

DRAYTON SOUTH COAL PROJECT

Biodiversity Assessment Report

For:

Hansen Bailey Pty Ltd

April 2015

Final



**PO Box 2474
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Report No. 9080RP11

The preparation of this report has been in accordance with the brief provided by the Client and has relied upon the data and results collected at or under the times and conditions specified in the report. All findings, conclusions or recommendations contained within the report are based only on the aforementioned circumstances. The report has been prepared for use by the Client and no responsibility for its use by other parties is accepted by Cumberland Ecology.

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Table of Contents

EXECUTIVE SUMMARY	<i>xiii</i>
1 INTRODUCTION	1
1.1 Background	1
1.2 Purpose	1
1.3 The Study Area	2
1.4 Report Structure	3
1.5 Related Studies	3
2 LEGISLATIVE FRAMEWORK	4
2.1 Commonwealth Legislation and Policies	4
2.1.1 Environmental Protection and Biodiversity Conservation Act 1999	4
2.1.2 Environmental Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (2012)	5
2.2 State Legislation and Policies	5
2.2.1 Environmental Planning and Assessment Act 1979	5
2.2.2 Threatened Species Conservation Act 1995	6
2.2.3 Fisheries Management Act 1994	6
2.2.4 NSW Biodiversity Offsets Policy for Major Projects (2014)	7
2.2.5 SEPP 44 – Koala Habitat Protection	8
3 PROJECT DESCRIPTION	10
4 EXISTING ENVIRONMENT	12
4.1 Regional Context	12
4.1.1 Bioregion	12
4.1.2 NSW (Mitchell) Landscapes	12
4.1.3 Conservation Reserves	13
4.2 Climate	14
4.3 Topography	14
4.4 Geology	15

Table of Contents *(Cont'd)*

4.5	Soils and Land Capability	15
4.6	Hydrology	16
4.6.1	Saddlers Creek	16
4.6.2	Hunter River	16
4.7	Land Use	17
4.8	Landscape Values	17
5	METHODS	18
5.1	Desktop Assessment	18
5.1.1	Literature Review	18
5.1.2	Threatened Species Database	19
5.1.3	Review of Regional Vegetation Mapping	19
5.2	Field Studies	20
5.3	Flora Survey	23
5.3.1	Vegetation Mapping	24
5.3.2	Floristic Census	25
5.3.3	Targeted Searches for Threatened Plants	25
5.3.4	Plot Sampling	25
5.3.5	Identification of Threatened Ecological Communities	26
5.3.6	Identification of Groundwater Dependent Ecosystems	28
5.3.7	Assessment Approach	31
5.4	Fauna Habitat Assessment	31
5.4.1	Hollow Assessment	32
5.5	Terrestrial Fauna Surveys	32
5.5.1	Trapping Surveys	35
5.5.2	Bat Surveys	36
5.5.3	Bird Surveys	37
5.5.4	Diurnal Surveys	37
5.5.5	Nocturnal Surveys – Spotlight Searches	38
5.5.6	Incidental Observations	38

Table of Contents *(Cont'd)*

5.6	Aquatic Survey	38
5.6.1	Habitat Assessment	39
5.6.2	Macroinvertebrate Sampling	41
5.6.3	AUSRIVAS and SIGNAL Analysis	41
5.7	Survey Limitation	42
6	RESULTS	44
6.1	Native Vegetation	44
6.1.1	Drayton South	44
6.1.2	Drayton Mine	50
6.1.3	Vegetation Listed under the EPBC Act	51
6.2	Flora Species	53
6.2.1	General Assemblage	53
6.2.2	Threatened Flora Species Recorded in the Study Area	54
6.2.3	Potential Threatened Flora Species	60
6.2.4	Invasive Flora Species	62
6.2.5	Flora Species listed under the EPBC Act	62
6.3	Fauna Habitat	64
6.3.1	Extant Habitat	64
6.3.2	Remnant Forest and Woodland	65
6.3.3	Regenerating Shrubland and Forest	72
6.3.4	Grassland	72
6.3.5	Planted Trees	75
6.3.6	Riparian Vegetation	75
6.3.7	Aquatic Habitat	76
6.4	Fauna Species	78
6.4.1	General Assemblage	78
6.4.2	Threatened Fauna Species Recorded in the Study Area	79
6.4.3	Potential Threatened Fauna	101
6.4.4	Invasive Fauna Species	110
6.4.5	Fauna Species Listed under the EPBC Act	111

Table of Contents *(Cont'd)*

6.5	Credit Species	112
6.6	Groundwater Dependent Ecosystems	114
6.7	Aquatic Results	115
6.7.1	Habitat Assessment	115
6.7.2	Site Condition and Ecological Integrity	122
6.7.3	Aquatic Vertebrate Species	129
6.7.4	Aquatic Threatened Species	131
7	PROJECT IMPACTS	132
7.1	Direct Impacts on Native Terrestrial Vegetation	132
7.1.1	Impacts on Threatened Ecological Communities	135
7.1.2	Loss of Important Habitat Features	138
7.1.3	Habitat Fragmentation and Patch Size	140
7.1.4	Reduction or Loss of Habitat Connectivity	142
7.1.5	Edge Effects	142
7.2	Direct Impacts on Threatened Species	144
7.2.1	Flora	145
7.2.2	Fauna	146
7.3	Summary of Direct Impacts on MNES	153
7.4	Indirect Impacts on Terrestrial Habitats	154
7.4.1	Competition for Resources	154
7.4.2	Noise	155
7.4.3	Light	155
7.4.4	Dust	156
7.4.5	Erosion	156
7.4.6	Vehicle Strike	157
7.4.7	Weeds, Feral Animals and Overabundant Native Species	157
7.5	Impacts on Groundwater Dependent Ecosystems	158
7.5.1	Impacts to Groundwater	158
7.5.2	Impacts to Groundwater Dependent Ecosystems	159
7.6	Aquatic Impacts	160

Table of Contents *(Cont'd)*

7.6.1	Water Quality and Habitat	160
7.6.2	Water Extraction	160
7.7	Cumulative Impacts	161
7.8	Duration and Timing of Impacts	166
7.9	Permanence and Reversibility of Impacts	166
8	MEASURES TO AVOID AND MITIGATE IMPACTS	167
8.1	Measures to Avoid Impacts	167
8.2	Measures to Mitigate Impacts	168
8.2.1	General Measures	168
8.2.2	Minimising Impacts during Development Works	169
8.2.3	Vegetation Restoration and Rehabilitation	170
8.2.4	Measures to Protect Threatened Species Onsite	171
8.2.5	Biodiversity Monitoring	173
8.2.6	Biodiversity Action Plan	175
8.3	Residual Impacts that cannot be Avoided or Mitigated	176
9	ASSESSMENT OF RESIDUAL IMPACTS	177
9.1	Credit Summary	177
9.1.1	Species Credits	177
9.1.2	Ecosystem Credits	178
9.2	Matters that Require Further Consideration	180
9.2.1	Box-Gum Woodland	180
9.2.2	Diuris tricolor (Pine Donkey Orchid)	183
10	COMPENSATORY MEASURES	188
11	CONCLUSION	189
	REFERENCES	190
	FIGURES	209

Table of Appendices

A.	SUMMARY OF ASSESSMENT OF MNES
B.	DESCRIPTIONS OF VEGETATION UNITS
C.	FLORA SPECIES LIST
D.	LIKELIHOOD OF OCCURRENCE - FLORA SPECIES
E.	FAUNA SPECIES LIST
F.	LIKELIHOOD OF OCCURRENCE - FAUNA SPECIES
G.	ASSESSMENTS OF SIGNIFICANCE
H.	BIODIVERSITY CREDIT REPORTS

List of Tables

S.1	Vegetation Map Units within the Study Area
S.2	Vegetation Communities in the Minor Additional Mining Areas at Drayton Mine
S.3	Threatened Fauna Species Recorded in the Study Area
2.1	Koala Feed Trees (Schedule 2 of SEPP 44)
4.1	Landscape Values Used in the Credit Calculator
5.1	Summary of Dates for Field Surveys Completed
5.2	Field Survey Weather Conditions (Jerrys Plains Forecasts)
5.3	Braun-Blanquet Scoring System
5.4	Cumulative Survey Effort completed for the Study Area
5.5	Cumberland Ecology Fauna Trapping Effort
6.1	Vegetation Map Units within the Study Area
6.2	Vegetation Map Units and relationship to Biometric Vegetation Types
6.3	Vegetation in the Minor Additional Mining Areas at Drayton Mine
6.4	Likelihood of Occurrence of TECs Listed under the EPBC Act in the Study

List of Tables

	Area
6.5	Likelihood of Occurrence of Flora Species Listed under the EPBC Act in Study Area
6.6	Qualitative Assessment – Remnant Forest and Woodland Habitat
6.7	Flowering Periods for Dominant Tree Species
6.8	Qualitative Assessment – Woodland Margins
6.9	Qualitative Assessment – Grassland Habitat
6.10	Qualitative Assessment – Riparian Habitat
6.11	Threatened Fauna Species Recorded in the Study Area
6.12	Foraging Guilds of Microbat Species Recorded in the Study Area
6.13	Likelihood of Occurrence of Fauna Species Listed under the EPBC Act in Study Area
6.14	Predicted "Ecosystem Credit" Species Associated with Onsite PCTs
6.15	Identified "Species Credit" Species
6.16	Summary of Aquatic Habitat Assessment
6.17	Health of Aquatic Sites According to AUSRIVAS Bands
6.18	AUSRIVAS Band Keys
6.19	Aquatic Physical and Chemical Data
6.20	SIGNAL Macroinvertebrate Scores
6.21	Vertebrate Fauna Recorded in the Hunter River
7.1	Areas of Vegetation to be Removed by the Project
7.2	Direct Project Impacts on MNES
7.3	Cumulative Impacts on Vegetation in the Muswellbrook LGA
9.1	Project Impacts – Species Credits
9.2	Project Impacts – Ecosystem Credits

List of Graphs

Graph 6.1	Biplot of the Condition of Each Aquatic Survey Site According to SIGNAL Scores	128
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List of Figures

Figure 1	Regional Locality
Figure 2	Conceptual Project Layout
Figure 3	Minor Additional Mining Areas at Drayton Mine
Figure 4	Landscape Features
Figure 5	Plot and Transect Locations
Figure 6	Fauna Survey Locations
Figure 7	Aquatic Survey Locations
Figure 8	Vegetation Units within the Study Area
Figure 9	Vegetation in the Additional Mining Areas at Drayton Mine
Figure 10	Threatened Species Recorded in the Study Area
Figure 11	Project Footprint
Figure 12	Vegetation within the Project Disturbance Footprint
Figure 13	Drayton Mine – Existing Offsets
Figure 14	Impact Summary

List of Photographs

Photograph 6.1	<i>Acacia pendula</i> clonal clump at the eastern patch in the Study Area	55
Photograph 6.2	<i>Acacia pendula</i> clonal clump at the western patch along Saddlers Creek	56
Photograph 6.3	<i>Eucalyptus camaldulensis</i> tree on Saddlers Creek, west of Edderton Road	57
Photograph 6.4	Threatened Orchid <i>Diuris tricolor</i> Recorded within the Study Area	59
Photograph 6.5	<i>Diuris tricolor</i> in Open Grassy Understorey	59
Photograph 6.6	Open grassy Box-Gum Woodland Habitat where <i>Diuris tricolor</i> was Recorded	60
Photograph 6.7	A Large Tree Hollow in the Study Area	67
Photograph 6.8	Australian Kestrel in a Tree Hollow (Photo: D. Stojanovic, 2011)	67
Photograph 6.9	Stag Providing Valuable Large Hollows	68
Photograph 6.10	A Typical Hollow-bearing Tree in the Study Area	69
Photograph 6.11	Woodland Margins and Scattered Trees	71
Photograph 6.12	Grassland Habitat in the Study Area Containing Scattered	

List of Photographs

	Paddock Trees	74
Photograph 6.13	Grassland Habitat in the Minor Additional Mining Areas at Drayton Mine	74
Photograph 6.14	Aquatic Habitat along and within Saddlers Creek	76
Photograph 6.15	Industrial Dam at Drayton Mine	77
Photograph 6.16	Swift Parrot (Photo: D. Stojanovic, 2011)	83
Photograph 6.17	Brown Treecreeper (Photo: D. Stojanovic, 2011)	84
Photograph 6.18	Diamond Firetail (Photo: D. Stojanovic, 2011)	86
Photograph 6.19	Adult Grey-crowned Babbler (Photo: D. Stojanovic, 2011)	88
Photograph 6.20	Male Scarlet Robin (Photo: D. Stojanovic, 2011)	90
Photograph 6.21	Low-value Habitat at Site S1 along Saddlers Creek	117
Photograph 6.22	Low-value Habitat at Site S2 along Saddlers Creek	117
Photograph 6.23	Habitat Upstream of the Confluence of the Hunter River and Saddlers Creek	119
Photograph 6.24	Habitat at site H3 (Proposed Water Outflow Pipeline) along the Hunter River	120

Glossary of Terms

Anglo American	Anglo American Coal
AUSRIVAS	Australian Rivers Assessment System
BAP	Biodiversity Action Plan; a plan of management for onsite biodiversity, including the Project Disturbance Footprint
BBAM	BioBanking Assessment Methodology
BioBanking	A metric approach to assessing the biodiversity values of offset sites.
Biodiversity Credit	A unit measure used in BioBanking and the FBA to quantify biodiversity loss or gain
BOP	Biodiversity Offset Package
Box-Gum Woodland	CEEC listed under the EPBC Act and EEC listed under the TSC Act as <i>White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland</i> and White Box Yellow Box Blakely's Red Gum Woodland, respectively. Note that this refers collectively to both the woodland and grassland forms of the community.
BVT	Biometric Vegetation Type
CEEC	Critically Endangered Ecological Community
CHPP	Coal handling and preparation plant
DA	Development Application
DBH	Diameter at breast height
Deciduous (botanical)	Refers to the shedding of leaves at the end of a growing season
DoE	Commonwealth Department of the Environment
Dormancy (of seed)	Seed dormancy is defined as a state in which seeds are prevented from germinating even under environmental conditions normally favourable for germination. These conditions are a complex combination of water, light, temperature, gasses, mechanical restrictions, seed coats, and hormone structures.
DP&E	NSW Department of Planning and Environment (formerly the Department of Planning and Infrastructure)
DPI	NSW Department of Primary Industries
Drayton Mine	Drayton Mine is an operating coal mine in Coal Lease 229 and is managed by Anglo American. The mine commenced production in 1983 and predominately produces steaming coal for the export market at a maximum of 8 Mtpa of ROM coal
Drayton South	Proposed area for active mining operations in Exploration Licence 5460, including proposed associated infrastructure
Ecosystem Credit	A type of biodiversity credit that uses Biometric Vegetation Types as a

	surrogate measure of biodiversity value
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EP&A Act	NSW <i>Environmental Planning and Assessment Act 1979</i> (under which Development Consent for the Project is sought)
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
FBA	Framework for Biodiversity Assessment. This is the metric approach to biodiversity assessment that underpins the NSW Major Projects Biodiversity Offsets Policy (2014)
FM Act	<i>Fisheries Management Act 1994</i>
GDE	Groundwater Dependent Ecosystem
Germination (botanical)	Refers to the process by which a plant grows from a seed
GIS	Geographic Information System
GPS	Global Positioning System
HRSTS	Hunter River Salinity Trading Scheme
Hunter LLS	Hunter Local Land Services, formerly the Hunter-Central Rivers Catchment Management Authority
Inoculant	Used in this report to refer to the introduction of an infective agent (e.g. mycorrhizal fungi) into a plant to promote plant health
KTP	Key threatening process
LGA	Local Government Area
Locality	Land within 20 km radius of the Project Boundary
Microclimate	A microclimate is a local atmospheric zone where the climate differs from the surrounding area. The term may refer to areas as small as a few square metres (for example a garden bed) or as large as many square kilometres
Minor additional mining areas	Additional areas at Drayton Mine that will allow for additional mining through the existing industrial dam and to enable establishment of sustainable high walls in the East, North and South Pits
ML	Mining Lease
MNES	Matters of National Environmental Significance that are listed in the EPBC Act
Mtpa	Million tonnes per annum
MU	Map unit
Mycorrhizal fungal symbiont	Refers to a fungus that lives in association with the roots of a vascular plant. The mycorrhizal fungal symbiont often delivers benefits to the host plant in the form of minerals and nutrients such as phosphorus and nitrogen, whilst the plant provides the symbiont with relatively constant and direct access to carbohydrates, such as glucose and sucrose.
NP&W Act	<i>National Parks and Wildlife Act 1974</i>

