Year round	Low likelihood	Moderate likelihood
Scarlet Robin *Petroica boodang*	V	-	Timed area search, targeted search	Year round	Moderate likelihood	Recorded
Speckled Warbler *Chthonicola sagittata*	V	-	Timed area search, targeted search	Year round	Low likelihood	Moderate likelihood
Swift Parrot *Lathamus discolor*	-	E	Timed area search, targeted search	March-July	None	None.
Turquoise Parrot *Neophema pulchella*	V	-	Timed area search, targeted search	Year round	Low likelihood	Recorded

Table 2.5 Target threatened fauna survey methods and timing

Species	Status		Survey methods	Optimal survey timing	Habitat present in surface infrastructure area?	Habitat present in terrestrial study area?
	TSC Act	EPBC Act				
Varied Sittella *Daphoenositta chrysoptera*	V	-	Timed area search, targeted search	Year round	Low likelihood	Recorded
Bats						
Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*	V	-	Ultrasonic detection, harp trapping	October to March	Low likelihood	Recorded
Eastern False Pipistrelle *Falsistrellus tasmaniensis*	V	-	Ultrasonic detection, harp trapping	October to March	Low likelihood	Recorded
Eastern Freetail-bat *Mormopterus norfolkensis*	V	-	Ultrasonic detection, harp trapping	October to March	Low likelihood	Recorded
Greater Broad-nosed Bat *Scoteanax rueppellii*	V	-	Ultrasonic detection, harp trapping	October to March	None	Moderate likelihood
Large-eared Pied Bat *Chalinolobus dwyeri*	-	V	Ultrasonic detection, harp trapping	October to March	High likelihood	Recorded
Little Bentwing-bat *Miniopterus australis*	V	-	Ultrasonic detection, harp trapping	October to March	Low likelihood	Recorded
Southern Myotis *Myotis macropus*	V	-	Ultrasonic detection, harp trapping	October to March	High likelihood	Recorded
Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*	V	-	Ultrasonic detection, harp trapping	October to March	High likelihood	High likelihood
Mammals						
Eastern Pygmy Possum *Cercartetus nanus*	V	-	Elliott trapping and spotlighting	Year round	None	Moderate potential
Brush-tailed Rock-Wallaby *Petrogale penicillata*	E	-	Search for scats and daytime searches	Year round	None	None
Koala *Phascolarctos cinereus*	V	V	Spot assessments and spotlighting/call playback	Year round	Moderate potential	Recorded
Spotted-tailed Quoll *Dasyurus maculatus maculatus*	V	E	Searches for habitat and signs, baited cameras	Year round	Low likelihood.	Moderate likelihood
Yellow-bellied Glider *Petaurus australis*	V	-	Spotlighting/call playback	Year round	None	High likelihood

Notes: 1. TSC Act - Threatened Species Conservation Act 1995, EPBC Act - Environment Protection and Biodiversity Conservation Act 1999, V - vulnerable, E - endangered, , Mi – migratory.

2.6 Fauna survey methods

2.6.1 Survey guidelines

Fauna surveys were also completed in accordance with the following guidelines:

- *Survey guidelines for Australia's threatened bats* (DEWHA 2010a);
- *Survey guidelines for Australia's threatened birds* (DEWHA 2010b);
- *Survey guidelines for Australia's threatened frogs* (DEWHA 2010c);
- *Survey guidelines for Australia's threatened mammals* (SEWPAC 2011a);
- *Survey guidelines for Australia's threatened reptiles* (SEWPAC 2011b); and
- *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC 2004).

An assessment of the compliance of fauna surveys against these guidelines is provided in Appendix B. All fauna surveys were compliant with the above guidelines.

2.6.2 Fauna habitat assessment

An assessment of fauna habitat types and habitat condition was undertaken at each plot location (a 50 m buffer around the 60 points) to determine appropriate locations for targeted fauna surveys. Specific habitat features and signs that were searched for included:

- hollow-bearing trees, including stags;
- bush rock and rocky outcrops;
- logs and artificial cover (eg discarded metal roofing);
- wetlands, drainage lines, rivers, dams and other water bodies;
- permanent soaks and seepages;
- areas that could act as dispersal corridors for plants and animals;
- winter-flowering eucalypts;
- nests, roosts, burrows and dens;
- glider feeding scars and Koala feed trees;
- chewed She-oak (*Allocasuarina spp*.) or Cypress Pine (*Callitris spp*.) cones; and
- scats.

2.6.3 Active reptile searches

Active reptile searches were targeted to reptile habitats including rocky outcrops and creeks. Searches were conducted between 9 am and 11 am over six days to increase the likelihood of detection of different reptile species.

Searches for basking reptiles were made on rocky outcrops and along creeks. Rocks and fallen timber were also turned over to search for burrowing or resting reptiles. On warm nights, surveys for basking reptiles were undertaken by spotlighting large trees and dirt tracks. Species identifications were made in the field and taxonomy was as per Wilson and Swan (2010).

The total reptile survey effort was 134 person hours. An additional 57 hours were spent completing targeted searches under rocks and in crevices for the threatened Broad-headed Snake at 13 locations in the project area (Figure 2.2).

2.6.4 Bird surveys

i Diurnal bird timed area search

Timed searches, each being 20 minutes in duration, were used to survey diurnal (day active) birds at 30 sites. Timed searches were extended to one person hour at sites where new species continued to be encountered.

The presence and abundance of all birds observed in the terrestrial study area during the timed searches were recorded. Birds were identified visually, with the aid of binoculars and/or by call identification. Surveys commenced in the early morning, within an hour of sunrise, when bird activity is greatest (Bibbly, Burgess and Hill 1992). Survey locations are shown in Figure 2.2. The total survey effort for diurnal birds was 82 person hours.

ii Nocturnal bird spotlighting and call broadcasting

Nocturnal bird spotlighting surveys commenced at sunset (to capture species emerging from roost sites and hollows) during favourable weather, that is, outside times of extreme wind and cold. Call broadcasting for threatened owl species (refer to Section 2.6.6ii) was also conducted. The total survey effort for nocturnal birds was 132 person hours.

In addition to nocturnal spotlight surveys, searches for any evidence of owls (eg pellets, wash on trees and used hollows) were undertaken during searches for signs of fauna. The total survey effort for fauna signs was over 167 person hours.

2.6.5 Microbat surveys

i Ultrasonic detection

Ultrasonic (Wildlife Acoustics SM2Bat) detectors were set up at 15 locations (Figure 2.2) in eight general areas within representative, potential microchiropteran bat habitat in the terrestrial study area, to record echolocation calls. Calls were recorded over the entire night, with a minimum of four nights at each location. Detectors were located adjacent to harp traps where possible (or nearby rock outcropping). A total of 66 detector nights were surveyed at the 15 locations.

Reference calls were recorded from trapped bats, upon their release, for comparison with the passively recorded calls and to increase the accuracy of call identification. Microbat sonograms were viewed in Analook for Windows (Corben 2011).

ii Harp trapping

Harp traps were placed at nine locations for a total of 38 trap nights (Figure 2.2). Traps were placed in suitable flyways throughout the terrestrial study area to sample all major habitats. Individuals captured were identified to species level, and other measurements and observations made, including age (based on canine wear), gender, weight and forearm length. In the case of Long-eared Bats (*Nyctophilus* spp.), ear length was also recorded as this is a character used to distinguish species.

iii Roost searches

Surveys targeting cave dwelling bat species were undertaken in rocky outcrops. Scat searches were undertaken in caves and rocky outcrops, and SM2Bat detectors were suitably placed to try to identify the roosting species. An inspection camera was also used to search for bats roosting in rock crevices.

2.6.6 Arboreal and ground-dwelling mammals

i Ground Elliott trapping

Eighty B-Elliott traps were installed on the ground adjacent to logs, ground vegetation and flowering banskias to target the Eastern Pygmy Possum and common ground-dwelling mammals. Traps were baited with a mixture of oats, honey and peanut butter, and adjacent trees were sprayed with a honey and water mixture to attract fauna. The total number of trap nights was 320. Trapping locations are shown in Figure 2.2.

Local materials (leaves and/or grasses) were placed as bedding on the floor of the traps, and waterproof bags were placed on the end of each trap to protect captured animals against heat, cold and rain. Traps were installed on the western side of a tree to prevent captured animals overheating in the morning sun. Trap checking commenced at 6 am and was completed no later than 8 am.

ii Spotlighting and call broadcasting

Spotlight searches were carried out, principally for threatened and other nocturnal mammal, bird and frog species within the terrestrial study area, though opportunistic sightings of other nocturnal fauna were also recorded. Calls of the following nocturnal species were broadcast during the spotlighting to elicit responses:

- frogs: Giant Burrowing Frog, Southern Barred Frog (*Mixophyes balbus*), and Littlejohns Tree Frog (*Litoria littlejohni*);
- mammals: Koala and Yellow-bellied Glider; and
- nocturnal birds: Powerful Owl, Barking Owl and Masked Owl.