NSW	New South Wales
OEH	NSW Office of Environment and Heritage, a division of the NSW Department of Premier and Cabinet (formerly the Department of Environment, Climate Change and Water)
PAC	NSW Planning Assessment Commission
PCT	Plant Community Type
PEA	Preliminary Environmental Assessment
PMST	EPBC Act Protected Matters Search Tool
Project Boundary	The Project Boundary encompasses all land required for the Project including the existing Drayton Mine, Drayton South and the transport corridor
Project Disturbance Footprint	The total area within the Study Area that will require clearing for mining and construction, and all infrastructure associated with the Project
Recruitment (botanical)	Refers to the successful establishment of new plants from seed, adding to the size of an existing population
ROM	Run of Mine. The raw coal extracted by methods of dragline and blasting
SEARs	Secretary's Environmental Assessment Requirements
SEPP 44	State Environmental Planning Policy No. 44 – Koala Habitat Protection
Species Credit	A type of biodiversity credit that represents threatened species values or their specific habitat
SSD	State Significant Development
Study Area	The Study Area comprises an overall area of approximately 4,572 ha and includes the proposed Drayton South disturbance footprint, the transport corridor, the Edderton Road realignment and water pipelines to the Hunter River. This area is the focus of the Biodiversity assessment report. The Study Area excludes the existing Drayton Mine as this area has been the focus of previous assessments
TEC	Threatened Ecological Community listed under the TSC Act and/or EPBC Act
the Project	The Drayton South Coal Project. This is the proposed extension of Drayton Mine and development of a 15 year open cut coal mining operation with associated infrastructure and services. Collectively encompasses Drayton Mine, Drayton South, the transport corridor which will link the two operational areas, the proposed Edderton Road realignment and water pipeline to the Hunter River. It also includes the minor additional mining areas at Drayton Mine
Threatened species	Flora and fauna listed under the TSC Act, EPBC Act and FM Act
TSC Act	NSW <i>Threatened Species Conservation Act 1995</i>
VIS	Vegetation Information System

Executive Summary

S1 Introduction

Cumberland Ecology was commissioned by Hansen Bailey on behalf of Anglo American Coal (Anglo American) to complete a biodiversity assessment report as part of the Environmental Impact Statement for the Drayton South Coal Project (the Project).

This biodiversity assessment aims to evaluate the impacts of the Project on biodiversity, particularly threatened species, populations and ecological communities protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), NSW *Threatened Species Conservation Act 1995* (TSC Act) and the NSW *Fisheries Management Act 1994*.

This biodiversity assessment report is required to be submitted with the Environmental Impact Statement and must apply the Framework for Biodiversity Assessment (FBA) to assess impacts on biodiversity. The scope of this biodiversity assessment includes:

- Addressing the Secretary's Environmental Assessment Requirements relating to ecology, issued on 19 December 2014;
- Describing and mapping vegetation communities, and identifying threatened vegetation communities protected under legislation;
- Identifying and mapping the location of threatened species protected under legislation;
- Assessing the likelihood that threatened species of flora and fauna could occur;
- Identifying and mapping key areas of habitat and corridors for fauna;
- Describing the types and extent of potential impacts arising from the Project;
- Assessing the impacts to threatened species, populations and ecological communities in accordance with Section 5A of the *Environmental Planning and Assessment Act 1979* and by applying the Framework for Biodiversity Assessment;
- Assessing impacts on Matters of National Environmental Significance listed under Commonwealth legislation;
- Identifying mitigation measures that will manage impacts on threatened species and areas of high conservation value; and
- Assessing residual impacts using the FBA methods.

S2 Project Background

Drayton Mine is located approximately 13 km south of the township of Muswellbrook in the Upper Hunter Valley of NSW. Drayton Mine is managed by Anglo Coal (Drayton Management) Pty Ltd which is owned by Anglo American. Drayton Mine commenced production in 1983 and currently holds Project Approval 06_0202 (dated 1 February 2008), which expires in 2017.

Drayton Mine runs out of coal in 2015, at which time the operation will have to close. The Project will allow for the continuation of the existing Drayton Mine for up to 15 years, by developing an open cut mining area within EL 5460. The Project will extract up to 7 Million tonnes per annum of export quality thermal coal by utilising existing Drayton Mine assets and infrastructure.

The Project was previously submitted for Project Approval under Part 3A of the *Environmental Planning and Assessment Act 1979* but was refused by the NSW Planning Assessment Commission.

The current Project addresses the reasons provided by the Planning Assessment Commission for the refusal of the previous application. The mine plan is defined by ridgelines nominated in the 'Drayton South Coal Project Planning Assessment Commission Review Report' for the previous application issued in December 2013. The Project will remain behind the ridgelines nominated by the Planning Assessment Commission. Significantly, this at least doubles the buffer setback distance from the Coolmore and Woodlands thoroughbred horse studs and is at least 2 km from the horse stud operational areas.

The current Project features a Project Disturbance Footprint of 1,441 ha, which represents a 25% reduction in mine footprint compared with the previous application. The current Project Disturbance Footprint of 1,441 ha includes approximately 1,438 ha of vegetated land.

S3 The Study Area

This biodiversity assessment report focuses on the Study Area, which is defined in this report as area of approximately 4,572 ha that includes the proposed Drayton South disturbance footprint, the transport corridor, the Edderton Road realignment and water pipelines to the Hunter River. The Study Area excludes the existing Drayton Mine, which was previously assessed by Hansen Bailey in 2007 as part of an ecology impact assessment for the Drayton Mine Extension Environmental Assessment.

As part of the current biodiversity assessment, minor additional mining areas comprising an overall area of approximately 37 ha at Drayton Mine were also assessed. These minor additional mining areas will allow for additional mining through an existing industrial dam at Drayton Mine, and enable the establishment of sustainable high walls in the East, North and South Pits. All other areas required to be utilised by the Project at Drayton Mine have been previously assessed and in most cases have been disturbed as part of the approved mining operations in this area.

S4 Methodology

S4.1 Desktop Study

Prior to field surveys, a desktop study was conducted to identify the key ecological attributes and issues of the Study Area and its surrounds. A comprehensive database of information relevant to the Study Area and surrounds exists as a result of numerous ecological studies conducted in the Hunter Valley region. This assessment considered published information gathered from numerous ecological studies completed for sites in the near vicinity of the Project including the Mt Arthur Coal Complex, Mount Pleasant, Drayton Mine, Bengalla Mine, Muswellbrook Coal and Bayswater B Power Station.

Relevant regional-scale vegetation mapping and was completed on behalf of the former Hunter-Central Rivers Catchment Management Authority (now the Hunter Local Land Services) was reviewed for this assessment. Other existing information on the biodiversity values of the Study Area and its surrounds were obtained through the Office of Environment and Heritage Atlas of NSW Wildlife database and Department of the Environment EPBC Act Protected Matters Search Tool.

The number and age of records of threatened species recorded within a 20 km radius of the Study Area was used to assess the likelihood of threatened species occurring. The EPBC Act Protected Matters Search Tool provides a list of Matters of National Environmental Significance that are predicted to occur based on the presence of suitable habitat, which was useful to guide threatened species searches during field surveys.

S4.2 Field Surveys

Extensive systematic surveys have been conducted of the Study Area and Drayton Mine in the past. Additional surveys were completed in between 2009 and 2015 by Cumberland Ecology as part of the current biodiversity assessment.

Field surveys included comprehensive flora, fauna and aquatic investigations over a range of seasons. Terrestrial surveys were conducted, where practicable, in accordance with accepted conventional guidelines and included floristic plot sampling, habitat assessments, targeted species searches, trapline surveys, nocturnal surveys and bat surveys (harp and Anabat). Biometric plot surveys were undertaken in recent years to comply with the Framework for Biodiversity Assessment methodology.

Aquatic assessments included visual assessments of the creekline environments, water quality sampling and analysis. The aquatic study was conducted in accordance with the methods prescribed in the Australian Rivers Assessment System.

S5 Results

S5.1 Condition of the Environment

The original character of the vegetation in the Study Area has been greatly altered as a result of historical and current land uses. The remnant forest and woodland now exist as scattered patches across the landscape, typically in gully and riparian areas that have historically been difficult to farm. These patches, although fragmented, occur in reasonable proximity of each other and form a relatively well-connected “stepping stone” corridor of vegetation across the local landscape. Some patches are large enough to provide reasonable interior habitat for native fauna and flora and these areas support a diversity of species in the understorey.

There are a few occurrences of old growth trees (i.e. trees that are greater than 90-100 years old) within the Study Area, particularly in association with deep gully lines. However, the majority of the remnant woodland is comprised of a mixture of relatively new regrowth, particularly of *Allocasuarina luehmannii* (Bulloak) and *Acacia salicina* (Cooba), and young but reproductively mature woodland (i.e. intact woodland of age between 40-90 years old). Scattered paddock trees that do not form woodland are also present across the Study Area.

The remainder of the Study Area is comprised of large areas of native pasture used for livestock grazing and smaller cultivated paddocks. The majority of the native pasture has been subject to low intensity grazing for a number of years and as such, supports a variable diversity of native groundcover species. Land to the west of Edderton Road is still being actively farmed. In general, vegetation in the Study Area to the west of Edderton Road is subject to greater grazing pressures and is more heavily modified than the vegetation to the east. The western part of the Study Area predominantly contains low diversity native grassland and cultivated areas.

The Study Area continues to support a suite of native flora and fauna species. Despite the history of clearing and intensive grazing, the area contains vegetation communities that are becoming increasingly significant in the Hunter region. Much of the Study Area shows resilience and capacity for woodland regeneration. If livestock are removed from native grassland and woodland margins, it is anticipated that such communities would readily regenerate from the existing seed bank.

The vegetation in the minor additional mining areas at Drayton Mine is highly modified and has been almost entirely cleared in the past. Infrastructure, such as a gravel-based erection pad and an industrial dam, and rehabilitated exotic grassland cover most of the minor additional mining areas and very little native vegetation remains. Much of the grassland areas are currently dominated by weeds and exotic pasture species.

S5.2 Vegetation Communities

Twelve vegetation map units (MUs) have been identified within the Study Area. The onsite extents of these MUs are summarised in **Table S.1**. The predominant vegetation unit within the Study Area is native grassland that has been derived from the clearing of the original woodland and forest communities. The native grassland unit is largely dominated by a

variety of native perennial grass and forb species but many exotic species are present as is typical of grazing lands. The majority of the remaining remnant woodland across the site is dominated by *Eucalyptus moluccana* (Grey Box) and comprises the community MU 5: Central Hunter Box-Ironbark Woodland.

Table S.1 Vegetation Map Units within the Study Area

Map Unit	Vegetation Map Unit name, as referred to in this Biodiversity Assessment Report	Legal Status ¹		Area of Vegetation (ha)	
		TSC Act	EPBC Act	Within Study Area	Within Disturbance Footprint
MU 1	Upper Hunter White Box-Ironbark Grassy Woodland	EEC	CEEC	93.6	3.8
MU 2	Upper Hunter White Box-Ironbark Grassy Woodland Derived Native Grassland	EEC	CEEC	159.2	2.7
MU 3	Hunter Floodplain Red Gum Woodland	EEC	CEEC	39.4	10.9
MU 4	Hunter Floodplain Red Gum Woodland Derived Native Grassland	EEC	CEEC	10.1	4.3
MU 5	Central Hunter Box-Ironbark Woodland	EEC	-	477.4	150.9
MU 6	Narrabeen Foothills Slaty Box Woodland	VEC	-	98.8	97.0
MU 7	Central Hunter Bullock Forest Regeneration	-	-	55.6	25.9
MU 8	Hunter Valley River Oak Forest	-	-	2.2	2.2
MU 9	Cooba Scrub	-	-	52.1	-
MU 10	Planted Vegetation	-	-	8.3	-
MU 11	Other Grassland – moderate/good condition	-	-	2,304.0	981.0
MU 12	Other Grassland – low condition	-	-	1,264.8	159.4
TOTAL (to nearest whole hectare)				4,565	1,438

¹As listed under the Schedules of the TSC Act and EPBC Act.

Key: EEC = endangered ecological community; CEEC = critically endangered ecological community; VEC = vulnerable ecological community

Several of the woodland communities in the Study Area conform to communities that are listed as threatened ecological communities (TECs) under the TSC Act and/or the EPBC Act. The majority of these vegetation communities conform to *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland* listed under the EPBC Act and the *White Box Yellow Box Blakely's Red Gum Woodland* listed under the TSC Act, herein collectively referred to as Box-Gum Woodland.

Other TECs recorded in the Study Area include *Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* and *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion*, which are both listed under the TSC Act.

The vegetation that occurs in the minor additional mining areas at Drayton Mine is dominated by rehabilitated exotic grasslands (**Table S.2**). A small area (0.4 ha) of woody regeneration conforms to *Hunter Lowland Redgum Forest*, which is a TEC listed under the TSC Act. This occurrence is highly modified and has little opportunities for recovery.

Table S.2 Vegetation Communities in the Minor Additional Mining Areas at Drayton Mine

Vegetation Community	Legal Status ¹		Area of Vegetation (ha)
	TSC Act	EPBC Act	
Acacia Revegetation Area	-	-	1.2
Other Grassland	-	-	7.4
Hunter Lowland Red Gum Forest	EEC	-	0.4
Exotic Grassland	-	-	10.2
TOTAL Vegetation			19
Industrial Dam	na	na	6.6
North Pit Erection Pad	na	na	2.6
Cleared Land	na	na	8.1
TOTAL Area			37

¹As listed under the Schedules of the TSC Act and EPBC Act.

Key: EEC = endangered ecological community

S5.3 Flora

Over 250 plant species were recorded in the Study Area, of which a high proportion is comprised of native species. Four threatened plant species listed under the TSC Act and/or the EPBC Act were recorded during surveys within the Study Area. These include:

- *Acacia pendula* (Weeping Myall) (Endangered Population in the Hunter catchment, TSC Act);
- *Eucalyptus camaldulensis* (River Red Gum) (Endangered Population in the Hunter catchment, TSC Act);
- *Cymbidium canaliculatum* (Tiger Orchid) (Endangered Population within the Hunter catchment (TSC Act); and
- *Diuris tricolor* (Pine Donkey Orchid) (Vulnerable, TSC Act and Endangered Population in the Muswellbrook LGA, TSC Act).

No threatened species were recorded in the minor additional mining areas at Drayton Mine. Due to the poor condition of these areas, none are likely to occur.

S5.4 Fauna

At least 176 fauna species have been detected within the Study Area. The faunal assemblage within the Study Area is dominated by a suite of bird species, and to a lesser extent, bats. Arboreal mammals were restricted to common and disturbance-adapted species such as possums. Small ground dwelling native fauna (mammals, reptiles and amphibians) are not as well represented within the Study Area. These trends may reflect the high degree of modification to the understorey habitat and general lack of forage and shelter, as well as the fragmented nature of the woodland present that may restrict movement.

Over the course of all surveys conducted in the Study Area, 21 threatened and / or migratory fauna species, comprising of 11 bird species and eight bat species, have been recorded (see **Table S.3**).

No threatened species were recorded in the minor additional mining areas at Drayton Mine. Due to the poor condition of the habitat in these areas, none are likely to occur.

Other threatened and migratory species are known to occur in the locality surrounding the Study Area and have potential to be impacted by the Project. These are discussed within the report.