Nocturnal surveys were conducted over a total of twelve nights, totalling 132 person hours of survey effort. Where possible, nights with rainfall and greater moon influence were avoided, as they are known to affect spotlight success (DEC 2004a).

iii Tracks, scats and signs

Opportunistic records of tracks, scats and signs (that indicate mammalian use of an area) were noted while completing other survey tasks. These tracks, scats and signs can sometimes lead to the identification of taxa to the species level and are therefore important presence indicators. A total of over 167 person hours were spent searching for tracks, scats and signs.

iv Spot assessment technique

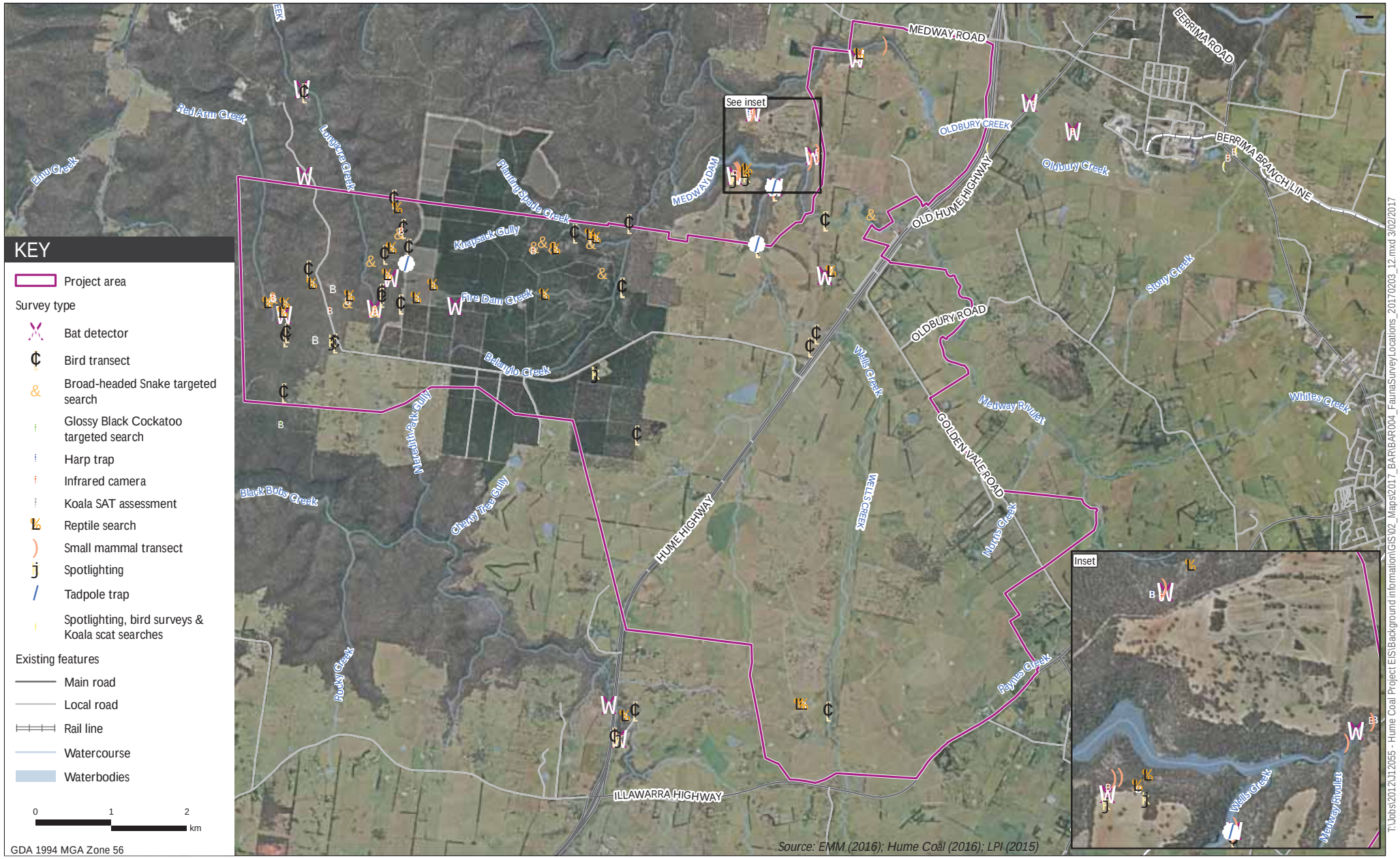
Koalas in a socially stable breeding population are known to repeatedly feed on a small number of trees (home range trees). As such, high activity areas can be determined based on the location and distribution of faecal pellets in suitable habitat. The spot assessment technique (SAT) (Phillips and Callaghan 2011) was used to assess the presence and activity level of Koalas in the terrestrial study area.

Spot assessments were completed at each plot and transect location containing trees to determine presence and/or activity levels. A total of 167 person hours were spent searching for habitat signs, specifically Koala pellets, over the survey period.

In accordance with SEPP 44, areas were identified as potential Koala habitat where feed trees listed in Schedule 2 of the SEPP comprised more than 15% of the total number of trees in the upper or lower strata of the canopy layer. Habitat assessments were also undertaken for Koalas in these locations.

v Camera traps

Motion-sensitive infrared (IR) cameras were placed in 16 locations throughout the terrestrial study area (Figure 2.2) for a total of 76 camera trap nights. The camera traps were baited with a sponge soaked in honey and truffle oil, targeting ground-based carnivores and omnivores. Cameras were positioned in identified fauna runways, often in gullies or in areas where water was available.



Targeted threatened species survey locations

Hume Coal Project

Biodiversity Assessment Report

Figure 2.2

2.7 Survey effort summary

A summary of all survey methods, survey effort and survey timing employed for the project is provided in Table 2.6.

Table 2.6 Summary of survey effort

Taxa group	Survey method	Total survey effort
Flora		
	Plot and transect surveys	64 plot and transect flora surveys
	Rapid vegetation assessments	45 locations
	Targeted threatened flora searches	206 person hours
Fauna		
General	Habitat assessments and searches for signs	167 person hours
Reptiles	Active searches	134 person hours
	Spotlighting	132 person hours
	Broad-headed Snake targeted searches	57 person hours
Birds	Timed diurnal searches	82 person hours
	Call broadcasting and spotlighting	132 person hours
Microchiropteran bats	Anabat detection	66 detector nights
	Harp trapping	38 trap nights
Non-flying mammals	Infrared camera surveys	76 trap nights
	Call broadcasting and spotlighting	132 person hours
Ground mammals	Elliott traps	320 trap nights
Koalas	Spot assessment technique	167 person hours
	Call broadcasting and spotlighting	132 person hours
Frogs	Call broadcasting and spotlighting	132 person hours

2.8 Limitations

Given the size of the terrestrial study area and the variation in land tenure, it was not possible to complete plot based vegetation surveys at all locations in the terrestrial study area. To account for this limitation, 45 rapid vegetation assessments were completed (refer to Section 2.4.5). Aerial photography interpretation, vegetation data recorded directly adjacent to the area and regional mapping datasets were used to infer the vegetation and habitat types. All the required plots and transects were completed within the surface infrastructure area in accordance with the FBA (OEH 2014).

2.9 Naming conventions

Naming conventions for each group targeted are shown in Table 2.7. While the nomenclature for many groups, for instance flora and birds, is relatively straightforward, some species of bat are currently undergoing taxonomic revisions, as represented in Churchill (2008). For example, the Freetail Bats (*Mormopterus spp.*) have recently been redescribed by Reardon (2014). Accordingly, as indicated in Table 2.7, this BAR adopts nomenclature for these species consistent with Reardon's taxonomic revisions for the group.

Table 2.7 Naming conventions by group

Group	Nomenclature adopted
Flora	Harden (1980) and PlantNET (RBGDT 2016)
Reptiles and amphibians	Wilson and Swan (2013) and Anstis (2013)
Birds	Morcombe (2000)
Bats	Churchill (2008) and Reardon (2014)
Mammals	Van Dyck, Gynther and Baker (2013)

2.10 Identification of groundwater dependent ecosystems

An assessment was completed in conjunction with EMM's groundwater specialists to identify terrestrial ecosystems which potentially utilise groundwater in the study areas. It included reviewing the Groundwater Dependent Ecosystem Atlas (Bureau of Meteorology 2013), previous studies completed in the region, groundwater monitoring data and groundwater modelling results. The groundwater monitoring and modelling methods and results are provided in full in the Hume Coal Project Water Assessment, which forms Appendix E of the EIS.