Table S.3 Threatened Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status¹	
			TSC Act	EPBC Act
BIRDS				
Apodidae	<i>Hirundapus caudacutus</i>	White-throated Needletail	-	Mi, Ma
Accipitridae	<i>Circus assimilis</i>	Spotted Harrier	V	-
Accipitridae	<i>Hieraaetus morphinoides</i>	Little Eagle	V	-
Psittacidae	<i>Lathamus discolor</i>	Swift Parrot	E	E; Ma
Strigidae	<i>Ninox connivens</i>	Barking Owl	V	-
Meropidae	<i>Merops ornatus</i>	Rainbow Bee-eater	-	Mi, Ma
Climacteridae	<i>Climacteris picumnus</i>	Brown Treecreeper	V	-
Acanthizidae	<i>Chthonicola sagittata</i>	Speckled Warbler	V	-
Meliphagidae	<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater (eastern subspecies)	V	-
Pomatostomidae	<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler (eastern subspecies)	V	-
Petroicidae	<i>Petroica boodang</i>	Scarlet Robin	V	-
Petroicidae	<i>Melanodryas cucullata</i>	Hooded Robin	V	-
Estrildidae	<i>Stagonopleura guttata</i>	Diamond Firetail	V	-
BATS				
Emballonuridae	<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail-bat	V	-
Molossidae	<i>Mormopterus norfolkensis</i>	Eastern Freetail-bat	V	-
Vespertilionidae	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V
Vespertilionidae	<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing-bat	V	-
Vespertilionidae	<i>Myotis macropus</i>	Southern Myotis	V	-
Vespertilionidae	<i>Nyctophilus corbeni</i>	Greater Long-eared Bat	V	V
Vespertilionidae	<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V	-
Vespertilionidae	<i>Vespadelus troughtoni</i>	Eastern Cave Bat	V	-

¹As listed under the Schedules of the TSC Act and EPBC Act.

Key: V = Vulnerable; E = Endangered; Mi = Migratory; Ma = Marine

S5.5 Matters Requiring Further Consideration

The Secretary's Environmental Assessment Requirements for the Project nominate *Diuris tricolor* (Pine Donkey Orchid) and Box-Gum Woodland as 'Matters Requiring Further Consideration' under the Framework for Biodiversity Assessment. Additional information is provided within the biodiversity assessment report to address impacts on these matters.

S6 Biodiversity Impacts

The largest direct impact of the Project is the removal of native vegetation from the Study Area. Approximately 1,438 ha of vegetation comprising remnant and regenerating forest and woodland and large areas of open grassland with scattered trees will be removed from the Study Area over the life of the Project. The key impacts on native vegetation in the Study Area include:

- Approximately 22 ha of Box-Gum Woodland; comprising approximately 15 ha of woodland and approximately 7 ha of derived native grassland;
- Approximately 248 ha of other TECs listed under the TSC Act;
- Approximately 28 ha of other native vegetation not listed under legislation; and
- Approximately 1,140 ha of grassland not listed under legislation.

Most of the woodland and forest vegetation to be cleared from the Study Area comprises TECs that have been over-cleared in the Central Hunter region and are therefore locally significant. When it is considered that these communities have undergone a large decline across their range due to cumulative clearing and that less than a third of their original distribution remains today, the Project is considered to have a significant impact on these communities if no ameliorative or compensatory actions are undertaken.

In addition to the above, the native vegetation communities to be cleared from the Study Area currently provide habitat for a range of flora and fauna, including species listed as threatened or migratory under the TSC Act and/or the EPBC Act. Without any amelioration or compensatory measures, the Project will also have a significant impact on a number of threatened plants, woodland birds, hollow-dependent microchiropteran bats and migratory species such as the Swift Parrot (*Lathamus discolor*). Due to the potential impacts to Box-Gum Woodland, Swift Parrot (*Lathamus discolor*) and Greater Long-eared Bat (*Nyctophilus corbeni*); the Project has been declared a controlled action under the EPBC Act.

The proposed disturbance to the minor additional mining areas at Drayton Mine is considered unlikely to have a significant impact on Hunter Lowland Redgum Forest. The removal of 0.4 ha of this TEC represents less than 1% of the existing occurrence under conservation at Drayton Mine. It is a small, isolated and highly modified patch that has little prospects for recovery; its proposed removal is unlikely to place the community in the locality at risk.

The proposed disturbance to the minor additional mining areas at Drayton Mine is also unlikely to have a significant impact on flora and fauna habitat as these areas have been highly disturbed in the past and currently retain little value as habitat for flora and fauna, including threatened species.

The project will entail clearing some of the communities listed as probable GDEs, including approximately 11 ha of the 39 ha of Hunter Floodplain Red Gum Woodland; and all of the 2.2 ha of Hunter River Oak Forest. The potential indirect impacts on the remaining areas of potential GDE are unlikely to be significant because the Project is predicted to have a negligible impact on flows in Saddlers Creek and the Hunter River. The availability of water from creek flow, overland flow and within soil (rather than alluvium) is likely to be sufficient to sustain the vegetation within these two communities.

The Project is considered unlikely to have a significant impact on the health and water quality of Saddlers Creek or the Hunter River. Analysis of macroinvertebrate and water sample results indicates both water courses and their riparian and floodplain corridors are degraded and modified from the original condition. Both suffer from erosion; weed infestations; removal of important in-stream habitat features; and the effects of agriculture, either by trampling by cattle or close cropping.

S6.1 Biodiversity Credits

The direct impacts of the Project on biodiversity have been assessed by applying the Framework for Biodiversity Assessment and using the Credit Calculator to quantify the direct loss of biodiversity.

Under the Framework for Biodiversity Assessment, the Project will generate 15,333 Ecosystem Credits and 1,555 Species Credits for impacts to native vegetation, threatened species habitat and threatened species. The Project will need to implement offsetting measures that can address this credit liability in order to compensate for the residual impacts of the Project.

S6.2 Cumulative Impacts

The Hunter Valley region is the State's primary coal producing region. Multiple coal mining projects are already established, or proposed and seeking development approval, in close proximity to the Project (NSW Department of Planning, 2005). Each mine has a significant disturbance footprint and requires land for associated infrastructure.

When considered together with the Project, a high proportion of the surrounding locality will be subject to extensive mining within the next two to three decades. Based upon available information of mining developments within the vicinity of the Project, the combined impacts of mining from projects currently approved, as well as the Project would represent a minimum loss of 4,625 ha of native forest and woodland and derived native grassland. Approximately 913 ha of this vegetation is Box-Gum Woodland. Another 805 ha of other threatened vegetation will be removed.

Without any amelioration, the Project would contribute to the cumulative impact on Box-Gum Woodland as listed under the TSC Act and the EPBC Act. It would also impact significantly on threatened woodland birds and hollow-dependent microchiropteran bats within the locality including the Swift Parrot and the Greater Long-eared Bat.

S7 Impact Mitigation

A number of amelioration measures have been designed to minimise the ecological impacts of the Project. The approach is based upon the following hierarchy of principles of avoidance, mitigation and compensation:

- **Avoid:** developments should be designed to avoid or minimise ecological impacts, where possible;
- **Mitigate:** where certain impacts are unavoidable through design changes, mitigation measures should be introduced to ameliorate the ecological impacts of the proposed development; and
- **Compensate:** the residual impacts of the Project, following the implementation of mitigation measures, should be compensated for in some way to offset what would otherwise be a net loss of habitat.

S7.1 Avoidance

The Project conceptual mine plan has undergone a number of major revisions since its inception. The current mine layout is the minimum practical disturbance area and has been designed to be in close proximity to Drayton Mine to allow for the utilisation of existing infrastructure. Although limiting the utilisation of the coal resource, the current mine layout has been significantly reduced from the previous application to increase the buffer distance between the Project and the horse stud properties located to the south. The conceptual mine plan also addresses the reasons provided by the Planning Assessment Commission for the refusal of the previous Drayton South application, with all proposed open cut mining areas located entirely within the extent of mining recommended by the Planning Assessment Commission in 2013.

The 25% reduction in the Project Disturbance Footprint from the previous Drayton South application correspondingly reduces the impacts on biodiversity, including impacts on TECs and threatened species. The revisions to the Project Disturbance Footprint has enabled the Project to avoid approximately 490 ha of vegetation and habitat for threatened species (comprising approximately 159 ha Box-Gum Woodland, 31 ha other TECs and 300 ha of non-listed vegetation). Construction of Project infrastructure and mining areas will be conducted progressively in conjunction with rehabilitation, to spread the disturbance over time and thus to minimise the loss of vegetation at any particular point in time.

The current conceptual mine plan balances the impacts on the surrounding environment with the continued provision of social and economic benefits currently generated by Drayton Mine to the wider community, and delivers a Project that is in the public interest.

S7.2 Mitigation Measures

The mitigation measures proposed for the Project are focussed around the following key objectives:

- To minimise vegetation and habitat loss where practicable;
- To protect threatened species that are known to occur onsite;
- To progressively rehabilitate and restore native vegetation over the life of the Project; and
- To implement a monitoring programme to track the progress of mitigation and rehabilitation activities.

These mitigation measures will be implemented in accordance with a Biodiversity Action Plan that will enable Anglo American to enact the ‘avoid and mitigate’ principles during the construction and operation of the mine. The Biodiversity Action Plan is the key document that will ensure that the Project’s conservation objectives are met for mitigation works to be completed onsite and that impacts to biodiversity are adequately managed for the life of the Project.

The Biodiversity Action Plan is intended to be a working document that guides all facets of biodiversity management and biodiversity mitigation for the Project, and will include clear objectives and actions. The Biodiversity Action Plan will specify what measures will be undertaken, how they will be undertaken, and will provide a timeline to ensure that all activities are conducted according to the plan. The Biodiversity Action Plan will provide key performance indicators against which to measure progress and will specify appropriate review periods where progress is reviewed and the document updated as required.

S7.3 Compensatory Measures

Anglo American is committed to delivering a substantial offsetting strategy that addresses the residual impacts of the Project. The Project adopts a “maintain or improve” approach to offsetting; this means that the offsetting strategy will aim to achieve no net loss of biodiversity values, including the area and condition of habitat for fauna, over the life of the Project.

The offset strategy will be focussed on the protection, restoration and maintenance of onsite and offsite conservation lands and will be prepared in accordance with Anglo American’s internal Biodiversity Performance Standard (2011), which is consistent with the “maintain or improve” approach as it requires that:

- The target of no net biodiversity loss or net positive contribution to biodiversity is to be considered at the operational level based on the biodiversity risk and/or opportunity posed to the business;

- Operational biodiversity action plans should be aligned with National Biodiversity Frameworks and take cognisance of regional and/or local conservation planning frameworks where these exist; and
- Where there is the potential for significant adverse or positive impacts on biodiversity the implications of this risk and/or opportunity facing the operation needs to be assessed and the extent of the risk or opportunity translated into a business case for biodiversity management.

The offsetting strategy is described and discussed in the EIS biodiversity offset strategy report, which has been prepared to support the EIS.

S8 Conclusion

Despite the impacts of past agriculture, the Project would have a substantial impact on the ecology of the local area. If no mitigation and compensation measures were proposed, it would result in the net loss of 1,438 ha of vegetation comprising approximately 291 ha of native forest and woodland and 1,147 ha of grassland vegetation from the Study Area, which includes 22 ha of Box-Gum Woodland and 248 ha of other TECs listed under the TSC Act.

Most of the vegetation proposed to be cleared from the Study Area comprises TECs that have been over-cleared in the Central Hunter region and are therefore locally significant. When it is considered that these communities have undergone a large decline across their range due to cumulative clearing and that less than a third of their original distribution remains today, the Project is considered to have a significant impact on TECs if no ameliorative or compensatory actions are undertaken. The vegetation that is proposed to be cleared from the Study Area also provides habitat for a range of threatened species. A total of 21 threatened and/or migratory fauna species and four threatened flora species listed under the TSC Act and/or EPBC Act were recorded or are likely to occur within the Study Area.

In recognition of the potential ecological impacts of the Project, Anglo American will implement a series of mitigation measures to ameliorate the impacts of the Project. Anglo American is committed to delivering a substantial offsetting strategy that addresses the residual impacts of the Project. The Project adopts a “maintain or improve” approach to offsetting; this means that the offsetting strategy will aim to achieve no net loss of biodiversity values, including the area and condition of habitat for fauna, over the life of the Project.

Chapter 1

Introduction

1.1 Background

Drayton Mine is located approximately 13 km south of the township of Muswellbrook in the Upper Hunter Valley of NSW (see **Figure 1**). Drayton Mine has been operating in the Muswellbrook community for over 30 years and runs out of coal in 2015. Cumberland Ecology was commissioned by Hansen Bailey on behalf of Anglo American Coal (Anglo American) to complete a biodiversity assessment report as part of the Environmental Impact Statement (EIS) for the Drayton South Coal Project (the Project).

The Project will allow for the continuation of the existing Drayton Mine for up to 15 years, by developing an open cut mining area within EL 5460. The Project will extract up to 7 Million tonnes per annum (Mtpa) of export quality thermal coal by utilising existing Drayton Mine assets and infrastructure.

The Project was previously submitted for Project Approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) but was refused by the NSW Planning Assessment Commission (PAC).

The current Project addresses the reasons provided by the PAC for the refusal of the previous application. The mine plan is defined by ridgelines nominated in the 'Drayton South Coal Project PAC Review Report' for the previous application issued in December 2013. The Project will remain behind the ridgelines nominated by the PAC. Significantly, this at least doubles the buffer setback distance from the Coolmore and Woodlands thoroughbred horse studs and is at least 2 km from the horse stud operational areas.

1.2 Purpose

This biodiversity assessment aims to evaluate the impacts of the Project on biodiversity, particularly threatened species, populations and ecological communities protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), New South Wales (NSW) *Threatened Species Conservation Act 1995* (TSC Act) and the NSW *Fisheries Management Act 1994* (FM Act).

This biodiversity assessment report is required to be submitted with the EIS and must apply the Framework for Biodiversity Assessment (FBA) to assess impacts on biodiversity. The FBA requires that proposed offsets are assessed using the BioBanking Assessment

Methodology (BBAM). The assessment of offsets proposed for the Project is covered in the EIS biodiversity offset strategy report.

The scope of this biodiversity assessment includes:

- Addressing the Secretary's Environmental Assessment Requirements (SEARs) relating to ecology, issued on 19 December 2014;
- Describing and mapping vegetation communities, and identifying threatened vegetation communities protected under legislation;
- Identifying and mapping the location of threatened species protected under legislation;
- Assessing the likelihood that threatened species of flora and fauna could occur;
- Identifying and mapping key areas of habitat and corridors for fauna;
- Describing the types and extent of potential impacts arising from the Project;
- Assessing the impacts to threatened species, populations and ecological communities in accordance with Section 5A of the EP&A Act and by applying the FBA;
- Assessing impacts on Matters of National Environmental Significance (MNES) listed under Commonwealth legislation;
- Identifying mitigation measures that will manage impacts on threatened species and areas of high conservation value; and
- Assessing residual impacts using the FBA methods.

1.3 The Study Area

This biodiversity assessment report focuses on the Study Area, which is defined in this report as area of approximately 4,572 ha that includes the proposed Drayton South disturbance footprint, the transport corridor, the Edderton Road realignment and water pipelines to the Hunter River. The Study Area excludes the existing Drayton Mine, which has been previously assessed by Hansen Bailey (2007) as part of an ecology impact assessment for the Drayton Mine Extension Environmental Assessment.

As part of the current biodiversity assessment, minor additional mining areas comprising an overall area of approximately 37 ha at Drayton Mine were also assessed. These minor additional mining areas will allow for additional mining through an existing industrial dam at Drayton Mine, and enable the establishment of sustainable high walls in the East, North and South Pits. All other areas required to be utilised by the Project at Drayton Mine have been previously assessed and in most cases have been disturbed as part of the approved mining operations in this area.

1.4 Report Structure

The remainder of this assessment is structured as follows:

- **Chapter 2** Legislative Framework;
- **Chapter 3** Project Description;
- **Chapter 4** Description of the Existing Environment;
- **Chapter 5** Assessment Methods;
- **Chapter 6** Assessment Results;
- **Chapter 7** Project Impacts;
- **Chapter 8** Measures to Avoid and Mitigate Impacts;
- **Chapter 9** Assessment of Residual Impacts;
- **Chapter 10** Compensatory Measures; and
- **Chapter 11** Assessment Conclusions.

1.5 Related Studies

The studies that are to be read in conjunction with this assessment include the following:

- The EIS biodiversity offset strategy report;
- The EIS stygofauna impact assessment;
- The EIS agricultural impact statement;
- The EIS surface water impact assessment;
- The EIS groundwater impact assessment; and
- The EIS soil and land capability impact assessment.

Chapter 2

Legislative Framework

2.1 Commonwealth Legislation and Policies

2.1.1 *Environmental Protection and Biodiversity Conservation Act 1999*

Under the EPBC Act, any action (which includes a development, project or activity) that is considered likely to have a significant impact on MNES (including nationally threatened ecological communities [TECs], species and listed migratory species) must be referred to the Commonwealth Department of the Environment (DoE). The purpose of the referral is to allow a decision to be made about whether an action is a “controlled action” and requires approval on a Commonwealth level.

The Project was referred to the Commonwealth Minister for the Environment in December 2014. Following submission of the referral the Minister for the DoE declared the Project to be a controlled action under section 75 of the EPBC Act due to likely impacts on the following MNES:

- Listed threatened species and communities; and
- A water resource, in relation to coal seam gas development and large coal mining development.

The Project will be assessed under the terms of the bilateral agreement between the Commonwealth and NSW governments relating to environmental assessment (the assessment bilateral agreement). For this reason, this biodiversity assessment report assesses the potential impacts on MNES; a summary of the assessment of MNES is provided in **Appendix A** of this report.

2.1.2 Environmental Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (2012)

The Commonwealth Government adopted the EPBC Act Environmental Offsets Policy in October 2012, which replaces the draft policy statement *Use of environmental offsets under the EPBC Act (2007)*.

The EPBC Act offsets policy outlines the Government's approach to the use of environmental offsets under the EPBC Act and relates to all MNES. The EPBC Act offsets policy applies to offsetting requirements in terrestrial and aquatic (including marine) environments.

The EPBC Act offsets policy allows for 90% of offsetting requirements to be addressed by direct offsets and the remaining 10% to be addressed by indirect offsets.

2.2 State Legislation and Policies

2.2.1 Environmental Planning and Assessment Act 1979

The EP&A Act is the overarching planning legislation in NSW. This act provides for the creation of planning instruments that guide land use. The EP&A Act also provides for the consideration of the environment and biodiversity values, which is addressed in Section 5A (Significant effect on species, populations or ecological communities or their habitats). This includes threatened species, communities, habitat and processes as listed under the TSC Act and FM Act.

The Project is classed as a State Significant Development (SSD) under Division 4.1 of the EP&A Act and so the Development Application (DA) must be accompanied by an EIS. The EIS is to be prepared in accordance with SEARs issued from the Department of Planning and Environment (DP&E).

The SEARs for the Project were issued on 19 December 2014. This biodiversity assessment report, which forms a component of the EIS, has been prepared in accordance with the SEARs concerning biodiversity. The SEARs require that for biodiversity, the EIS must include:

An assessment of the likely biodiversity impacts of the development, having regard to the NSW Biodiversity Offsets Policy for Major Projects and OEHS [the Office of Environment and Heritage] requirements.

The OEH requirements submitted to DP&E have nominated the following as Matters Requiring Further Consideration:

- Pine Donkey Orchid (*Diuris tricolor*), which is listed by the TSC Act as a threatened species and an endangered population in the Muswellbrook local government area (LGA); and
- *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland* critically endangered ecological community (CEEC) listed under the EPBC Act and the *White Box Yellow Box Blakely's Red Gum Woodland* endangered ecological community (EEC) listed under the TSC Act, herein collectively referred to as the Box-Gum Woodland.

The biodiversity assessment report is required to provide additional information in accordance with Section 9.2 of the FBA (OEH, 2014b).

2.2.2 Threatened Species Conservation Act 1995

The TSC Act is the key piece of legislation in NSW relating to the protection and management of biodiversity and threatened species. The TSC Act aims to protect and encourage the recovery of threatened species, populations and communities that are listed under the TSC Act through threat abatement and species recovery programs.

The TSC Act requires consideration of whether a development (Part 4), an activity (Part 5) or a SSD (Division 4.1) is likely to significantly impact threatened species, populations, communities or their habitat. The potential impacts of any developments, land use changes or activities would need to undergo an "Assessment of Significance" under Section 5A of the EP&A Act.

2.2.3 Fisheries Management Act 1994

Threatened species legislation in NSW consists of both the FM Act, and the TSC Act. The FM Act deals with threatened fish and marine vegetation and associated threatening processes and is administered by the NSW Department of Primary Industries (DPI). The TSC Act deals with all other threatened biota and threatening processes in the State and is administered by the OEH. Under the FM Act, "fish" means marine, estuarine or freshwater fish or other aquatic animal life at any stage of their life history and includes molluscs, crustaceans, echinoderms, beach worms and other polychaetes.

2.2.4 NSW Biodiversity Offsets Policy for Major Projects (2014)

The NSW Biodiversity Offsets Policy for Major Projects was adopted in September 2014 and applies to SSD and State Significant Infrastructure (SSI).

The NSW offsets policy is underpinned by the FBA, which is an assessment approach that standardises the methods and procedures for assessing biodiversity impacts on development sites and determining biodiversity offsets for those impacts. The FBA is supported by the Credit Calculator, which is a web based decision tool that quantifies impacts using Biodiversity Credits as a unit measure.

The FBA requires that the BioBanking Credit Calculator is used by an accredited assessor acting for the proponent, to assess and quantify the biodiversity values of an offset site. The BioBanking Credit Calculator also uses Biodiversity Credits as a unit measure.

The NSW offsets policy will be implemented for a transitional period of 12-18 months from the 1 October 2014. During this period, proponents and the consent authority will apply the NSW offsets policy to new major projects and certain existing projects in consultation with stakeholders. There will be some flexibility in the policy's application to address any technical or administrative issues.

If application of the NSW offsets policy or the FBA results in perverse outcomes that do not reflect the intentions of the policy, the consent authority may vary the application of the policy or FBA to address the issues.

After the transitional implementation period is lapsed, it is intended that legislative change will be made to formalise the approach to biodiversity assessment and offsetting in the planning approval process, which is described below.

As the FBA applies predominantly to terrestrial biodiversity, the NSW offsets policy and FBA refers to the DPI *Policy and Guidelines for Fish Habitat Conservation and Management (2013)* for guidance on assessing and offsetting aquatic impacts.

The DPI policy and guidelines state that the aim of aquatic habitat assessments should be to define the presence of 'key fish habitat' within and around the impact site and then to determine the impacts on such habitats that could arise from the development by considering a number of different factors. The DPI key fish habitat map for the Muswellbrook LGA indicates that Saddlers Creek and the Hunter River are considered to be key fish habitat.

For aquatic fauna assessments, a site inspection and desktop review may be sufficient for sites where fish and/or other aquatic fauna are well documented, and no threatened species are recorded.

2.2.5 SEPP 44 – Koala Habitat Protection

Schedule 1 of NSW *State Environmental Planning Policy 44 – Koala Habitat Protection* (SEPP 44) identifies Muswellbrook and Singleton as LGAs to which this planning instrument applies (Department of Planning, 1995). In accordance with SEPP 44, it must be ascertained whether the Study Area contains potential koala habitat; if so, whether the Study Area then contains core koala habitat. The SEPP defines potential and core koala habitat as follows:

- "Potential koala habitat" means areas of native vegetation where the trees of the types listed in Schedule 2 (Koala Feed Trees – see **Table 2.1**) constitute at least 15% of the total number of trees in the upper or lower strata of the tree component; and
- "Core koala habitat" means an area of land with a resident population of koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population.

Table 2.1 Koala Feed Trees (Schedule 2 of SEPP 44)

Scientific Name	Common Name
<i>Eucalyptus tereticornis</i>	Forest red gum
<i>Eucalyptus microcorys</i>	Tallowwood
<i>Eucalyptus punctata</i>	Grey Gum
<i>Eucalyptus viminalis</i>	Ribbon or manna gum
<i>Eucalyptus camaldulensis</i>	River Red Gum
<i>Eucalyptus haemastoma</i>	Broad leaved scribbly gum
<i>Eucalyptus signata</i>	Scribbly gum
<i>Eucalyptus albens</i>	White box
<i>Eucalyptus populnea</i>	Bimble box or poplar box
<i>Eucalyptus robusta</i>	Swamp mahogany

In addition to SEPP 44, a NSW Recovery Plan for the Koala has been prepared and is described below.

i. NSW Recovery Plan for the Koala

In addition to the SEPP, a State-wide Koala Recovery Plan (DECC (NSW), 2008b) has been prepared that details the current status of koalas and outlines the actions that are required to aid the recovery of the species. The recovery plan identifies the loss and degradation of habitat as being the most significant threat to the species, particularly those that are associated with agriculture and urban expansion.

ii. Assessing Koala Habitat

The recovery plan provides definitions for the categorisation of koala habitat based on the presence and abundance of known food tree species. The categorisation of koala habitat serves to aid the assessment of koala habitat value by ranking koala habitat as primary, secondary (Class A, B, C) or tertiary koala habitat. Categorisation of habitat follows that outlined by Phillips (Phillips *et al.*, 2000).

The recovery plan defines different management regions within NSW called Koala Management Areas (KMA) for which typical primary, secondary and supplementary koala food tree species are listed. No Koala Plan of Management exists for either of the Muswellbrook and Singleton LGAs.

Chapter 3

Project Description

The current Project features a Project Disturbance Footprint of 1,441 ha, which represents a 25% reduction in mine footprint compared with the previous application. The current Project Disturbance Footprint of 1,441 ha includes approximately 1,438 ha of vegetated land.

The Project generally includes:

- Continuation of operations at Drayton Mine as currently approved with minor additional mining within the existing East, North and South Mining Areas for a period of 15 years;
- Development of a new open cut mining area with EL 5460 mining up to 6.4 Mtpa Run-Of-Mine (ROM) coal;
- Ongoing employment of a workforce of up to 500 full time equivalent employees;
- Utilisation of the existing Drayton Mine equipment fleet;
- Storage of water, and emplacement of tailings and rejects generated by the Project in existing Drayton Mine voids;
- Utilisation of the existing Drayton Mine infrastructure including the CHPP, rail loop and associated infrastructure, workshops, bath houses and administration offices;
- Construction of a transport corridor to the new mining area;
- Continued utilisation of the Antiene Rail Spur off the Main Northern Railway Line to transport product coal to the Port of Newcastle for export;
- Realigning and upgrading a section of Edderton Road;
- Continuation of mutually beneficial arrangements with neighbours Macquarie Generation and Mt Arthur Coal Mine;
- Installation of further water management and power reticulation infrastructure to support the new mining areas; and
- Progressive rehabilitation of disturbed areas as mining operations are completed.

Figure 2 illustrates the conceptual layout of the Project.

Figure 3 illustrates the minor additional mining areas at Drayton Mine. These will allow for additional mining through an existing industrial dam at Drayton Mine, and enable the establishment of sustainable high walls in the East, North and South Pits.

Chapter 4

Existing Environment

4.1 Regional Context

4.1.1 *Bioregion*

The Study Area is located within the Hunter sub-region of the Sydney Basin Bioregion, a large area that encompasses approximately 3,624,008 ha of the central east coast of NSW (OEH, 2011b). A significant proportion of the Hunter River catchment is included within this bioregion.

The Sydney Basin Bioregion is one of the most diverse bioregions in Australia as a result of the variation in geology, topography and climate. The Hunter Valley is distinctive from the elevated sandstone plateaus and escarpments that form much of the bioregion. Due to the lower topography that extends through the ranges, the Hunter Valley has, for millennia, acted as a conduit to facilitate the convergence and exchange of coastal and inland biota, resulting in a number of unique intergrade communities (Peake, 2006; OEH, 2011b). The region is therefore influenced by adjacent bioregions, including the NSW North Coast, the Brigalow Belt South and the NSW South Western Slopes which result in unique environments and biodiversity (DEC, 2005).

The region would have once supported extensive areas of grassy eucalypt woodlands and open forests, however as a consequence of highly arable soils a substantial proportion of the region was historically cleared of its native vegetation for agricultural use such as dairy farming, crop farming, cattle, horse breeding and viticulture. The contemporary Hunter Valley landscape is highly modified because the region continues to support the agricultural industry as well as mining and support industries. Remnant vegetation in the Hunter Valley is now typically separated by grassland, urban areas or cropland (Peake, 2006).

4.1.2 *NSW (Mitchell) Landscapes*

The majority of the Study Area is located within the Central Hunter Foothills Mitchell landscape. Remaining areas of the Study Area are located within the Upper Hunter Channels and Floodplain landscape and the Hunter River Basalts landscape. A description of these Mitchell landscapes are taken from Mitchell (2002) and reproduced below:

i. *Central Hunter Foothills*

Undulating lowlands, rounded to steep hills with rock outcrop on ridges on Permian lithic sandstone, conglomerate, shale and coal, general elevation 40 to 300m with a few higher peaks, local relief 30 to 120m. Red-brown to yellow brown harsh texture-contrast soils on slopes, dark coloured clays in valleys and limited accumulations of sand and gravel in streams. Woodlands to open forest of *Corymbia maculata* (Spotted Gum), *Eucalyptus tereticornis* (Forest Red Gum), *Eucalyptus crebra* (Narrow-leaved Ironbark), *Eucalyptus sideroxylon* (Red Ironbark), *Eucalyptus albens* (White Box), *Eucalyptus dawsonii* (Slaty Box), *Angophora floribunda* (Rough-barked Apple) with *Themeda triandra* (Kangaroo Grass) and *Austrodanthonia* sp (Wallaby Grass).

ii. *Upper Hunter Channels and Floodplain*

Channel, floodplain and terraces of the Hunter River and its tributaries upstream of Denman on Quaternary alluvium, general elevation 100 to 200m, local relief 25m. Harsh yellow brown texture-contrast soils on the third terrace, gradational sandy loam on the second terrace and loamy sand on the low terrace and floodplain. Limited areas of Tertiary river gravels on bedrock spurs. Open grassland with *Eucalyptus albens* (White Box), *Eucalyptus melliodora* (Yellow Box), *Eucalyptus blakelyi* (Blakely's Red Gum), *Angophora floribunda* (Rough-barked Apple) and patches of *Casuarina glauca* (Swamp Oak) on brackish and saline flats, *Casuarina cunninghamiana* (River Oak) along the streams.

iii. *Hunter River Basalts*

Limited areas of Tertiary basalt caps forming flat-topped or low rounded hills, general elevation 60 to 180m. Red-brown well-structured stony loam, dark cracking clays often with linear gilgai patterns. Open grassy woodland of *Eucalyptus albens* (White Box), *Eucalyptus melliodora* (Yellow Box), *Eucalyptus laevopinea* (Silvertop Stringybark), *Eucalyptus tereticornis* (Forest Red Gum) and *Allocasuarina leuhmannii* (Bulloak).

4.1.3 *Conservation Reserves*

A number of significant conservation areas that are managed as national parks and nature reserves are located within the Upper Hunter region which encompasses the Upper Hunter, Muswellbrook and Singleton Shires (Fitzgerald and Wilkinson, 2009). The closest conservation areas to the Project are Wollemi National Park, 6 km to the south, the largest reserve in the bioregion at 501,703 ha, and Ravensworth Conservation Reserve to of the Study Area. Yengo (154,328 ha), Goulburn River (72,296 ha), Mt Royal (6,920 ha) and Barrington Tops (74,567 ha) National Parks are also within the Hunter sub-bioregion.

Wollemi National Park is a substantial conservation area within the Project locality (20 km radius of the Project Boundary). It provides extensive protected habitat and is known to support a number of flora and fauna species also recorded within the Study Area. It is located in the Hunter River catchment at the junction of two distinct subregions (Hunter and Wollemi). The park is characterised by a unique mix of geologies, vegetation communities and fauna diversity as a result of this convergence of species that are typically endemic to the separate bioregions (OEH, 2011b).

A number of fauna populations lie towards the limit of their known range and ecological tolerance within the national park; this can influence their distribution and dispersal into the wider locality.