The Groundwater Dependent Ecosystems Atlas was viewed to identify local vegetation types that are potentially groundwater dependent. In addition, ecological characteristics of vegetation communities in the local area were reviewed to identify any features such as landscape position or species composition which may indicate high dependence on groundwater availability. For example, upland swamps are recognised as groundwater dependent ecosystems.

Accessible sites where basalt or shale caps were predicted by geology maps (reference) and sites at the shale/sandstone boundary were visited during the field surveys to identify the potential for springs to occur. All springs noted were recorded.

Modelled depth to groundwater data was also modelled for the study areas (refer to Appendix Eof the EIS) and was reviewed to identify where groundwater could potentially be accessible for terrestrial vegetation. Specifically, the model outputs were used to identify areas where shallow groundwater (0 to 10 m below the ground surface) occurs. Three categories of potential groundwater interaction were identified in the modelling, comprising:

- high potential for groundwater interaction (0 to 3 m groundwater depth below surface);
- moderate potential for groundwater interaction (3 to 5 m groundwater depth below surface); and
- low potential for groundwater interaction (5 to 10 m groundwater depth below surface).

Native vegetation maps were then overlaid on the shallow groundwater distribution maps, in GIS, to determine which patches could potentially access subsurface groundwater, and which category of interaction they fit into (ie high, moderate or low interaction). This was done using native vegetation mapping prepared for this BAR (Figure 4.1) along with mapping of the surrounding area, available in the *Wingecarribee Biodiversity Strategy* (EcoLogical 2003). Areas of overlap, that is where native vegetation communities coincided with shallow groundwater, were identified as 'potential GDEs', requiring further investigation to understand their groundwater dependence (or otherwise). The vegetation and fauna assemblages that rely on these areas for habitat were identified.

Other vegetation and hydrogeology data were then analysed to understand the nature and likely degree of any groundwater dependence of the various ecosystems. In particular, groundwater hydrographs for representative bore locations (which provide information on groundwater levels, and the timing and likely availability of the groundwater resource to ecosystems in these areas) were analysed, in conjunction with potential rooting depths of key species. The timing and volume of groundwater contributions to creek baseflows, as determined by groundwater modelling, was also considered.

Ecosystems identified with potential for reliance on either the surface or subsurface expression of groundwater are identified in Section 4.5 and shown in Figure 4.7. Baseflow contributions to creeks accessed by terrestrial fauna have also been considered.

Following the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (DPI 2016), potential GDEs were categorised, based on their degree of dependence on groundwater. GDEs are divided into three main categories, comprising:

- non-dependent (ie do not access groundwater);
- facultative (have some degree of dependence on groundwater; and
- entirely dependent/obligate (ie essential to ecosystem functioning).

Non-dependent ecosystems include drier terrestrial vegetation that does not overlie groundwater and rely solely on rainfall for ecosystem functioning. Ecosystems with a facultative dependence would rely on groundwater to support ecosystem functioning, but would also rely on rainfall and surface flows. Entirely dependent/obligate ecosystems are solely dependent on groundwater for functioning (ie karts/cave ecosystems).

Ecosystems with a facultative dependence can be further divided into three sub-categories, including:

- opportunistic: these ecosystems will use groundwater where available, but can exist without the input of groundwater, as long as there is no prolonged drought. Examples of opportunistic ecosystems include coastal mangroves, saltmarshes and Banksia woodlands.
- proportional: these ecosystems take a proportion of their water requirements from groundwater, however there is no absolute threshold for groundwater availability below which ecosystem structure or function is impaired, and can respond to changes in groundwater at any level. Examples of proportional ecosystems include glacial lakes and alpine bogs; and
- highly dependent: these ecosystems take a high proportion of their water requirements from groundwater and can only tolerate small changes in groundwater levels for short periods of time. Examples of highly dependent ecosystems include Paperbark swamps in northern Australia and wetlands of the basalt plains in Victorian.

The categories of groundwater dependency identified in the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (DPI 2016) are summarised by the flowchart shown in Plate 2.1.

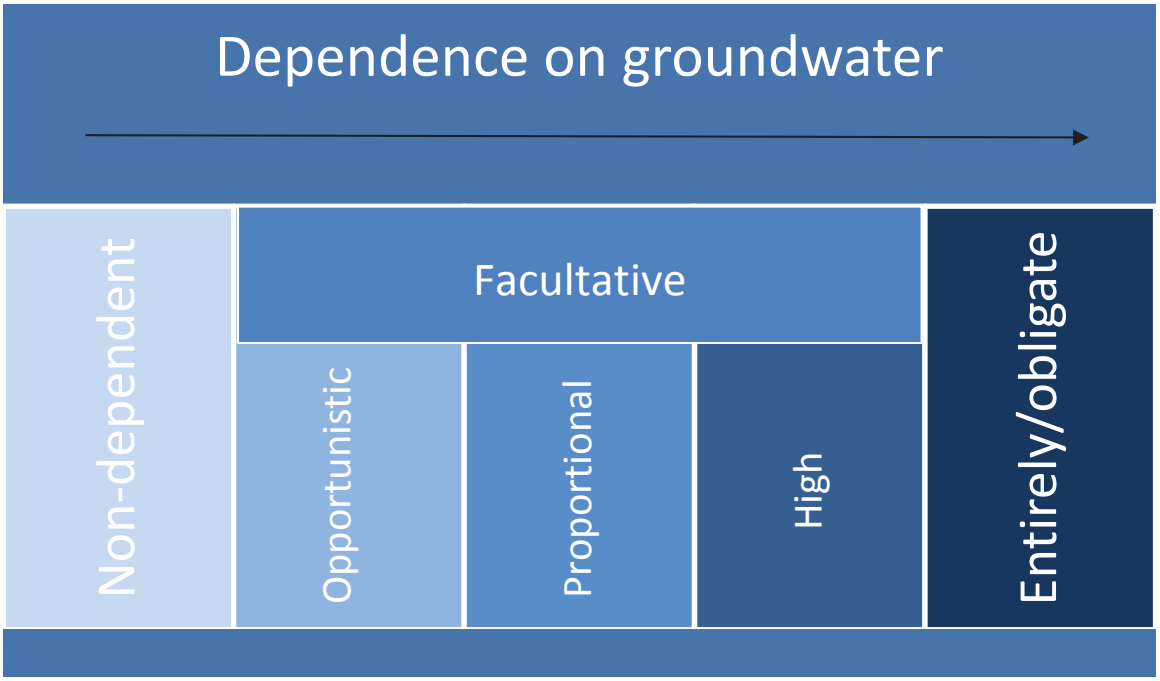


Plate 2.1 GDE categories

2.11 Aquatic assessment methods

2.11.1 Database searches

Table 2.8 summarises the database searches performed to identify any threatened aquatic species in and surrounding the aquatic study area. Recent searches were completed in 2016 to determine if any new species had been listed since commencement of the biodiversity assessment in 2013. Threatened species, listed under the FM Act and/or EPBC Act previously recorded or predicted to occur within the search extents shown in Table 2.8 are provided in Appendix E.

Table 2.8 Database search details

Source	Search date(s)	Search extent
Protected Matters Search Tool www.environment.gov.au/webgis-framework-apps/pmst/pmst.jsf/	15 March 2013 14 April 2014 9 June 2016	5 km radius of the aquatic study area
Atlas of NSW Wildlife www.environment.nsw.gov.au/atlasapp/	15 March 2013 14 April 2014 9 June 2016	Wingecarribee LGA Hawkesbury Nepean MCA
DPI Threatened and Protected Species Records Viewer www.dpi.nsw.gov.au/species-protection	15 March 2013 14 April 2014 9 June 2016	Wingecarribee LGA Hawkesbury Nepean MCA

Based on the outcomes of the searches, aquatic habitats within the aquatic study area were assessed to determine their suitability to support listed species. This information was used to design the survey program.

2.11.2 Survey locations and timing

Surveys were undertaken at a total of 46 sites in the aquatic study area in autumn 2013 and 2014, and spring 2013 and 2015. Surveys were undertaken during spring and autumn to address species seasonality, in accordance with the *NSW AUSRIVAS Sampling and Processing Manual* (Turak et al 2004).