Comprehensive surveys have been undertaken in Wollemi National Park (DEC, 2005) which have recorded:

- High native vertebrate diversity with over 320 fauna species recorded;
- At least 33 fauna listed under the EPBC Act and/or TSC Act;
- A number of threatened species largely associated with grassy Box woodlands on fertile slopes and valleys including:
 - Woodland birds - Black-chinned Honeyeater (eastern subspecies) (*Melithreptus gularis* subsp. *gularis*); Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis* subsp. *temporalis*); Diamond Firetail (*Stagonopleura guttata*); Speckled Warbler (*Chthonicola sagittata*); Brown Treecreeper (eastern subspecies) (*Climacteris picumnus* subsp. *victoriae*); Regent Honeyeater (*Anthochaera phrygia*); Hooded Robin (south-eastern form) (*Melanodryas cucullata* subsp. *cucullata*);
 - Barking Owl (*Ninox connivens*);
 - Squirrel Glider (*Petaurus norfolcensis*); and
 - Greater Long-eared Bat (*Nyctophilus corbeni*).

4.2 Climate

The Hunter region generally experiences warm, temperate climate conditions. Summer months are typically hot and humid, with average maximum temperatures of 31.7°C. Severe thunderstorms are common in summer and rainfall is high, averaging 641.7 mm per annum (Jerrys Plains). Winter months are mild, cool and dry, with low rainfall and minimum temperatures averaging 17.1°C (Bureau of Meteorology, 2015).

4.3 Topography

The region is characterised by undulating terrain with broad crests and wide valleys, gullies, a meandering river system on a wide flood plain (OEH, 2011b) and piedmonts, the transition zone between plains and low relief hills to adjacent mountains.

The western portion of the Study Area is generally flat or gently undulating. The landscape becomes progressively steep with a greater frequency of features such as gullies, creeks and pond chains toward Plashett Dam on the eastern boundary.

The topographic elevation ranges from approximately RL 100 m near the Hunter River to RL 200 m at a ridgeline that dissects the Study Area. The land adjacent to Saddlers Creek is flat but becomes undulating to hilly moving away from the creekline with slope gradients increasing to between 20% and 30%.

4.4 Geology

The Hunter Valley is characterised by a complex of Permian shales, sandstones, conglomerates, volcanics and coal seams (OEH, 2011b). The region is bounded to the north by the Hunter Thrust fault and to the south by Narrabeen Group sandstone outcrops and cliffs, which form high plateaus. Beneath the Study Area lies weathered bedrock and coal seams from the late Permian Upper Coal measures, which incorporates the Wittingham Coal Measures. This geological feature is the major coal producing unit in the region and extends below Muswellbrook, Denman and Singleton (DEC, 2005; NSW Department of Planning, 2005).

The Project sits above a Permian coal seam sequence that is overlain by thin Quaternary alluvial deposits. The relatively shallow and extensive Permian geology means coal resources are generally easy to access and thus economically feasible to mine. The Quaternary alluvial and colluvial deposits consist of sand and gravel, and occur along parts of Saddlers Creek and Saltwater Creek.

4.5 Soils and Land Capability

The Study Area is characterised by geochemically benign sodic soils which have a limited top soil profile, light to medium clay content and moderate fertility. The *1:250,000 Singleton Soil Landscape Series Sheet* (SI 56-1) indicates that the soils in the majority of the Study Area are characterised by the Brays Hill soil landscape. Land in the north west of the Study Area associated with Saddlers Creek and its tributaries are underlain by soils of the Bayswater landscape grouping.

The soils are generally structurally unstable, skeletal and shallow, and are subject to dispersion when wet. These natural properties generally produce highly erodible soils (Harpstead *et al.*, 2001), particularly along tracks and ephemeral drainage lines. In the Study Area, the effects of erosion are compounded by the removal of ground vegetation and root systems that would typically bind soil particles together, and by continued grazing and hoof damage.

Historically, farmers managing the land within the Study Area have established contour banks and swales to control soil erosion. Where contours and soil grading have occurred, the horizons of the original soil profile have been mixed and the seed banks have been degraded, resulting in lower diversity vegetation.

In accordance with the NSW rural land capability assessment system, *Systems Used to Classify Rural Lands in New South Wales* (Cunningham *et al.*, 1988), the Study Area is primarily composed of Class VI and Class VII land, with a portion of Class IV and Class V

land running in parallel with Saddlers Creek. The majority of the land is generally associated with gradual to moderate slopes, erosion, acidification, salinisation, loss of organic matter, decline in soil structure and poor drainage conditions making the area suitable only for livestock grazing. Further details can be obtained from the EIS soil and land capability impact assessment.

4.6 Hydrology

4.6.1 Saddlers Creek

The Study Area lies within the Saddlers Creek catchment, which is part of the larger Hunter River catchment area (13,400 km²). Other sub-catchments within or in the vicinity of the Study Area include those associated with Plashett Dam (approximately 800 ha and also known as Saltwater Creek), Whites Creek, Fairford Creek, Parnell Creek and some smaller, unnamed creeks.

The hydrological regime of the Study Area and surrounds consists of:

- A Quaternary alluvial aquifer system associated with the Hunter River and tributary creeks and a smaller alluvial system associated with Saddlers Creek and minor tributaries;
- A thin veneer of weathered bedrock (regolith); and
- The coal seams of the Permian Wittingham Coal Measures.

The Hunter River alluvium contains a basal gravel layer whilst the upper section of the alluvium is predominantly silt with minor portions of clay. In comparison, all of the Saddlers Creek alluvium, which is relatively thin, has a clay dominated composition. The groundwater quality of the alluvial aquifers is variable with the poorest quality water in the basal sections due to discharge from the underlying coal seam aquifers (AGE, 2012).

4.6.2 Hunter River

The Hunter River is the major watercourse of the Hunter Valley region and lies immediately to the south of the Study Area, flowing from west to east towards the coast near Newcastle. The Hunter River is also fed by numerous tributaries including Saddlers Creek. Consequently, the health of each watercourse intercepting the Hunter River in turn affects the health of the entire aquatic system.

The Hunter River flow regime is regulated by upstream dams, including Glenbawn Dam, which has the largest water storage capacity in the region. This system accounts for the majority of the Hunter River catchment and creates a consistent supply of water for domestic, industrial (including mining), environmental and agricultural (including irrigation and stock-watering) activities (SEWPaC 2009). The Hunter River is also fed by numerous tributaries including Saddlers Creek. Consequently, the health of each watercourse intercepting the Hunter River in turn affects the health of the entire aquatic system. Regulation and water extraction from the Hunter River has resulted in the alteration of

natural geomorphology characterised by old alluvial or floodplain terraces (Brierley *et al.*, 2005; Fryirs *et al.*, 2009) and disrupted flow regimes.

4.7 Land Use

Large-scale, open cut coal mines are well established across the Hunter Valley landscape and have significantly altered the natural landform of the region. The fertile soils in this area also support viticulture and agriculture, including thoroughbred horse breeding, commercial dairy farming and grazing. The current dominant land uses within and adjacent to the Study Area include thoroughbred horse breeding, viticulture, agriculture, cattle grazing, industrial activities such as open cut coal mining and power generation and rural residential areas.

Land within the Study Area has been highly modified, having been extensively cleared for grazing purposes and pasture improvement or cropping. As a result, few remnant trees exist. Some small portions of the Study Area are composed of immature, fragmented woodland, forest communities and native grasslands. These patches of regrowth vary in native plant species diversity and are subject to varying degrees of weed invasion.

4.8 Landscape Values

Features that were used in the Credit Calculator to determine the Landscape Value Score are listed in **Table 4.1** and are illustrated on **Figure 4**.

Table 4.1 Landscape Values Used in the Credit Calculator

Feature	Value
IBRA bioregion / subregion	Sydney Basin / Hunter
NSW Mitchell landscape region	Central Hunter Foothills
Native vegetation extent (%) (Before):	
- Outer Assessment Circle	11-15
- Inner Assessment Circle	21-25
Native vegetation extent (%) (After):	
- Outer Assessment Circle	11-15
- Inner Assessment Circle	06-10
Connectivity Value:	
- Linkage width (m) (Before / After)	0-5 / 0-5
- Overstorey condition (Before / After)	PFC at BM / PFC at BM
- Midstorey/groundcover condition (Before / After)	PFC at BM / PFC at BM
Patch Size (ha)	1,154.68
Landscape Value Score	14.20

Chapter 5

Methods

The environment within the Study Area was systematically surveyed in 2000 (Ecotone, 2000; The Ecology Lab Pty Ltd, 2000); and then in 2009, 2011, 2013 and 2015 (Cumberland Ecology). Field surveys that were conducted within the Study Area during the above studies include comprehensive flora, fauna and aquatic investigations over a range of seasons. Cumberland Ecology conducted a “gap analysis” of the early ecological studies and then designed fieldwork to build upon the earlier work and provide ecological baseline information that would comply with State guidelines for assessment.

This chapter summarises the methods of survey that have been completed within the Study Area to date, with particular focus on the recent surveys that were completed by Cumberland Ecology for this biodiversity assessment report.

5.1 Desktop Assessment

5.1.1 Literature Review

i. Locality Studies

For the purposes of this report it is appropriate to draw upon ecological literature prepared for various parts of the “locality” surrounding the Study Area. The locality is here defined as land within a 20 km radius of the Study Area, which includes much of the Muswellbrook LGA. The locality includes coal mines (such as Mt Arthur Coal Complex, Drayton Mine, Bengalla Mine and the proposed Mount Pleasant Project), grazing lands, irrigated farmlands, a portion of the Hunter River and a portion of Wollemi National Park.

An extensive baseline of ecological data is available for the locality as numerous ecological studies have been conducted for the nearby mining projects and conservation area. These include various studies undertaken for the Bayswater Power Station (Resource Planning Pty Limited 1993; Eco Logical Australia Pty Ltd 2009) and Mt Arthur Coal Complex (Dames and Moore 2000; Umwelt (Australia) Pty Limited 2006a, 2006b, 2007; Cumberland Ecology 2009). Regional mapping of the vegetation of the central Hunter Valley has also been undertaken by Peake (2006). These studies have been reviewed and relevant information from them used in the preparation of this biodiversity assessment report.

ii. Study Area

Field surveys of various parts of the Study Area were completed in 2000, 2009, 2011, 2013 and 2015. The results are provided in this biodiversity assessment report. A review of earlier investigations of the Study Area and Drayton Mine was conducted to supplement surveys by Cumberland Ecology, and include the following:

- Flora and Fauna and Threatened Species Assessment for the proposed coal mining area at Saddlers Creek Ecotone for Shell Coal Pty Ltd – Ecotone, 2000;
- Saddlers Creek Environmental Feasibility Study: Assessment of Fish Habitats – The Ecology Lab, 2000;
- Bird Surveys of the Proposed Drayton Mine Extension – Saunders, 2006;
- Drayton Mine Fauna Surveys – Cumberland Ecology, 2007;
- Drayton Mine Extension Flora and Fauna Impact Assessment. Prepared for Anglo Coal (Drayton Management) Pty Limited – Hansen Bailey, 2007; and
- Ecological Assessment of Section 75W Modification for Drayton Mine – Cumberland Ecology, 2009.

5.1.2 Threatened Species Database

Other existing information on the biodiversity values of the Study Area and its surrounds were obtained from the OEH Atlas of NSW Wildlife database (OEH, 2015) and DoE EPBC Act Protected Matters Search Tool (PMST) (DoE, 2015). The number and age of records of threatened species recorded within the Muswellbrook LGA was used to assess the likelihood of occurrence of threatened species. The EPBC Act PMST provides a list of MNES that are predicted to occur based on the presence of suitable habitat, which was used to guide threatened species searches during field survey.

5.1.3 Review of Regional Vegetation Mapping

Regional-scale vegetation mapping of the central Hunter Valley was completed between 1996 and 2006 on behalf of the former Hunter-Central Rivers Catchment Management Authority (now the Hunter Local Land Services, or Hunter LLS) (Peake, 2006). The Hunter Remnant Vegetation Project documented the distribution of remnant communities and designated community descriptions based on floristic composition. It should be noted that this mapping is regional-scale and thus broad in its delineation of communities.

The regional mapping was used to inform initial vegetation surveys of the Study Area. Field surveys by Cumberland Ecology assessed the accuracy of this mapping by ground-truthing communities through reconnaissance and plot data. As a result, mapping included in this biodiversity assessment report differs from the regional mapping as it provides a more fine-scale breakdown of vegetation communities and also shows the extent of regeneration that has occurred since the regional mapping was published. Further details are provided in **Section 5.3.1**.

5.2 Field Studies

Cumberland Ecology has conducted several field surveys of the Study Area that collectively comply with standards provided in the OEH 'Threatened Biodiversity Survey and Assessment Guidelines for Development and Activities' (DEC (NSW), 2004c) and the OEH 'Threatened Species Assessment Guidelines' (DEC (NSW), 2005d). For the current biodiversity assessment, metric data was collected in accordance with the methods prescribed in the FBA (OEH, 2014b) and the BBAM (OEH, 2014a). Details of these field surveys are outlined below.

Field surveys were undertaken over several seasons to maximise the chance of observing migratory species and breeding species, and the chance of recording plants in flower or with fertile material for accurate identification. Early surveys completed in 2009 to 2010 were conducted as a preliminary study to investigate the key biodiversity issues of the Study Area and to ascertain the accuracy of regional vegetation mapping covering the Study Area. This information was used to guide more detailed surveys that followed in 2011.

For the purposes of assessing the current condition of Saddlers Creek and to assess the potential impacts of the proposed pumping station and water discharge locations along the Hunter River, an aquatic survey was conducted in 2011 (see **Section 5.6** for further details). The survey focused on habitat assessments; in-situ water quality measurements and macroinvertebrate sampling that were undertaken in accordance with the Australian River Assessment System (AUSRIVAS) procedures; and limited vertebrate sampling. The Hunter River is known to provide substantial fish habitat and has been studied in detail by a range of other authors. The fish assemblages of the river within the Upper Hunter Valley are well known and have been described by means of literature review. This information was considered in the assessment of the potential aquatic impacts of the Project.

The minor additional mining areas at Drayton Mine were surveyed over one day. The survey involved observations of surrounding land use and extent of human disturbance; type, condition and age structure of vegetation; searches for threatened flora species; and assessment of available fauna habitat and microhabitat features. Photographs were taken in order to provide an indication of the current condition of the habitat.

The dates over which field surveys were completed are summarised in **Table 5.1**.

Table 5.1 Summary of Dates for Field Surveys Completed

Dates of Survey	Tasks Completed	Completed By
11 January 2000	- Aquatic vertebrate survey - visual habitat assessment at two sites; a large farm dam and at the Saddlers Creek/Edderton Rd causeway	The Ecology Lab
February 2000	-Floristic systematic transects -Flora random meander transects -Spotlighting and call playback	Ecotone

Table 5.1 Summary of Dates for Field Surveys Completed

Dates of Survey	Tasks Completed	Completed By
30 September – 2 October 2009	-Hair tube surveys -Anabat surveys -Harp trapping and tripline bat survey -Bird census -Observations and notes on land use and condition -Broad-scale vegetation ground-truthing -Vegetation plot sampling -Threatened flora species searches -General habitat assessment -Targeted searches of potentially suitable flora and fauna habitat for threatened species recorded in neighbouring mine leases	Cumberland Ecology
26 – 28 October 2009	-Vegetation mapping -Habitat assessment -Bird census -Spotlighting -Additional threatened flora species searches	Cumberland Ecology
2 – 3 November 2009	-Vegetation mapping and plot sampling -Habitat assessment -Bird census -Spotlighting -Additional threatened flora species searches	Cumberland Ecology
2 November 2010	-Targeted threatened flora survey (with focus on threatened orchids)	Cumberland Ecology
14 – 18 March, 2011 (summer session)	-Mammal trapping -Vegetation plot sampling -Threatened flora survey (with focus on <i>Acacia pendula</i>) -Threatened bat surveys	Cumberland Ecology
2 – 3 May, 2011 (aquatic session)	-Water quality sampling along Saddlers Creek, Hunter River and at the confluence with the Hunter River -Macroinvertebrate sampling -Riparian habitat assessment	Cumberland Ecology
16 – 18 June, 2011	-Systematic bird census, including winter migratory species -Habitat assessment (birds)	
20 – 24 June, 2011	-Systematic bird census, including winter migratory species	Cumberland

Table 5.1 Summary of Dates for Field Surveys Completed

Dates of Survey	Tasks Completed	Completed By
(autumn/winter session)	-Habitat assessment including tree hollows -Mammal trapping -Diurnal and spotlighting surveys -Vegetation plot sampling	Ecology
11-12 August, 2011	-Vegetation mapping and plot sampling	Cumberland Ecology
23 September, 2011 (spring session)	-Targeted threatened flora survey (with focus on threatened orchids and <i>Acacia pendula</i>) -Vegetation plot sampling	Cumberland Ecology
7 March, 2013	-BioBanking plot and transect sampling	Cumberland Ecology
16-17 February, 2015	-BioBanking plot and transect sampling	Cumberland Ecology

A summary of weather conditions in the locality using Jerrys Plains forecasts (Bureau of Meteorology, 2015) of the Study Area during recent surveys is provided in **Table 5.2**. The March 2011 summer session field work was hampered by significant rainfall and severe storm warnings which restricted access to the survey sites and limited the number of trap nights.

Table 5.2 Field Survey Weather Conditions (Jerrys Plains Forecasts)

Survey Session	Date	Min (°C)	Max (°C)	Rain (mm)	Notes
Preliminary	30/09/2009	3.8	27.6	0	
	1/10/2009	4.2	34.5	0	
	2/10/2009	9.9	27.2	0	
	26/10/2009	13.6	16.9	7.4	
	27/10/2009	12.8	18.5	16.2	
	28/10/2009	12.3	27.3	0	
	2/11/2009	12.6	36.7	0	
	3/11/2009	16	39	0	
	2/11/2010	26.6	36.7	0	
Summer	14/03/2011	18.2	33.5	0	Severe thunderstorm warnings
	15/03/2011	18.7	27.7	11	
	16/03/2011	16.5	32.2	0.4	

Table 5.2 Field Survey Weather Conditions (Jerrys Plains Forecasts)

Survey Session	Date	Min (°C)	Max (°C)	Rain (mm)	Notes
Aquatic	17/03/2011	17	25.3	4.8	Highest rainfall for March
	18/03/2011	18.7	25.8	18.4	
	2/05/2011	7.2	20.1	0	
Winter	3/05/2011	8.5	22.5	0	
	16/06/2011	-	17.9	44.0	
	17/06/2011	-	-	0.2	
	18/06/2011	-	17.5	0	
	20/06/2011	9.3	18.3	0	
	21/06/2011	-	20	0	
	22/06/2011	8.8	13.6	2.6	
	23/06/2011	-	-	-	
	24/06/2011	-	12	-	
Vegetation	11/08/2011	4.2	17	0.2	
	12/08/2011	2.8	17.8	0	
Spring	23/09/2011	6.5	31	0	
BioBanking	7/3/2013	-	-	0	
	16/02/2015	14.9	32.8	12.4	
	17/02/2015	15.1	32.8	0	

Source: Bureau of Meteorology (2015)

5.3 Flora Survey

The key objectives of the flora surveys were to map the vegetation communities occurring within the Study Area and to conduct targeted threatened species searches for those that were considered to have potential to occur.

The methods that were used during floristic survey of the Study Area are listed below:

- Plot sampling (400 m²) to obtain information on floristic composition and community structure. Native species occurring within a 1000 m² sampling area was sampled to enable identification and assessment of Box-Gum Woodland;
- Meander-transect surveys to obtain information on vegetation community distribution in the Study Area and ground-truth the occurrence and extent of different community types; and

- Random meander surveys in areas of suitable habitat to detect additional flora species not recorded within the plots.

5.3.1 Vegetation Mapping

Vegetation mapping was undertaken in three broad stages:

- Development of a preliminary vegetation map based on desktop review of available datasets and studies, and using aerial photograph interpretation techniques and Geographic Information Systems (GIS) software (MapInfo Professional 12.5);
- Collection of detailed site data during field surveys to validate the preliminary mapping and to inform final mapping outputs; and
- Review and refinement of the preliminary vegetation map based on field datasets.

A preliminary base vegetation map was developed prior to field work. Vegetation boundaries, or polygons, were initially identified based on existing mapping and vegetation community descriptions by Peake (2006) and then adjusted based on aerial photograph interpretation of high resolution imagery. This information, in combination with the interrogation of topographical and geological datasets, was used to assist in the delineation of vegetation boundaries and to broadly assign vegetation types.

Walking and driving meander-transect surveys were then conducted to ground-truth the occurrence and extent of different community types and to obtain a thorough understanding of key remnant areas of vegetation (general site floristics; topographical characters; and aspect). Records of vegetation units and boundary changes were made using a handheld Global Positioning Systems (GPS) unit. Broad units were sampled using standardised 400 m² plots to obtain site-specific information on floristics and community structure.

The field information was then used to refine the preliminary vegetation map.

i. Vegetation Classification and Community Descriptions

Remnant native vegetation communities are classified in accordance with the vegetation communities described in Peake (2006). Nomenclature assigned to each remnant native vegetation community is consistent with vegetation names identified in Peake (2006). Map unit (MU) numbers have been assigned to each vegetation community for ease of reference.

All vegetation communities have been matched to an approved Plant Vegetation Type (PCT) and Biometric Vegetation Type (BVT) in the Vegetation Information System (VIS) Classification database administered and maintained by OEH. This is required to assess the Project using the FBA (OEH, 2014b).

5.3.2 Floristic Census

The flora assemblage within the Study Area was recorded by plot sampling, random meander surveys and through targeted searches for threatened species. All vascular plants recorded or collected were identified using keys and nomenclature provided in Harden (1990-1993). Other references used to assist identification of selected plant taxa include Richardson *et al* (2006) and Brooker and Kleinig (1990). Where known, taxonomic and nomenclatural changes have been incorporated into the results, as derived from PlantNET (Botanic Gardens Trust, 2015). Any specimens that were not readily identifiable were lodged for identification with the National Herbarium of NSW at the Royal Botanic Gardens, Sydney.

5.3.3 Targeted Searches for Threatened Plants

Targeted searches for threatened flora species likely to occur in the Study Area were undertaken as part of the flora surveys. Targeted surveys were conducted firstly through random meander surveys and then meander-transect surveys of suitable areas of habitat.

Additional targeted searches were also conducted in spring to specifically search for threatened orchids (e.g. *Diuris tricolor*, *Prasophyllum* sp. Wybong and *Pterostylis gibbosa*), and to collect suitable reproductive material that could be used to positively identify certain species (e.g. *Acacia pendula*). This was because these orchids have very short flowering periods after which they die back and are not detectable.

5.3.4 Plot Sampling

A cumulative total of 57 detailed floristic plots were sampled within woodland and grassland. Locations were chosen to reflect the condition and composition of the vegetation patch.

In each plot, the following information was recorded as a minimum:

- All vascular flora species present within the plot or directly adjacent to the plot;
- The stratum in which each species occurred;
- The relative frequency of occurrence of each plant species;
- Vegetation structural data (i.e. height and percentage cover of each stratum);
- A waypoint to mark the location of the plot, using a handheld GPS; and
- Photographs of the plot.

The relative abundance and cover of each species within each plot sampled between 2009 and 2013 was approximated using a scoring system based on the Braun-Blanquet scoring system (Braun-Blanquet, 1927). The scores used are provided in **Table 5.3**.

Table 5.3 Braun-Blanquet Scoring System

Class	Cover-abundance	Notes
+	Few Individuals (less than 1% cover)	Herbs, sedges and grasses: within 4 m ² Shrubs and small trees: less than 5 individuals
1	Many Individuals (less than 5% cover)	Herbs, sedges and grasses: within 20 m ² Shrubs and small trees: 5 or more individuals One medium – large overhanging tree
2	5 - less than 25% cover	-
3	25 - less than 50% cover	-
4	50 - less than 75% cover	-
5	75 - 100% cover	-

In 2015, the relative abundance and cover of each species was recorded in 1% increments for species covers comprising less than 1% of the ground cover within the plot, and then estimated to the nearest 5% for species covers comprising more than 5% of the ground cover within the plot, which is consistent with the FBA (OEH, 2014b).

As grassland areas are extensive, seven rapid assessment plots were also sampled in grassland to guide sampling design and to augment the plot dataset. In rapid assessment plots, the following information was recorded:

- Whether the plot was dominated by native perennial grass species;
- All native groundcover herbs and ferns (i.e. not grass species); and
- Whether the percentage foliage cover of the native ground stratum was at least 50%.

Metric data along 50 m transect lines and within 50 x 20 m plots were sampled in accordance with the BBAM (OEH, 2014a). These were sampled at 51 locations where detailed floristic plots were sampled. Three additional locations were sampled for metric data and a total native species count recorded within a 20 x 20 m plot area. Plot locations are shown in **Figure 5**.

5.3.5 Identification of Threatened Ecological Communities

The literature review of vegetation in the locality and vegetation mapping by Peake (2006) indicated high potential for the occurrence of the Box-Gum Woodland in the Study Area. Box-Gum Woodland occurs as a woodland community and also as a grassland community. Guidelines for the identification of Box-Gum Woodland are available and as such, specific surveying criteria were used to identify the community (see **Section 5.3.5ii**).

i. *Criteria for Identifying Ecological Communities*

Many of the Hunter Valley vegetation communities display ecotonal traits and are often difficult to distinguish from one another. Typically, only a variation in the proportion of canopy species indicates a change from one vegetation unit to a different vegetation unit.

The floristic composition of the understorey is often very similar, particularly where the land practices are similar over a large area. This also makes it difficult to discern the original communities from which native grassland areas are derived. Supplementary information such as slope, aspect, soil and underlying geology were considered to delineate between vegetation communities and areas of grassland derived from the different forest and woodland communities.

Ecological communities in the Study Area were determined by comparing plot data and field notes against published information, including descriptions within the TSC Act Final Determinations, EPBC Act Listing Advice and Peake (2006). Identification was based on community criteria such as geology, topography, known distribution, habitat descriptions and the number of recognised important or diagnostic species. Data was compared with the final determinations for listed communities under the TSC and EPBC Act to assess the presence of TECs.

ii. *Criteria for Identifying Box-Gum Woodland*

a. EPBC Act Criteria

Box-Gum Woodland is a CEEC listed under the EPBC Act. This community is also listed as an EEC under the TSC Act. There are slight differences in the listing criteria. In order to determine whether vegetation communities in the Study Area comprised Box-Gum Woodland, vegetation communities were sampled according to the detailed methodology that is prescribed within the EPBC Act Policy Statement for assessing the presence of Box-Gum Woodland community (DEH, 2006).

The eastern limits of Box-Gum Woodland occur in the Upper Hunter Valley. In this region, it is common for the community to comprise intergrades of the dominant tree species, rather than pure stands. The latest advice to the Commonwealth Minister for the Environment regarding the listing of Box-Gum Woodland states that *Eucalyptus albens* x *Eucalyptus moluccana* (White Box – Grey Box intergrades) should be included in the definition of this community (Threatened Species Scientific Committee, 2010). Thus, this biodiversity assessment report includes areas containing *Eucalyptus albens* x *Eucalyptus moluccana* (White Box – Grey Box intergrades) or native grasslands that are derived from communities containing *Eucalyptus albens* x *Eucalyptus moluccana* (White Box – Grey Box intergrades), as Box-Gum Woodland.

b. TSC Act Criteria

There is no such prescriptive methodology to identify Box-Gum Woodland under the TSC Act. A detailed description that defines Box-Gum Woodland is included in the Final Determination made in 2004 by the NSW Scientific Committee to list the community as a

CEEC under the TSC Act (NSW Scientific Committee, 2002). The presence of the community is determined on the basis of its consistency with the community described within the Final Determination.

The following community descriptors have been taken directly from the Final Determination for Box-Gum Woodland:

“White Box Yellow Box Blakely’s Red Gum Woodland is the name given to the ecological community characterised by the assemblage of species listed in paragraph 3 [of this determination].”

“White Box Yellow Box Blakely’s Red Gum Woodland includes those woodlands where the characteristic tree species include one or more of the following species in varying proportions and combinations – Eucalyptus albens (White Box), Eucalyptus melliodora (Yellow Box) or Eucalyptus blakelyi (Blakely’s Red Gum).”

“In some locations, the tree overstorey may be absent as a result of past clearing or thinning and at these locations only an understorey may be present.”

“Woodlands including Eucalyptus crebra, Eucalyptus dawsonii and Eucalyptus moluccana (and intergrades with Eucalyptus albens)...are also included.”

“Intergrades between Eucalyptus blakelyi and Eucalyptus teretecornis may also occur here.”

“Disturbed remnants are still considered to form part of the community including remnants where the vegetation, either understorey, overstorey or both, would, under appropriate management, respond to assisted natural regeneration, such as where the natural soil and associated seed bank are still at least partially intact.”

5.3.6 Identification of Groundwater Dependent Ecosystems

Groundwater refers to water that has filtered down from the surface and occupies spaces within the underlying earth and geology in a saturated state (DLWC (NSW), 2002). Groundwater dependent ecosystems (GDEs) are defined as *“Any ecosystem that uses groundwater at any time or for any duration in order to maintain its composition and condition”* (Serov et al., 2012).

Biologically available groundwater can include regional groundwater, particularly where it is shallow enough for plants roots to reach or where it becomes accessible via caves or at other low points in the landscape. However, where regional groundwater is deeper, more transient and perched systems of groundwater can also provide water for support of GDEs. These can include discontinuous shallow aquifers within alluvium associated with flood plains. Many native plant species use groundwater at some stage of their life cycle, either through their root system or at surface discharge points such as springs and wetlands.

The NSW Office of Water Risk Assessment guidelines for Groundwater Dependent Ecosystems broadly divide GDEs into subsurface or underground ecosystems (eg. Karst and

Cave ecosystems) and Surface or Above ground ecosystems. Above ground GDEs found in NSW include:

- Groundwater Dependent Wetlands;
- Baseflow Streams (Surface Water Ecosystems);
- Estuarine and near shore marine ecosystems; and
- Phreatophytes (Groundwater dependent terrestrial ecosystems)

Of these GDEs, the ecosystem with the most relevance to the Study Area is the phreatophyte or 'terrestrial vegetation'. However riparian vegetation also conforms to the definition of a baseflow GDE.

i. Terrestrial Vegetation GDE

Terrestrial Vegetation is a type of GDE that does not rely on the surface expression of groundwater but depends on the subsurface presence of groundwater, often accessed via the capillary fringe (ie. the subsurface water just above the water table that is not completely saturated). They consist of deep and/or shallow rooted vegetation communities that can rely on groundwater for survival, particularly in areas of shallow groundwater. While there are many localised ecosystems with a high dependence on groundwater which would suffer in its absence, most of Australia supports low-dependence ecosystems (Hatton and Evans, 1998). Most vegetation communities are likely to use groundwater to some degree; however, open forest and woodland vegetation are known to rely principally on soil water and not groundwater.

Riparian vegetation, which occurs in association with creeks, rivers and the floodplains of major rivers, is primarily a form of Terrestrial Vegetation GDE. Riparian vegetation takes up soil water but is also likely to rely at least partially on groundwater. The degree of groundwater use can depend on the landscape position. Groundwater is often closer to the surface on valley floors and flats and so vegetation in such areas may be more dependent upon groundwater (O'Grady *et al.*, 2006b).

In general, ephemeral creeks like the tributaries of rivers such as the Hunter River are seasonally variable and often empty rapidly, to be replenished during floods or high rainfall events (DLWC (NSW), 2002). Riparian vegetation along such ephemeral creeks may rely more heavily on groundwater during dry periods.

The degree of dependency is also determined by whether groundwater uptake by the dominant trees is obligate or opportunistic (O'Grady *et al.*, 2006b). Typical riparian tree species such as *Eucalyptus tereticornis* (Forest Red Gum) and *Angophora floribunda* (Rough-barked Apple) can use both soil water and shallow groundwater. These species are more likely to have opportunistic groundwater dependency, as they can occur in a range of landscape positions and are likely to rely on soil water at higher elevations (although it is noted that these species are mostly found on lower elevations as part of a riparian community).

In contrast, some species (such as some *Casuarina* spp. or *Melaleuca* spp.) can have obligate groundwater dependency and may rely mostly or even completely on groundwater to sustain them.

Without using methods such as stable isotope analysis and bore holes, assessing whether ecosystems are groundwater dependent is generally based on the presence of particular species - particularly tree species. The identification of GDEs in the Study Area was determined on the basis of the presence of species such as *Eucalyptus camaldulensis* (River Red Gum), *Eucalyptus tereticornis* (Forest Red Gum) and *Casuarina cunninghamiana* (River Oak). This is because floodplain and creekline communities dominated by such canopy species as *Eucalyptus camaldulensis* (River Red Gum), *Eucalyptus tereticornis* (Forest Red Gum) and *Casuarina cunninghamiana* (River Oak) are likely to have some root access to deep watertables and thus comprise a GDE.