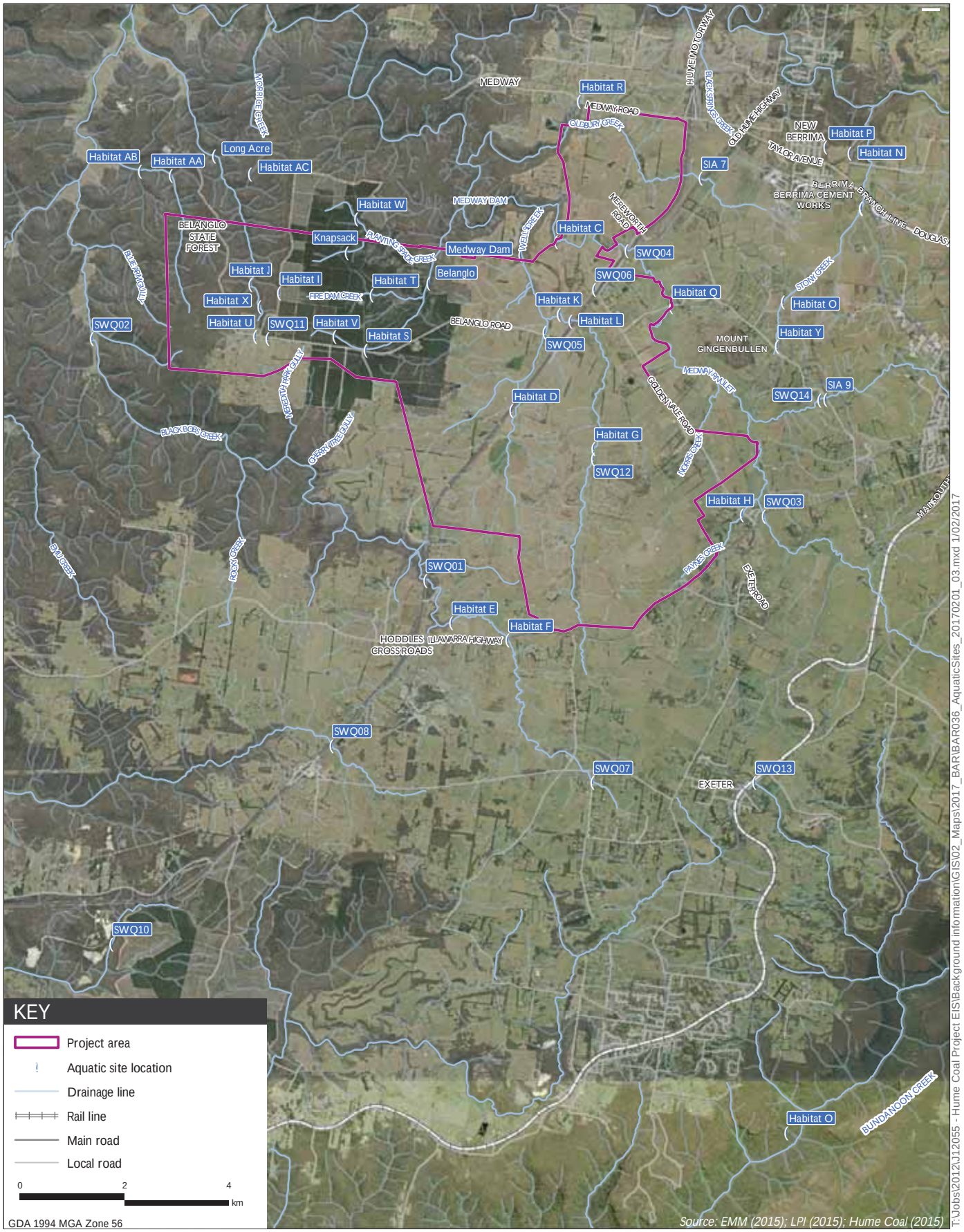
Aquatic surveys were undertaken at 14 sites where access was available and habitat was suitable for quantitative surveys. The surveys included general aquatic habitat quality assessments targeted habitat assessments for listed species, waterway classification, water quality, macroinvertebrate, fish and turtle sampling.

The survey locations, timing and placement with regard to potential impact (surface infrastructure, undermining and the aquatic study area) are listed in Table 2.9 and shown on Figure 2.3.

Table 2.9 Aquatic survey locations and timing

Survey location	Stream	Survey timing			
		Autumn 2013	Spring 2013	Autumn 2014	Spring 2015
SWQ01	Black Bobs Creek (midstream)	✓	✓		
SWQ02	Black Bobs Creek (downstream)	✓	✓		
SWQ03	Medway Rivulet (upstream)	✓	✓		
SWQ04	Medway Rivulet (downstream)	✓	✓		
SWQ05	Wells Creek	✓	✓		
SWQ08	Long Swamp Creek	✓	✓		
SWQ10	Hanging Rock Swamp Creek	✓	✓		
SWQ12	Wells Creek	✓	✓		
Medway Dam	Medway Dam			✓	
SIA 7	Oldbury Creek			✓	
SIA 9	Oldbury Creek			✓	
Knapsack	Knapsack Creek				✓
Longacre	Longacre Creek				✓
Belanglo	Belanglo Creek				✓

Habitat assessments, targeted habitat assessments for listed species, and waterway classifications were undertaken at 32 sites where access was not available or habitat was not suitable for quantitative aquatic surveys. These locations are shown on Figure 2.3 and listed in Table 2.10.



T:\Jobs\2012\J12055 - Hume Coal Project EIS\Background information\GIS\02_Maps\2017_BAR\BAR036_AquaticSites_20170201_03.mxd 1/02/2017

Aquatic survey and habitat assessment locations

Hume Coal Project
Biodiversity Assessment Report

Figure 2.3

Table 2.10 Habitat assessment locations and timing

Habitat assessment location	Stream	Assessment timing		
		Autumn 2013	Autumn 2014	Spring 2015
SWQ06	Belanglo Creek	✓		
SWQ07	Black Bobs Creek	✓		
SWQ11	Longacre Creek	✓		
SWQ13	Indigo Creek	✓		
SWQ14	Whites Creek	✓		
Habitat C	Medway Rivulet	✓		
Habitat D	Unnamed tributary of Wells Creek	✓		
Habitat E	Black Bobs Creek	✓		
Habitat F	Black Bobs Creek	✓		
Habitat G	Wells Creek	✓		
Habitat H	Medway Rivulet	✓		
Habitat I	Unnamed Creek	✓		
Habitat J	Longacre Creek	✓		
Habitat K	Unnamed tributary of Wells Creek		✓	
Habitat L	Unnamed tributary of Wells Creek		✓	
Habitat M	Stony Creek		✓	
Habitat N	Stony Creek		✓	
Habitat O	Bundanoon Creek		✓	
Habitat P	Unnamed tributary of Wingecarribee River		✓	
Habitat Q	Medway Rivulet		✓	
Habitat R	Unnamed tributary of Oldbury Creek		✓	
Habitat S	Belanglo Creek			✓
Habitat T	Fire Dam Creek			✓
Habitat U	Longacre Creek			✓
Habitat V	Belanglo Creek			✓
Habitat W	Planting Spade Creek			✓
Habitat X	Longacre Creek			✓
Habitat Y	Stony Creek			✓
Habitat Z	Stony Creek			✓
Habitat AA	Red Arm Creek			✓
Habitat AB	Red Arm Creek			✓
Habitat AC	Oldbury Creek			✓

2.11.3 Survey methods

i Macroinvertebrates

The macroinvertebrate surveys were undertaken at the sites using sampling methodologies that complied with the *NSW AUSRIVAS Sampling and Processing Manual* (Turak, Waddell and Johnstone, 2004) for the collection and processing (live-picking) of macroinvertebrate samples. Each sampling site was defined as a 100 m waterway reach.

Edge habitats were sampled where present (no pool habitat was present at any site). Within each reach a distance of 10 m of each habitat type was sampled using a 250 µm sweep/dip net with an opening of 250 mm x 250 mm x 250 mm. The contents of the net were emptied into sorting trays.

The animals were live-picked using forceps over a minimum 30-minute period. The resulting specimens were placed into labelled sample jars containing 70% ethanol and transported to the laboratory for identification and enumeration. It is noted that Wells Creek SW05 was not sampled for macronvertebrates due to lack of access in the road easement.

Macroinvertebrate samples were identified to family and counted using the latest identification keys from the Cooperative Research Centre for Freshwater Ecology, with a stereo microscope. The order and family of each specimen were recorded in Excel spreadsheets for analysis.

Macroinvertebrate surveys targeted threatened species previously recorded in the Hawkesbury Nepean MCA. These comprised the larvae and adults of Adam's Emerald Dragonfly (*Archaeophya adamsi*), listed as an endangered species under the FM Act.