Riparian communities can also be considered as baseflow GDEs if the waterbody has a significant groundwater input into its baseflow. or river baseflows (Boulton and Hancock, 2006; O'Grady *et al.*, 2006a; Serov *et al.*, 2012).

ii. River Base Flow Systems GDE

Baseflow GDEs occur where groundwater discharge provides a significant baseflow component to the river. Baseflow typically emerges as springs or as diffuse flow from saturated sediments or rock underlying the stream and banks and are crucial for maintaining instream and near stream ecosystems. Although no permanently flowing rivers are present in the Study Area, the Hunter River is in close proximity to the southern boundary of the Study Area and vegetation in this area is likely to comprise a Baseflow GDE as the flow in the river is augmented by groundwater. It is estimated that an average of up to 40% of any rivers' flow duration is comprised of groundwater-fed baseflow (DLWC (NSW), 2002).

iii. Wetland GDEs

Groundwater dependent wetlands are defined as land permanently or temporarily under water or waterlogged with a known or likely component of groundwater discharge in their hydrologic cycle. Temporary groundwater dependent wetlands are defined as wetlands that have groundwater derived surface water and are waterlogged with sufficient frequency and / or duration to affect the biota (Serov *et al.*, 2012). No groundwater dependent wetlands are present in the study area

iv. Estuarine and near shore marine GDEs

Estuarine and near shore marine GDEs consist of ecosystems situated at the end of drainage systems and the discharge area for aquifers and can be separated from coastal wetlands by the reliance on seawater and tidal influences (Serov *et al.*, 2012). No estuarine and near shore marine GDEs are present in the study area.

v. *Subsurface GDEs*

Subsurface GDEs broadly occur in three forms, namely

- Karst and caves.
- Subsurface aquifer ecosystems.
- Underground stream ecosystems.

These ecosystems largely consist of tiny microscopic species including crustaceans known as stygofauna. Although no caves are present in the Study Area, some stygofauna have been identified in the groundwater and these have been assessed by the EIS stygofauna impact assessment.

5.3.7 Assessment Approach

The EIS groundwater impact assessment was reviewed to determine the degree of impact that was predicted to the groundwater as a result of the project, and the duration of such impacts. These potential impacts were then considered with respect to the plant communities that could conceivably be exposed to the impacts and the position of such communities within the landscape.

5.4 Fauna Habitat Assessment

The assemblage of fauna species within the Study Area is influenced by habitat availability and general factors such as area, configuration and connectivity to other areas of intact vegetation. These factors affect the quality of the habitat on a broader, landscape scale. The Study Area contains three broad habitat types that vary in their value for various fauna. These are:

- Remnant woodland and open forest;
- Grassland; and
- Riparian vegetation associated with Saddlers Creek and its minor tributaries and drainage lines.

Habitat condition was assessed by noting ground, shrub/understorey and canopy cover; number and size of tree hollows present; habitat features such as bush rock, fallen trees, forage trees and wetland areas such as creeks and soaks; and signs of fauna usage such as nests, scats and scratches. An assessment of the structural complexity of vegetation, the age structure of the forest and the nature and extent of human disturbance throughout the Study Area was undertaken and considered.

5.4.1 Hollow Assessment

Hollows are used as a general indication of habitat quality for arboreal fauna, and hollow-dependent birds and bats. Hollows observed during surveys were recorded and the general vegetation condition and tree maturity were used to predict whether trees onsite are likely to contain hollows. Indirect indicators of fauna use of the site such as droppings, diggings, footprints, scratches, nests, burrows, paths and runways were also noted.

5.5 Terrestrial Fauna Surveys

The Study Area has been well surveyed for fauna in previous studies and the results were used to guide the fauna surveys for this biodiversity assessment report. The sampling methods and cumulative survey effort of various ecology studies (Ecotone, 2000; The Ecology Lab Pty Ltd, 2000; Cumberland Ecology, 2009, 2011) conducted in the Study Area are summarised in **Table 5.4**.

Fauna surveys completed for this biodiversity assessment were conducted, where possible, in accordance with Office of Environment Heritage (OEH) guidelines for ecological assessment (DEC (NSW), 2004b) and Australian River Assessment System (AUSRIVAS) sampling procedures for aquatic habitats (Turak and Waddell, 2001b). Surveys were undertaken over several seasons to maximise detection of fauna species. As the OEH survey guidelines are based upon stratification units, the Study Area was stratified using vegetation units as a surrogate for fauna habitat and survey effort was allocated accordingly.

The survey methods utilised during the Cumberland Ecology surveys for this biodiversity assessment are described in the following sections. Fauna survey locations established for this biodiversity assessment are shown in **Figure 6**.

Table 5.4 Cumulative Survey Effort completed for the Study Area

Survey Method	Ecology Study			TOTAL Survey Effort
	Cumberland Ecology	Ecotone	The Ecology Lab	
Arboreal Traps	270	-	-	270 trap nights
Terrestrial Traps	123	-	-	123 trap nights
Arboreal Hair tubes	214	168	-	382 trap nights
Terrestrial Hair tubes	85	516	-	601 trap nights
Cage Trap	11	-	-	11 trap nights
Harp Traps	4	11	-	15 trap nights
Tripline	-	2	-	2 person hours
IR Camera	19	-	-	19 trap nights
Anabat Recordings	13	6	-	19 trap nights
Walking Spotlight Surveys	4	12	-	13 person hours
Vehicle Spotlighting Transects	6	Opportunisticly	-	>6 person hours
General Diurnal Bird Census	4	Time periods not specified	-	> 4 person hours
Systematic Diurnal Bird Census	18.6	-	-	18.6 person hours
Nocturnal call playback	-	3.5	-	3.5 person hours
Specialist herpetofauna census (diurnal and nocturnal)	-	8	-	8 person hours
Aquatic Sampling	8 sites	-	2 sites	10 sites

Table 5.5 Cumberland Ecology Fauna Trapping Effort

	Summer Session				Winter Session				
	Trapline 1	Trapline 2	Trapline 3	Trapline 4	Trapline 5	Trapline 6	Trapline 7	Trapline 8	TOTAL TRAP NIGHTS
Nights Open	4	3	4	4	4	4	4	4	23
Vegetation Type	Narrabeen Footslopes Slaty Box Woodland	Central Hunter Box-Ironbark Woodland	Upper Hunter White Box- Ironbark Grassy Woodland	Hunter Floodplain Red Gum Woodland and Derived Native Grassland	(200 m from) Central Hunter Box-Ironbark Woodland	Narrabeen Footslopes Slaty Box Woodland	Central Hunter Box-Ironbark Woodland	Narrabeen Footslopes Slaty Box Woodland	
Arboreal Traps	10	10	5	5	10	10	10	10	270
Terrestrial Traps	7	5	10	10	-	-	-	-	123
Arboreal Hair tubes	4	3	5	4	10	10	10	9	217
Terrestrial Hair tubes	6	7	5	5	-	-	-	-	85
Cage Trap	Yes	Yes	Yes	No	No	No	No	No	11
IR Camera	4 nights	3 nights	4 nights	None	2 nights	2 nights	2 nights	2 nights	19

5.5.1 *Trapping Surveys*

Trapping was used to detect fauna occurring in the Study Area. Four traplines were established during each of the summer and winter seasonal surveys in 2011 in habitat deemed suitable for terrestrial and arboreal mammal species. A summary of the trapping effort is provided in **Table 5.5**. Traps were checked and re-set early each morning, and any fauna captured was identified and released.

i. Arboreal and Terrestrial Traplines

A total of 393 Elliot trap nights were established during surveys for this biodiversity assessment. Combinations of the following traps were utilised in fauna traplines:

- Medium Elliot (B) traps for small to medium sized fauna;
- Small Elliot (A) traps for small sized fauna; and
- Wire Cage traps for large terrestrial fauna.

A total of 70 arboreal traps were used over summer and winter survey sessions. Traps were positioned on platforms attached to habitat trees at a height of approximately 2 m and a distance of 10 to 30 m apart depending on availability. Large trees were chosen, specifically those that showed evidence of usage, such as scats at the base of the tree, scratch marks on the trunk and hollows. To prevent water entering the traps, they were set with the entrance tilted slightly downward. Traps were also positioned away from direct morning sunlight to reduce the potential for prolonged heat exposure.

A total of 32 terrestrial traps were set during the summer survey session. Traps were positioned in suitable ground habitat at the base of trees, in shrubbery or against logs, approximately 20 m apart along the trapline.

All traps were covered with tough plastic bags for protection from dew and rain, and lined with leaf litter and cotton wool during the winter trapping session to insulate any captured animals. Traps were baited with a mixture of peanut butter, honey and rolled oats with vanilla essence and re-baited when necessary. Each tree was sprayed with a honey and water mixture to attract fauna. Trapped fauna were carefully handled to avoid injury and distress, identified, then released into suitable habitat. Scat samples found at or in close vicinity to traps were sent for analysis to the specialist company Scats About.

ii. Hair Tubes

'Faunatech' plastic hair tubes designed to collect mammal hair were used to supplement arboreal and terrestrial traps. The plastic hair tubes were paired with Elliot traps along traplines near habitat features such as hollows, ground debris or shrubs. Each hair tube was lined with sticky wafers and baited with the rolled oats mixture. Arboreal hair tubes were attached to trees at heights of 2 to 3 m and positioned with the entrance facing downward. Trunks were sprayed with the honey-water mixture to attract mammals. Any hair samples collected were sent to Scats About for specialist analysis. A total of 299 hair tube trap nights were established during surveys completed for this biodiversity assessment.

iii. Cage Traps

During the summer trapping session, a cage trap was placed at the start of traplines 1 to 3 to target medium-large sized mammals, particularly quolls. Traps were baited with chicken and cat food and the mixture of peanut butter, honey and rolled oats. The traps were half-covered with sheets to provide some protection against wind and sun exposure.

A total of 11 cage trap nights were established during surveys for this biodiversity assessment.

iv. Infra-red Cameras

Infra-red (IR) cameras were used along traplines during both summer and winter survey sessions. Cameras were paired with cage traps at the start of traplines 1 to 3 for the duration of the summer survey session. Cameras were also used for at least 2 nights each at traplines 5 to 8 in the winter session to target arboreal fauna. Cameras were attached to trees and directed at the baited cage traps or arboreal Elliot traps and set to take still photographs when the motion sensor was activated. Footage was later analysed to identify any fauna species recorded and in which areas they were found.

A total of 19 IR-camera trap nights were established during surveys completed for this biodiversity assessment.

5.5.2 Bat Surveys

Microchiropteran bats (microbats) were surveyed in summer 2011 using the following detection methods:

- Ultrasonic bat recordings using Anabat Z-CAIM units; and
- Harp traps.

Anabat Z-CAIM units (Anabats) were used at multiple sites to record calls of microbats that could fly through or potentially roost or forage in different woodland habitats within the Study Area. Anabats were aimed upwards at large stags, live hollow-bearing trees or in potential flyways. The recorders were housed in plastic containers and covered in plastic bags to shield against rain and left out for between one and four nights depending on weather conditions and habitat location.

Anabats were programmed to automatically turn on one hour before dusk each evening and switch off one hour after dawn. Call data was analysed by bat specialist Greg Ford from Balance Environmental to determine which species were present within the Study Area. Echolocation calls were identified to one of two confidence levels: positive identification and possible species detection. As a precautionary measure, species not positively identified were considered to occur and added to the cumulative fauna species list.

Two harp traps were set at traplines 1 and 3 in between gaps in vegetation along dry creeklines considered suitable microbat flyways. Traps were opened at dusk, checked for microbats within two hours and then left for the night.

Traps were checked again in the early morning and closed (i.e. covered in sheets) to make the traps visible and prevent animals becoming entangled during the day. Due to adverse weather conditions, the harp traps were left open for two nights at each survey location.

5.5.3 Bird Surveys

Over the course of all survey sessions, incidental visual observations and calls of birds were identified and recorded.

i. Preliminary Bird Survey

During the 2009 surveys, general bird census was conducted at eight survey points corresponding to a vegetation sampling plot to obtain information about bird use in different vegetation units. Each bird census was conducted for 30 minutes and recorded all bird species heard or seen within or in the vicinity of the plots.

ii. Systematic Bird Survey

A systematic bird census was conducted in June 2011 to survey resident and winter migratory species. Winter migrants that may pass over or potentially use forage habitat in the Study Area as part of the wider geographic migratory range were specifically targeted.

A total of 20 sites, comprising the major habitat types in the Study Area were surveyed between 16 and 24 June, 2011 in accordance with Birds Australia Atlas search methods (Birds Australia, 2014). Fifteen of the 20 sites were surveyed at least three times; three sites were surveyed twice; and two sites were surveyed once as incidental surveys.

At each site, a 2 ha area was surveyed for 20 minutes and all species observed or heard were recorded. Call playback was used to elicit a response from various species and GPS readings were recorded when threatened species were observed or heard calling. Where possible, photographs were taken of threatened bird species. Incidental habitat assessments were also conducted. General notes on important habitat resources such as tree hollows, flowering trees and nests were recorded incidentally, as were any notable bird activities such as specific forage behaviour or signs of breeding activity.

5.5.4 Diurnal Surveys

Amphibians and reptiles were surveyed by undertaking diurnal active searches in suitable habitat. Habitats were surveyed for a set period of 30 minutes per sample site. One hour was spent surveying vegetation surrounding the main dam along Saddlers Creek. Searches involved lifting of bark, fallen logs, bush rock and scraping of top soil.

While one individual was recently recorded in the Mt Arthur Coal Mine lease, few records exist for koala in the Muswellbrook LGA. It was considered unlikely that koalas would use habitat in the Study Area due to low connectivity and a lack of abundant primary feed trees. No targeted search for koalas was conducted; however evidence of utilisation, including scats and claw marks, were searched for in suitable habitat during all surveys.

5.5.5 Nocturnal Surveys – Spotlight Searches

Spotlighting was conducted for nocturnal mammals, birds, amphibians and reptiles. Spotlighting transects were focussed on woodland patches throughout the Study Area, particularly those patches in the central to north eastern sections of the Study Area.

Nocturnal surveys were conducted using a hand-held spotlight while walking or from a slow moving vehicle. Handheld spotlights used to pick up animal movement and eye shine. Spotlights (100 watt) with dimmer knobs were used. Reflective eye-shine was used to pick out any animals. Incidental spotlighting was also conducted while travelling between transects at night.

Initially (i.e. during surveys conducted in 2009), walking spotlighting surveys were conducted for 1 hour each night by two ecologists to detect the presence of nocturnal fauna species at the site. During the 2011 surveys, each walking spotlight search was then conducted by at least two ecologists over 20 minutes. Six driving transects, each 1 km in length, were also conducted whilst travelling at 5 km an hour.

During this time, call playback was also used to elicit a vocal response from nocturnal animals. Amphibian searches were conducted in riparian habitat around Saddlers Creek.

5.5.6 Incidental Observations

During all survey events any incidental vertebrate fauna species that were heard calling, observed or otherwise detected on the basis of tracks or signs were recorded and listed in the total species list for the Study Area.

5.6 Aquatic Survey

A literature review was conducted to determine the likelihood of either Saddlers Creek or the Hunter River supporting abundant or diverse fish communities. The Hunter River provides more substantial fish habitat than Saddlers Creek and has been studied in detail by a range of other authors. The fish assemblages of the river within the Upper Hunter Valley are well known and have been described by means of literature review.

Vertebrate data from a previous study of Saddlers Creek that targeted fish and habitat availability (The Ecology Lab Pty Ltd, 2000) was also considered. This information demonstrated that minimal habitat exists within Saddlers Creek for fish owing to its small size and highly degraded ephemeral nature. Nevertheless, fish were collected within sweep nets from the pools of Saddlers Creek and were retained, identified and are discussed in this biodiversity assessment report.

In order to quantify the condition of the existing aquatic habitat to support conclusions about aquatic impacts, surveys were conducted between 2 and 3 May 2011 to provide baseline habitat and water quality data. This information will also be useful for future monitoring programs for the Project.