Targeted searches were completed for the habitat of the Giant Dragonfly (*Petalura gigantea*) in the project area, as it has previously been recorded at Long Swamp and Stingray Swamp in the south of the aquatic study area. Targeted surveys were not completed for the Giant Dragonfly as no suitable habitat was recorded in the project area. The species presence has been assumed in Long Swamp and Stingray Swamp, given their previous records in these locations.

ii Fish

A single wing fyke net, dual wing fyke net and six bait traps were deployed at each site. All nets were set to sample that a diversity of structural habitat was available to fish at each site (open water, amongst or against vegetation and woody material). The variety of passive sampling techniques available was used to increase the probability of recording a wider range of species and size classes. The following net or traps were deployed at each site:

- 1 x single wing fyke (large mesh) net with a central wing (8 m x 1.2 m) attached to the first supporting hoop (diameter = 0.65 m) with a stretched mesh size of 20 mm.
- 1 x large dual wing fyke nets with 2 wings (each 2.5 m x 1.2 m) attached to the first supporting hoop (diameter = 0.64 m) with a stretched mesh size of 20 mm.
- 6 x bait traps with a funnelled opening at each end (0.22m x 0.22m x 0.4m, with 2 mm stretched mesh) and placed in the littoral zone close to emergent vegetation, submerged macrophytes and woody debris.

The fyke nets were set with the closed end on one bank with the wing attached to the opposite bank. The nets were set in series so that they funnelled fish moving both upstream and downstream. The cod-end of each fyke net was always suspended out of the water to avoid mortality of any captured air breathing vertebrates and visually monitored while set.

Bait traps were an additional method of sampling fish amongst woody debris, dense vegetation, steep banks and deep waters. These were set by baiting the traps with dry dogfood and placed in a variety of habitats (eg open water, macrophytes beds, under snags over near overhangs) in water deeper than one metre and marked using small floats.

At each site with suitable open water, a 10 m seine net was used as an 'active' method of sampling small mid-water and benthic fish species. Each seine trawl was standardised to 10 m transects. Multiple replicates were sampled from each site to target the following habitat types:

- stands of emergent and submerged vegetation (requiring great care during retrieval to prevent fish escaping);
- areas adjacent to snags/woody structures;
- areas underneath overhanging vegetation; and
- open water.

To minimise the stress caused to fish species captured during passive and active sampling, all fish caught were immediately captured using a small dip net and placed in aerated holding tanks. The fish were identified by species, enumerated and immediately returned to the areas they were captured from. All noxious species were euthanased in clove oil water and removed from the site. These methods comply with the requirements of the JSA Scientific Collection Permit (P12/0027-1.0).

Fish surveys targeted two endangered species listed under the FM Act and EPBC Act, predicted by the Protected Matters Search Tool to occur within 5 km of the aquatic study area. These comprised:

- Macquarie Perch (*Macquaria australasica*); and
- Australian Grayling (*Prototroctes mareana*).

iii Fish habitat assessment

Habitat assessments were undertaken to determine the site's suitability to support listed aquatic species predicted by the protected matters search tool and commonly occurring aquatic species. The assessments were based on the Australian Rivers Assessment Methodology (AUSRIVAS) (Turak, Waddell and Johnstone2004) protocols and recorded habitat variables such as: benthic substrate, water depth and vegetation/ water percentage and coverage (including shading). Each assessment site was defined as a 100 m reach. Targeted habitat assessments for listed species were undertaken based on specific habitat attributes that provide key physical requirements to support listed species.

The DPI NSW Fish Habitat Assessment Classification (Fairfull and Witheridge 2003) and *Policy and Guidelines for Fish Habitat Conservation and Management NSW* (update 2013) (DPI 2013) were used to categorise the waterways with regard to their potential to support fish communities (Table 2.11).

Table 2.11 Fish habitat classification

Classification	Stream characteristics
Class 1: Major fish habitat/ Highly sensitive key fish habitat	Major permanently or intermittently flowing waterway (eg river or major creek); habitat of a threatened fish species or critical habitat. Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags(coarse woody debris) greater than 300 mm in diameter or 3 metres in length, or native aquatic plants.
Class 2: Moderate fish habitat/ Moderately sensitive key fish habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks and semi-permanent or permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and /or fish observed inhabiting the area. Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in Class 1. Weir pools and dams up to full supply level where the weir or dam is across a natural waterway.
Class 3: Minimal fish habitat/ Minimally sensitive key fish habitat may include	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (eg fish, yabbies). Semi-permanent pools from within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats. Coastal and freshwater habitats not included in Classes 1 or 2. Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation.
Class 4 Unlikely fish habitat	Named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water pools after rain events (eg dry gullies or shallow floodplain depressions with no permanent aquatic flora present).

iv Platypus habitat assessment

Targeted searches were undertaken at the aquatic survey and habitat assessment sites for platypus habitat (ie sandy creek banks) in the aquatic study area.

v Turtles

Four 'opera house' and ring net traps were deployed in areas of suitable turtle habitat. Traps were set by baiting the traps with ox hearts and placed in a variety of habitats (eg open water, aquatic plant beds, under snags over near overhangs) in water deeper than 1 m and marked using small floats. The nets were placed with one corner above the water line to enable continued breathing while turtles were in the trap. These methods comply with the requirements of the JSA Scientific Collection Permit (P12/0027-1.0).

vi Water quality

Water quality was surveyed at 0.5 m depth using a calibrated Yeokal 611 hand-held, multi-probe device to record:

- pH: acidity or alkalinity;
- turbidity (NTU): suspended particulate and colloidal material;
- conductivity (µs/cm): total concentration of salts;
- temperature (oC): temperature of water column; and
- dissolved oxygen (% saturation): difference between respiration and photosynthesis.

The water quality sampling was undertaken following the relevant procedures outlined in:

- AS/NZS 6557.1:1998 Water Quality-Sampling-Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples;
- AS/NZS 5667.6:1998 Water Quality-Sampling-Guidance on sampling of rivers and streams. Provides detailed guidance on the design of sampling programs, sampling techniques and the handling and preservation of samples from rivers and streams; and
- Australian Guidelines for Water Quality Monitoring and Reporting (2000).

vii Data analysis

The data was analysed using univariate analysis and specialised macroinvertebrate analysis systems, which are described in Table 2.12. The statistical methods used to analyse the data were determined based on the sampling data and survey replication, to provide statistically robust comparisons between sites and environmental data.

Table 2.12 Data analysis summary

Variable	Analysis	Description
Environmental: Water quality	ANZECC/ARMCANZ Guidelines (ANZECC Guidelines)	Trigger values for slightly – moderately disturbed ecosystems: Estuaries.
Biotic and Environmental	Univariate	Descriptive graphical statistics.
Macroinvertebrates	SIGNAL2 (Stream Invertebrate Grade Number – Average Level)	A SIGNAL score gives an indication of water quality in the river from which the sample was collected. SIGNAL can provide indications of the types of pollution and other physical and chemical factors that are affecting the macroinvertebrate community. A diagram outlining the interpretation of SIGNAL2 results is provided in Figure 7.
Macroinvertebrates	EPT Index (Ephemeroptera, Plecoptera and Trichoptera Index)	The EPT Index uses three orders of aquatic insects that are easily sorted and identified and are commonly used as an indicator of water quality (ephemeroptera, plecoptera and trichoptera). The greater the pollution, the lower the species richness expected.

2.12 Stygofauna assessment methods

Stygofauna were assessed for the project as the OEH, DPI and Fisheries NSW assessment recommendations require that an assessment of groundwater dependent ecosystems is provided. Groundwater systems containing Stygofauna are groundwater dependent ecosystems and accordingly are assessed in this report.

2.12.1 Literature review

A review was completed of previous stygofauna studies, comprising:

- *Stygofauna diversity and distribution in Eastern Australian cave and karst areas* (Thurgate et al 2001);
- *Stygofauna baseline assessment for Kangaloon borefield investigations – Southern Highlands, NSW* (Hose 2008);

- *Upper Nepean (Kangaloon) Borefield Project Environmental Assessment* (KBR 2008); and
- *The amphipod (Crustacea) stygofauna of Australia: description of new taxa (Melitidae, Neoniphargidae, Paramelitidae), and a synopsis of known species* (Bradbury and Williams 1997).

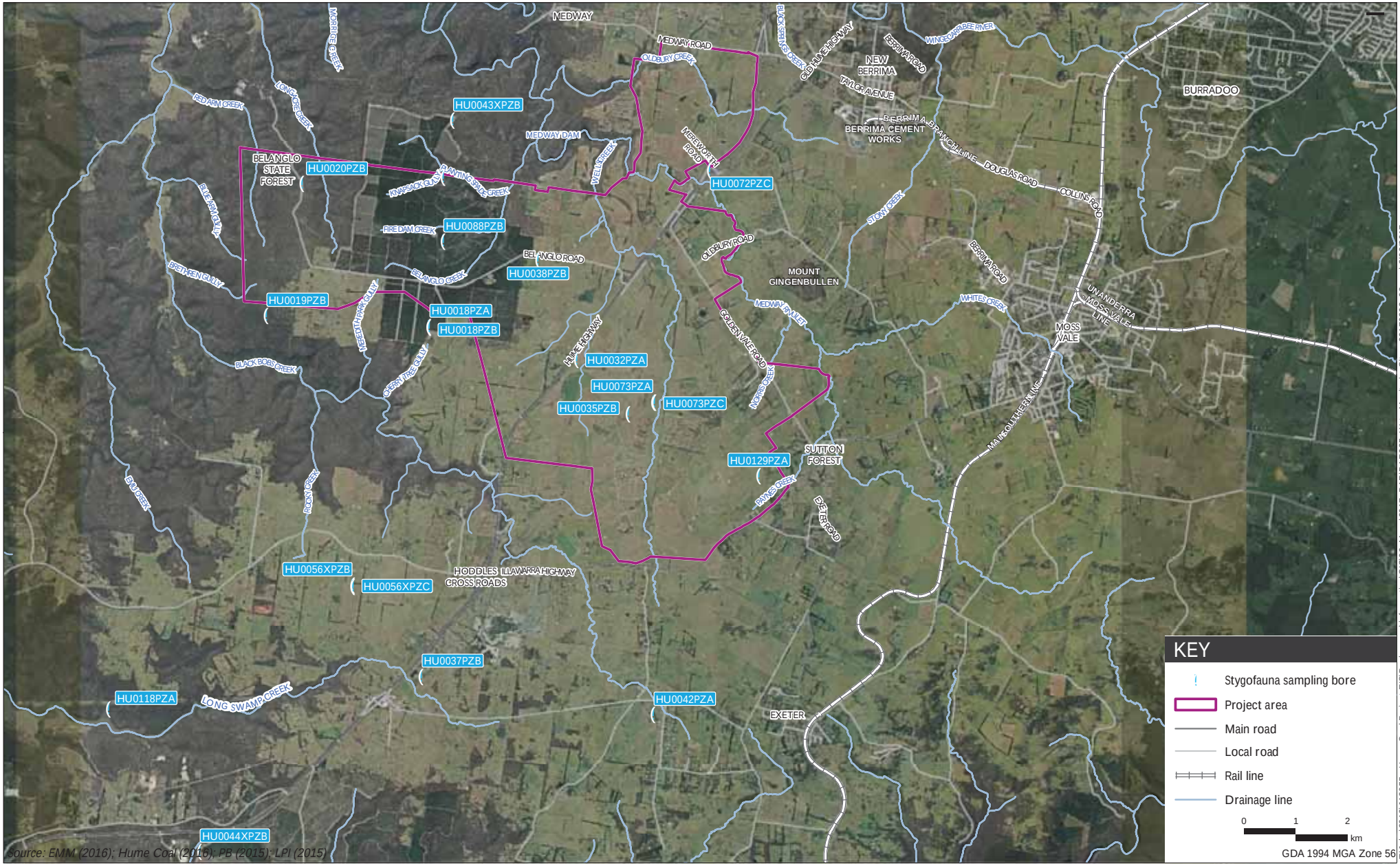
The review focused on determining the super orders and families of stygofauna (as few are identified to a species level) in the region. The purpose of the literature review was to develop appropriate sampling methods for stygofauna. The development of the sampling methods is detailed in Appendix J.

2.12.2 Survey locations and timing

Surveys were undertaken at 20 groundwater boreholes in autumn 2013 and 2014 and spring 2013, in the aquatic study area. The surveys sampled a variety of depth profiles across the bores to target various groundwater systems (15.3-17 2m depths). The survey locations and bore placement with regard to potential impact (surface infrastructure, undermining and the aquatic study area) are listed in Table 2.13 and shown in Figure 2.4.

Table 2.13 Stygofauna survey locations

Bore	Depth (m)	Survey timing		
		Autumn 2013	Spring 2013	Autumn 2014
HU0018PZA	108	✓	✓	
HU0018PZB	90	✓	✓	
HU0019PZB	84	✓	✓	
HU0020PZB	88	✓	✓	
HU0032PZA	121	✓	✓	
HU0035PZB	35	✓	✓	
HU0037PZB	90	✓	✓	
HU0038PZB	78	✓	✓	
HU0042PZA	162	✓	✓	
HU0043XPZB	87	✓	✓	
HU0044XPZB	12	✓	✓	
HU0056XPZB	140		✓	
HU0056XPZC	26		✓	
HU0072PZC	46	✓	✓	
HU0073PZA	172	✓	✓	
HU0073PZC	86	✓	✓	
HU0088PZB	128			✓
HU0096PZB	101.3			✓
HU0118PZA	15.3			✓
HU0129PZA	171			✓



Stygofauna survey locations

Hume Coal Project

Biodiversity Assessment Report

Figure 2.4

2.12.3 Survey methods

Stygofauna surveys were undertaken using haul nets, sometimes referred to as weighted 'plankton' nets. A haul net (50 and 150 µm mesh size), was lowered to the bottom of each bore sampled. The net was bounced up and down to agitate sediments and increase the yield at the base of the bore and then slowly retrieved, filtering stygofauna out of the water column on the upward haul. The net was lowered and retrieved six times. The contents of the net were emptied into a sampling jar of 70% ethanol after each haul by unscrewing the removable vial at the base of the net.

The average water table depth in the boreholes in the project area is 46 m and the average depth of the bores is 106 m. While most of the bores in the project area are either located in the Hawkesbury Sandstone or Illawarra Coal Measures which are generally fast replenishing, the bore network also has a number of bores that are in shale or are slow replenishing. The bore network ranged in the depth of the bores, water table level and variability of replenishment rates of the bores. In order to maintain consistency between data collection methods to enable comparisons between bores and seasons, it was determined that net sampling was the most appropriate method (Hose and Lategan 2012).

Stygofauna samples were identified to family and counted with a stereo microscope. The orders and families of each specimen were recorded in Excel spreadsheets for analysis.

3 Landscape values

This chapter describes the landscape values of the project area and terrestrial study area in accordance with Chapter 4 of the FBA. These landscape values have been used to inform BioBanking calculations for the project.The chapter also describes aquatic landscape values of the aquatic study area.

3.1 Overview

The project area is approximately 3 km west of Moss Vale, in the Wingecarribee LGA and the Southern Highlands region of NSW. It is in an area that is highly modified, including due to historical and current agricultural and forestry practices and infrastructure development. Native vegetation in the project area is highly fragmented and covers a relatively small proportion of the terrestrial study area. It is principally restricted to the north-western corner, in parts of the Belanglo State Forest, and small patches in the central northern terrestrial study area, associated with creeks and gullies (Figure 4.1). Isolated remnant paddock trees occur in the eastern and northern parts of the project area.

While there are no conservation areas within the terrestrial study area, there are some national parks and nature reserves in the surrounding region (Figure 1.1). Bangadilly National Park (NP), Kerrawarry Nature Reserve (NR) and Tarlo River NP are located around 5, 10 and 20 km west of the project area, respectively. Nattai NP is approximately 18 km north of the project area, and Morton NP is 5 km to the south. The Upper Nepean State Conservation Area is around 18 km north-east of the project area (Figure 1.1).

The overview site map (Figure 1.4) and overview landscape map (Figure 1.5) illustrate the landscape values of the project area and terrestrial study area. Individual site maps and landscape maps prepared in accordance with the scale requirements of the FBA are provided in Appendix A.

3.2 IBRA Bioregion

The project is in the Sydney Basin Bioregion, and covers both the Burragorang and Moss Vale sub-regions of the Hawkesbury/Nepean major catchment area, as defined under the Interim Biogeographic Regionalisation for Australia (IBRA) system. The surface infrastructure area is located in the Moss Vale sub-region.

The project is located in the former Hawkesbury-Nepean Catchment Management Area, which now falls within the broader area now administered by South East Local Land Services, namely the Hawkesbury/Nepean Major Catchment Area (MCA). The IBRA subregion boundaries are shown on the overview site map (Figure 1.4) and overview landscape map (Figure 1.5). Individual site maps and landscape maps prepared in accordance with the scale requirements of the FBA are provided in Appendix A.

3.3 Mitchell landscapes

The terrestrial study area is divided into three Mitchell landscapes, namely Moss Vale (Moss Vale Highlands), Burragorang (Nattai Plateau) and Robertson basalt landscape. Mitchell Landscapes are defined by OEH as 'areas of land with relatively homogenous geomorphology, soils and broad vegetation types which have been mapped at 1:250,000 scale'. These landscape units have been mapped by DECC (2002) and their coverage within and surrounding the terrestrial study area are shown on the overview site map (Figure 1.4) and overview landscape map (Figure 1.5). Individual site maps and landscape maps prepared in accordance with the scale requirements of the FBA are provided in Appendix A.

The Moss Vale (Moss Vale Highlands) Mitchell landscape is mapped across most of the central and eastern parts of the terrestrial study area, as well as the far north-west. Based on the description given by DECC (2002), it is typically characterised by rolling hills and rounded peaks with deep channel incision on horizontal Triassic alternating quartz sandstone and shale. It has a general elevation of 700 to 850 m above sea level (ASL) and local relief to 80 m. Widespread yellow and grey texture-contrast soils are present, with deep yellow earth on friable sandstone, often with concretionary ironstone and accumulations of clan quartz sand in valleys.

The Burragorang (Nattai Plateau) landscape is mapped across parts of the central northern and western terrestrial study area. It is characterised by steeply dissected plateau remnants on lower Triassic lithic sandstone, shale and tuff, abundant rock outcrop and cliffs and steep debris slopes. Elevations are generally 600 to 700 m and local relief is up to 80 m. Shallow sand and occasional yellow texture-contrast soils are present in this landscape.

The Robertson basalt landscape is characterised by flat hills and small plateaus above the undulating shale hills of the Moss Vale Highlands landscape on Tertiary basalt flows. Typical elevations range from 800 to 850 m ASL with a local relief of 40 m. Soils are characterised by red and red-brown structured loam and clay loam with uniform or gradational profiles, good water holding-capacity and high fertility.

Surface infrastructure areas intersect the Moss Vale (Moss Vale Highlands) and Burragorang (Nattai Plateau) Mitchell landscapes.

3.3.1 Rivers and drainage lines

The majority of the project area is within the Wingecarribee River catchment of the Upper Nepean and Upstream Warragamba Water Source, which is managed under the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011*. A small portion of the south-east corner of the project area is within the Bundanoon Creek catchment, a sub-catchment of the Shoalhaven River catchment (Parsons Brinckerhoff 2016), and this is still managed under the same water sharing plan.

The project area is traversed by several drainage lines generally flowing in a north to north-westerly direction, all of which discharge to the Wingecarribee River, at least 5 km downstream (north west) of the project boundary. Rivers and drainage lines in and surrounding the project area are shown on Figure 1.2, and include the following local sub-catchments of the Wingecarribee River catchment:

- Medway Rivulet catchment, incorporating the Oldbury Creek sub-catchment, where a majority of the project area and the surface infrastructure is located; and
- Black Bobs Creek catchment, incorporating Redarm Creek and Longacre Creek catchments.

The Wingecarribee River flows east to west, north of the project area. Medway Rivulet is the predominant drainage line in the project area. Its major tributaries include Oldbury Creek, Paynes Creek, Wells Creek, Wells Creek Tributary and Whites Creek. The headwaters of Medway Rivulet commence near Moss Vale.

Oldbury Creek commences near New Berrima and joins the Medway Rivulet 1.5 km downstream from Medway Dam. Similarly to the Medway Rivulet, the creek is characterised by several in-stream storages that impede continuous flow within the upper catchment. A large agricultural in-stream storage dam is located near the northern part the surface infrastructure area. Treated sewerage from the Berrima sewerage treatment plant discharges directly into Oldbury Creek. Medway Rivulet and Olbury Creek intersect the surface infrastructure area (Figure 1.4 and Figure 1.5).

The aquatic study area encompasses the river and drainage lines referred to above. It also includes other large and small waterways in the aquatic study area, which vary in stream order. All waterways in the aquatic study area are listed in Table 3.1 and shown on Figure 3.1.

Table 3.1 Stream order in the aquatic study area

Stream name	Stream order	Total length in aquatic study area (km)
Apple Gully	2	0.6
Baronga Creek	3 and 4	3.7
Belanglo Creek	1 to 4	4.7
Black Bobs Creek	2 to 5	25.0
Black Springs Creek	1 to 4	1.8
Blue Arm Gully	1 and 2	2.6
Box Gully	1 and 2	1.7
Brethren Gully	1 to 3	2.0
Bundanoon Creek	5	7.5
Cherry Tree Gully	1 to 3	1.5
Christmas Creek and Gully	1 and 2	3.5
Coal Creek	3	1.8
Dimmocks Creek	1 to 3	2.7
Emu Creek	2 to 4	11.6
Ferntree Gully	1 and 2	1.6
Fire Dam Creek	1 and 2	2.4
Hanging Rock Swamp	2 to 4	5.7
Indigo Creek	1 to 3	4.7
Johnstones Creek	2	0.6
Knapsack Gully	1 and 2	1.3
Long Swamp Creek	1 to 5	10.7
Longacre Creek	3 and 4	6.0
Lutwyche Creek	2	0.4
Medway Rivulet	2 to 5	25.5
Meredith Park Gully	1 to 3	2.4
Morrice Creek	2 and 3	1.6
Mundego Swamp	2 and 3	1.7
Munros Gully	1 and 2	1.8
Norris Creek	1 and 2	2.2
Oldbury Creek	3 and 4	8.3
Paddys River	4 and 5	19.5
Paynes Creek	2 and 3	2.3
Planting Spade Creek	1 to 3	2.7
Red Arm Creel	1 to 4	4.3
Reedy Creek	1 to 4	5.4
Rocky Creek	1 to 3	3.6
Stonequarry Creek	3 and 4	6.0

Table 3.1 Stream order in the aquatic study area

Stream name	Stream order	Total length in aquatic study area (km)
Stony Creek	2 to 5	5.7
Wells Creek	3 and 4	11.2
Whites Creek	2 to 4	6.8
Wingecarribee River	5 and 6	10.7

There are also a number of small unnamed waterways in the aquatic study area all having a stream order of 1 to 3, with the exception of one waterway that has a stream order of 4.

3.3.2 Key fish habitats in the Wingecarribee Shire

Key fish habitat is defined as an aquatic habitat that is important to the sustainability of recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species. In freshwater systems, most permanent and semi-permanent rivers, creeks, lakes, lagoons, billabongs, weir impoundments and impoundments up to the top of the bank are considered key fish habitats. Small headwater creeks and gullies that flow for short periods after rain and farm dams on such systems are excluded, as are artificial waterbodies except for those that support populations of threatened fish or invertebrates. The key fish habitat map for the Wingecarribee LGA identifies the reaches of Medway Rivulet, Belanglo Creek, Black Bobs Creek and Wells Creek in the project area as key fish habitats (Plate 3.1).

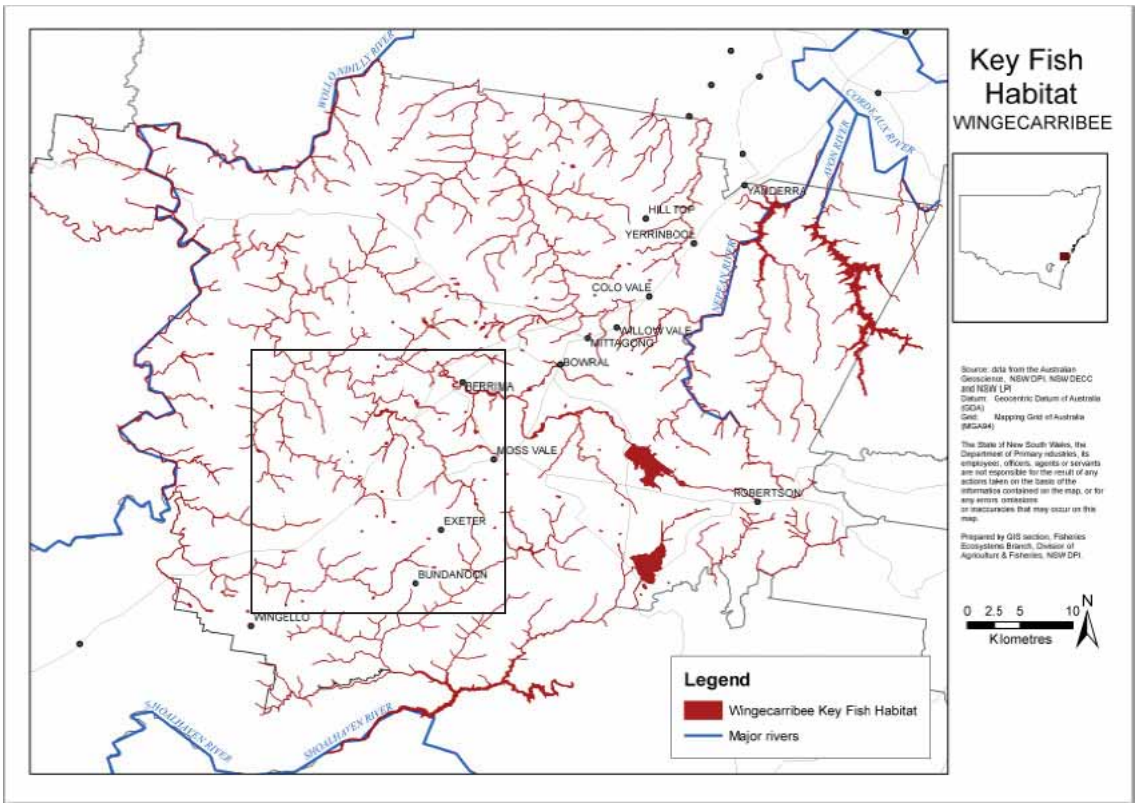
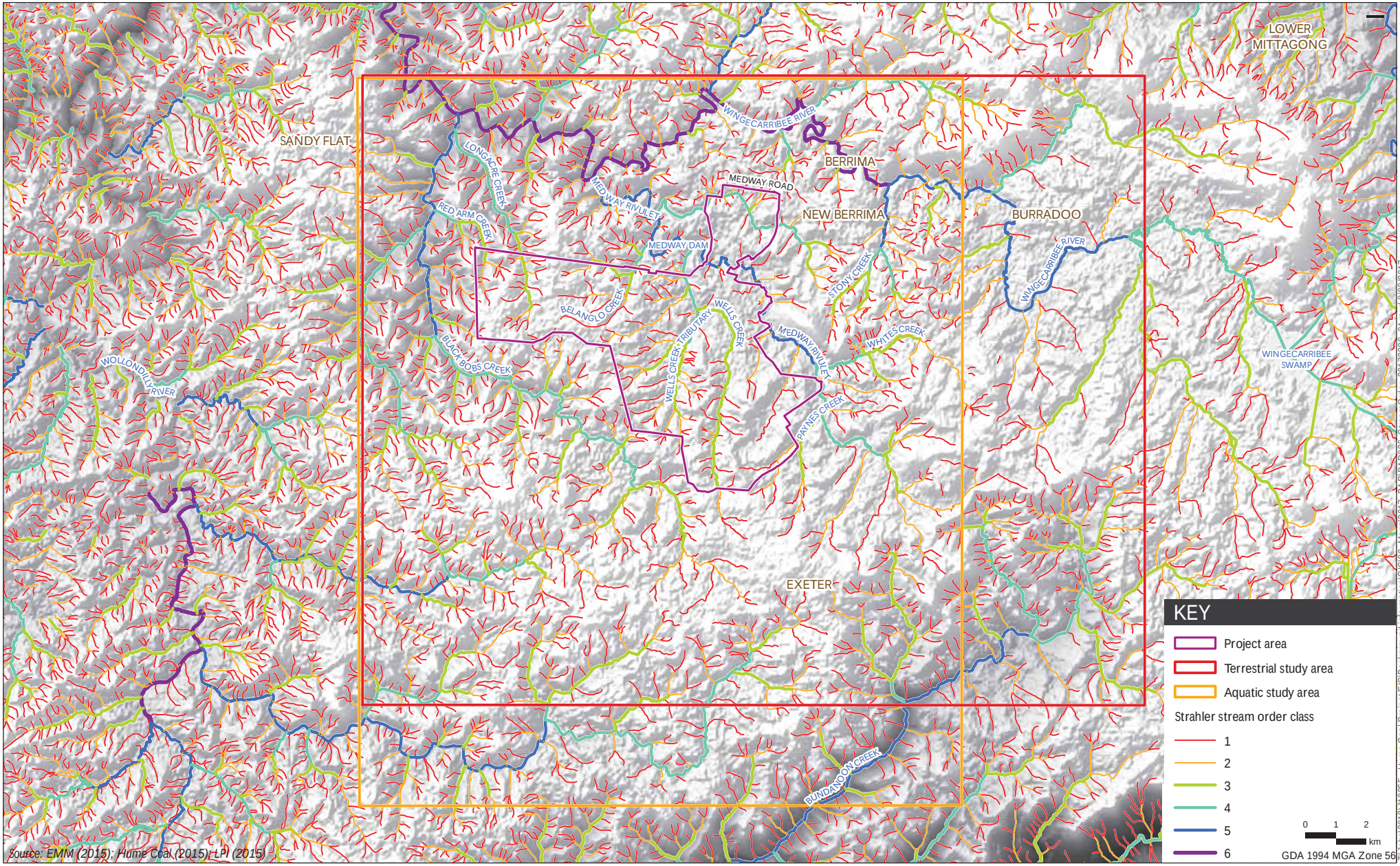


Plate 3.1 Key fish habitat in the Wingecarribee LGA (DPI 2007) (approximate aquatic study area shown in black square)



Stream order in the project area and surrounds

Hume Coal Project

Biodiversity Assessment Report

Figure 3.1

3.3.3 Wetlands

No wetlands occur in the project area, however a number of small dams are present, some with aquatic vegetation. Medway Dam is the largest body of standing water in the locality and terrestrial and aquatic study areas (Figure 1.1).

Paddys River Swamps, comprising Long, Hanging Rock, Mundego, and Stingray Swamps, are approximately 7, 9, 15 and 8 km south-west of the project area (Figure 4.7), respectively. Paddys River Swamps are also listed on the Directory of Nationally Important Wetlands (DoE 2010).

3.3.4 Biodiversity links

There are no recognised state significant biodiversity links within the terrestrial study area. The *Framework for Biodiversity Assessment* (OEH 2014) states that for an area to be classified as a state or regionally significant biodiversity link, it must be identified as such in a plan approved by the Chief Executive of OEH. Additionally, a riparian buffer of 50 m on either side of a 6th order stream or greater, or around an important wetland or estuarine area, would also constitute a state significant biodiversity link.

A riparian buffer of 20 m on either side of a 4th or 5th order stream can be considered a regionally significant biodiversity link. Oldbury Creek and Medway Rivulet in the surface infrastructure area represent 4th and 5th order drainage lines, respectively. They each have vegetated riparian buffers in excess of 50 m in places, however the riparian corridor is much narrower on average. The conveyor will cross a section of Medway Rivulet where the riparian corridor is approximately 23 m wide in total (ie not 20 m on either side). As an elevated conveyor will be installed, no native vegetation will be impacted by its installation. Therefore the project will not impact regionally significant biodiversity links. The regionally significant biodiversity link is shown on the overview site map (Figure 1.4) and overview landscape map (Figure 1.5).

Vegetation connectivity to the area of greatest change (ie the inner assessment circle) is poor given the fragmentation of vegetation. Therefore, removal of paddock trees for the surface infrastructure area will not reduce the width of connecting links.

3.3.5 Other landscape values

No other landscape values have been identified, in the SEARs or otherwise, as requiring consideration in the project's biodiversity assessment.

3.4 Native vegetation

3.4.1 Native vegetation within the assessment circles

An inner assessment circle of 100 ha was placed around the area of greatest change in the surface infrastructure area. Given the avoidance of most intact patches of native vegetation for the project, the area of greatest change overlies paddock trees in exotic grassland. Accordingly, the inner assessment circle was placed over this area.

In accordance with the FBA (OEH 2014), native vegetation extent is calculated based on the patches of native vegetation that are present. Therefore, the area of intact patches of native vegetation was mapped and used to calculate native vegetation extent in the inner assessment circle.

The FBA requires that the outer assessment circle is ten times the size of the inner assessment circle. Accordingly, the outer assessment circle was calculated at 1,000 ha. The area of native vegetation shown on aerial mapping and observed in the field was greater than predicted by existing vegetation mapping (EcoLogical 2013), and therefore the entire extent of intact native vegetation was mapped and used to calculate the area of native vegetation in the outer assessment circle. The extent of native vegetation in the outer assessment circle was extrapolated from a combination of field results and regional mapping datasets. The inner and outer assessment circle, and the extent of native vegetation within them, is shown on the overview site map (Figure 1.4) and overview landscape map (Figure 1.5). Individual site maps and landscape maps prepared in accordance with the scale requirements of the FBA are provided in Appendix A.

Native vegetation cover is currently highly fragmented in both the inner and outer assessment circle prior to disturbance. Table 3.2 summarises native vegetation cover in both the inner and outer assessment circle both pre and post project-related disturbance. There is no change in percentage of native vegetation cover in the inner or outer assessment circle following disturbance. The landscape score for the assessment circles provided by the BioBanking calculator is 12.

Table 3.2 Native vegetation in the assessment circles before and after development

Assessment circle	Before development (ha)	After development (ha)	Before development (% cover)[1]	After development (% cover)[2]
Inner assessment circle	2.00	2.00	<5	<5
Outer assessment circle	157.69	157.67	11-15	11-15

Notes *1. Prior to any vegetation clearing for the project.*

2. Following any vegetation clearing for the project.