Sampling was undertaken at four points on Saddlers Creek; at the confluence of Saddlers Creek with the Hunter River; and at various points on the Hunter River near the proposed water intake and discharge pipeline locations (**Figure 7**).

The aquatic survey was undertaken in accordance with the AUSRIVAS sampling procedures and involved undertaking habitat assessments, in-situ water quality measurements and macroinvertebrate samples at eight designated sites, in order to provide an indication of the current condition at select locations along Saddlers Creek and the Hunter River.

The main aquatic survey sites were:

- H1 – Hunter River, at the confluence with Saddlers Creek;
- H2 – Hunter River, upstream of the proposed water extraction/discharge pipelines;
- H3 – Hunter River, at the proposed water discharge pipeline;
- H4 – Hunter River confluence, before Saddlers Creek flows into the river; and
- S1 to S4 – Various samples sites along Saddlers Creek.

The aquatic survey sites included:

- Riffle and pool areas at the confluence of the Hunter River and Saddlers Creek in the south western corner of the Study Area;
- The proposed water intake/outflow sites along the Hunter River; and
- In ephemeral pools along Saddlers Creek.

The methods for the aquatic survey components are described in more detail below.

5.6.1 Habitat Assessment

GPS coordinates were taken at each survey location and the following assessments conducted.

i. Current land use and visual site assessment of disturbance related to human activities

The assessment involved recording the levels of stream ecosystem alteration and summarising the impacts of land use on either side of the watercourses; in this case, how agricultural disturbances have affected riparian vegetation, bank stability, debris and pollution etc.

ii. Site attributes

The following site attributes were recorded at each of the sample sites:

- Topography;

- Water level, flow and clarity;
- Riparian vegetation;
- Stream width;
- Evidence of bank erosion or sedimentation;
- Presence of artificial or natural barriers that impede fish movement; and
- Sampling conditions.

iii. Attributes of riffle and edge habitats

The following attributes of riffle and edge habitats were recorded at each of the sample sites:

- Natural substrate description; and
- Depth (m).

iv. In-situ water quality measurements using a water quality meter

The following water quality attributes were recorded at each of the sample sites:

- Conductivity ($\mu\text{S}/\text{cm}$): Measures the total concentration of inorganic ions (salts) in the water;
- Dissolved oxygen (DO) (ppm): Reflects the equilibrium between oxygen consuming processes (e.g. respiration) and oxygen releasing processes (e.g. photosynthesis);
- Temperature ($^{\circ}\text{C}$): Temperature of the water at the time of sampling;
- pH: Measure of the acidity or alkalinity of the water; and
- Turbidity (NTU): Measures the amount of light-scattering properties of water. Influenced by the presence of suspended particulate and colloidal matter such as suspended clay, silt, phytoplankton and detritus.

v. Collection of water samples for laboratory analysis

Water samples were taken prior to macroinvertebrate sampling along the banks of the Saddlers Creek and the Hunter River. Four samples were taken along Saddlers Creek, and four along the Hunter River. Samples were appropriately labelled for later analysis by the National Measurement Institute (NMI) for the following:

- Nutrients (nitrogen, dissolved nitrogen, total phosphorus);
- Major ions;
- Mercury; and

- Alkalinity.

5.6.2 Macroinvertebrate Sampling

Aquatic macroinvertebrates are used as biological indicators of freshwater ecosystem health due to their sensitivity to changes in water quality, flow regime and general habitat condition (von der Ohe and Liess, 2004; Rosenberg *et al.*, 2008; Utz *et al.*, 2009). The presence or absence of particular species, diversity, composition and abundance of communities provide general measures of health which can be used to assess any impacts on aquatic systems (Maher and Norris, 1990).

Sampling involved disturbance of the substratum, debris and bank edges at each survey location to dislodge organisms; a 250 micron mesh net was held downstream to collect invertebrates. Where possible, a 10 m section of habitat was surveyed along a 100 m stretch at each location.

Samples were live-sorted over a 40 to 60 minute time frame to maximise the diversity of macroinvertebrates collected. Active, common taxa were picked first, followed by searches for cryptic and/or small taxa. Specimens were preserved in 70% ethanol and labelled for further analysis. Macroinvertebrate analysis involved identification to family level. Some taxa were sorted to phylum, sub-family and class as recommended by the AUSRIVAS guide. All macroinvertebrates were identified using taxonomic keys and aquatic invertebrate guides (Hawking J H, 1994; Hawking and Smith, 1997; Chessman, 2003).

5.6.3 AUSRIVAS and SIGNAL Analysis

The following macroinvertebrate scoring systems were used to give an indication of water quality of the sample collection sites.

i. AUSRIVAS Analysis

The AUSRIVAS is a set of statistical computer models that compare macroinvertebrates collected from a sample site with macroinvertebrates listed in a database for a large number of reference sites throughout Australia. Reference sites are those believed to be the least altered by human activity.

The AUSRIVAS models match the sample site to reference sites of similar types of streams in the same State or region. If the test site is lacking the macroinvertebrate families that are expected to occur, it assumes that the sample site is more affected by human influences than the reference sites (Turak and Waddell, 2001a).

It should be noted that AUSRIVAS uses rapid bio-assessment procedures to calculate river condition. This method is less sensitive than traditional quantitative procedures that are often more time-consuming and expensive; however it provides a preliminary indication of aquatic health.

ii. SIGNAL Analysis

Stream Invertebrate Grade Number – Average Level (SIGNAL) was used to analyse macroinvertebrates at each site and obtain an indication of water quality. This method was originally developed to assess impacts of organic pollutants and is considered a good method of assessing water quality. It assesses a site based on the macroinvertebrates found and whether the species are commonly found in healthy or unhealthy sites, rather than based on species diversity (Rutherford *et al.*, 2000). Invertebrates are given individual weighted grades depending on assigned environmental pollution sensitivity grades and the number of specimens collected. A high SIGNAL grade means the invertebrate is sensitive to most forms of pollution, while a lower grade means the invertebrate is tolerant of a range of environmental conditions. SIGNAL then assigns each sample site a 'score' between 1 and 10 based on the weighted grades of the invertebrates collected, which are then plotted to assess aquatic health.

The following SIGNAL scores indicate water quality (Chessman, 2003):

- Score less than 4 – severe pollution;
- Score of 4 to 5 – moderate pollution;
- Score of 5 to 6 – fair water quality; and
- Score of greater than 6 – good water quality.

5.7 Survey Limitation

The Study Area, immediate surrounds and broader locality have been surveyed numerous times over many years for various projects, including Mt Arthur Coal Mine, Mount Pleasant and Drayton Mine. As a result, detailed baseline vegetation and fauna data (including threatened species known and expected to occur within the locality) exists and are well documented on a spatial and temporal scale. Existing landscape information, vegetation mapping and baseline data on individual species was used to augment field results for the Project. When combined, this information provides a database that is sufficiently comprehensive to support the ecology impact assessment.

The field surveys have produced reliable information regarding flora and fauna species occurrences within the Study Area and are considered to be adequate to support the assessment of the Project impacts. Notwithstanding this, the data produced by the surveys is intended only to be indicative of the types of species that could occur and not an absolute census of all flora and fauna species of the Study Area. Although many species were detected during field surveys, additional species are likely to be present that have not been observed. Factors such as inclement weather, seasonality, migration schedules, population density and cryptic life histories can all affect the ability to detect species on ground. In particular, the summer fauna survey effort in the Study Area and also the offsite offset property were limited by severe weather that impaired access to the site and likely reduced fauna activity, making species difficult to detect.

To address the above limitations, surveys were conducted across all seasons to account for flowering schedules, breeding times and patterns, seasonal migration, and other variations affecting detectability. In addition to this, presence of suitable habitat was considered when assessing the potential occurrence of a given threatened species. Where potential habitat was present and the species was known to occur at other locations in the locality, it was assumed that the species had potential to occur and were thus assessed accordingly.

The field survey effort in the minor additional mining areas at Drayton Mine is considered to be adequate as Drayton Mine has been extensively surveyed in recent years and the flora and fauna are well known. In addition to this, the combined area of the minor additional mining areas is relatively small and currently supports very little native vegetation.

Chapter 6

Results

6.1 Native Vegetation

6.1.1 Drayton South

The original character of the vegetation in the Study Area has been greatly altered as a result of historical and current land uses. Originally the vegetation in the Study Area and surrounds would have been dominated by open forest and woodland. Following European settlement, the majority of the treed vegetation was cleared to provide large areas of pasture for livestock. As a result, a high proportion of the Study Area is now dominated by extensive areas of native perennial grassland of various diversity and floristic composition. Weed and feral animal invasion, in combination with cattle grazing, has also contributed to the contemporary landscape. The resultant mosaic of grasslands and remnant woodland patches is typical of the Muswellbrook locality and a result of extensive agricultural practices.

The remnant forest and woodland now exist as scattered patches across the landscape, typically in gully and riparian areas that have historically been difficult to farm. There are a few occurrences of old growth trees (i.e. trees that are greater than 90-100 years old) within the Study Area, particularly in association with deep gully lines. However, the majority of the remnant woodland is comprised of a mixture of relatively new regrowth, particularly of *Allocasuarina luehmannii* (Bulloak) and *Acacia salicina* (Cooba), and young but reproductively mature woodland (i.e. intact and self-sustaining woodland of age between 40-90 years old). Scattered paddock trees that do not form woodland are also present across the Study Area.

There are a few occurrences of old growth trees (i.e. trees that are greater than 90-100 years old) within the Study Area, particularly in association with deep gully lines. However, the majority of the remnant woodland is comprised of a mixture of relatively new regrowth, particularly of *Allocasuarina luehmannii* (Bulloak) and *Acacia salicina* (Cooba), and young but reproductively mature woodland (i.e. intact woodland of age between 40-90 years old). Scattered paddock trees that do not form woodland are also present across the Study Area.

Despite these land practices, the Study Area continues to support a suite of native flora and fauna species, and vegetation communities that are becoming increasingly significant in the Hunter region. Much of the Study Area shows resilience and capacity for woodland regeneration. If livestock were removed from native grassland and woodland margins, it is anticipated that such communities would readily regenerate from the existing seed bank. In general, vegetation in the Study Area to the west of Edderton Road has been subject to

greater grazing pressures and is more heavily modified than the vegetation to the east. The western part of the Study Area predominantly contains low diversity native grassland and cultivated areas. Wooded areas are sparse and canopy trees are typically restricted to scattered occurrences of *Eucalyptus dawsonii* (Slaty Box) trees and stags. Regenerating *Allocasuarina luehmannii* (Bulloak) and *Acacia salicina* (Cooba) dominate the shrub and small tree stratum.

i. Identified Map Units within the Study Area

Twelve MUs have been identified within the Study Area (**Table 6.1**). The extent of occurrence of each MU has been determined using a combination of both regional mapping information and results from ground-truthing by Cumberland Ecology (**Figure 8**). Detailed descriptions of each of the mapped MUs are provided in **Appendix B**.

The majority of the vegetation within the Study Area is comprised of grassland that has been derived from the clearing of the original woodland and forest communities. These grassland areas are used largely as native pasture for grazing. Grassland areas are largely dominated by a variety of native perennial grass and forb species but many exotic species are present as is typical of grazing lands. Some areas of grassland to the west of Edderton Road are actively sown with food and grazing crops from time to time.

Some small patches of remnant vegetation still exist, particularly along riparian corridors and in steeper areas of the Study Area. The majority of the remnant vegetation is dominated by *Eucalyptus moluccana* (Grey Box) and comprises MU 5: Central Hunter Box-Ironbark Woodland.

ii. Threatened Ecological Communities

Four of the six native remnant woodland communities in the Study Area conform to communities that are listed as TECs under the TSC Act and/or the EPBC Act.

Two of the woodland communities conform to the EPBC Act and TSC Act listed Box-Gum Woodland. These are:

- Upper Hunter White Box-Ironbark Grassy Woodland; and
- Hunter Floodplain Red Gum Woodland.

Grassland derived from the historical clearing of these communities are also included within the Box-Gum Woodland listing. Box-Gum Woodland is a TEC that has been nominated in the SEARs as a Matter Requiring Further Consideration.

The other two TECs recorded in the Study Area are:

- *Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions*; and
- *Hunter Valley Foothills Slaty Gum Woodland in the Sydney Basin Bioregion*.

These TECs are both listed under the TSC Act but are not listed under the EPBC Act. Grassland derived from the clearing of these communities are not included within the TEC listings.

iii. Biometric Vegetation Types used in the FBA

The BVTs assigned to each MU for the purpose of carrying out FBA calculations is summarised in **Table 6.2**. For each BVT/MU, the table lists the corresponding PCT number, vegetation class and formations, condition (as defined by the FBA) and percentage value cleared within the catchment area.

Table 6.1 Vegetation Map Units within the Study Area

Map Unit	Vegetation Map Unit name, as referred to in this Biodiversity Assessment Report	Legal Status ¹		Conservation Listing	Area of Vegetation within Study Area (ha)
		TSC Act	EPBC Act		
MU 1	Upper Hunter White Box-Ironbark Grassy Woodland	EEC	CEEC	Conforms to Box-Gum Woodland. This community is dominated by White Box - Grey Box intergrades.	93.6
MU 2	Upper Hunter White Box-Ironbark Grassy Woodland Derived Native Grassland	EEC	CEEC	Conforms to Box-Gum Woodland	159.2
MU 3	Hunter Floodplain Red Gum Woodland	EEC	CEEC	Conforms to Box-Gum Woodland. Conforms to Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions, listed under the TSC Act only.	39.4
MU 4	Hunter Floodplain Red Gum Woodland Derived Native Grassland	EEC	CEEC	Conforms to Box-Gum Woodland	10.1
MU 5	Central Hunter Box-Ironbark Woodland	EEC	-	Conforms to Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions.	477.4
MU 6	Narrabeen Footslopes Slaty Box Woodland	VEC	-	Conforms to Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion.	98.8
MU 7	Central Hunter Bulloak Forest Regeneration	-	-	Not listed	55.6
MU 8	Hunter Valley River Oak Forest	-	-	Not listed	2.2

Table 6.1 Vegetation Map Units within the Study Area

Map Unit	Vegetation Map Unit name, as referred to in this Biodiversity Assessment Report	Legal Status ¹		Conservation Listing	Area of Vegetation within Study Area (ha)
		TSC Act	EPBC Act		
MU 9	Cooba Scrub	-	-	Not listed	52.1
MU 10	Planted Vegetation	-	-	Not listed	8.3
MU 11	Other Grassland – moderate/good condition	-	-	Not listed	2304.0
MU 12	Other Grassland – low condition	-	-	Not listed	1264.8
	Total Area of Vegetation within the Study Area (to the nearest whole hectare)				4565

¹As listed under the Schedules of the TSC Act and EPBC Act.

Key: EEC = endangered ecological community; CEEC = critically endangered ecological community; VEC = vulnerable ecological community.

Table 6.2 Vegetation Map Units and relationship to Biometric Vegetation Types

Map Unit (MU)	Vegetation Map Unit name, as referred to in this Biodiversity Assessment Report	Threatened Ecological Community (TEC)	Plant Community Type (PCT)	Biometric Vegetation Type (BVT)	% Cleared*	Vegetation Type, as used in the Vegetation Information System (VIS) Classification Database	Condition	Keith Formation	Keith Vegetation Class	Extent within Study Area (ha)	Extent within Project Disturbance Footprint (ha)
MU 1	Upper Hunter White Box-Ironbark Grassy Woodland	- Listed TSC Act, E: White Box Yellow Box Blakely's Red Gum Woodland - Listed EPBC Act, CE: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	1606	HU620	29%	White Box - Narrow-leaved Ironbark - Blakely's Red Gum shrubby open forest of the central and upper Hunter	Mod/Good	CH6B Dry Sclerophyll Forests (Shrubby sub-formation)	New England Dry Sclerophyll Forests	93.6	3.8
MU 2	Upper Hunter White Box-Ironbark Grassy Woodland Derived Native Grassland	- Listed TSC Act, E: White Box Yellow Box Blakely's Red Gum Woodland - Listed EPBC Act, CE: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	1606	HU620	29%	White Box - Narrow-leaved Ironbark - Blakely's Red Gum shrubby open forest of the central and upper Hunter	Mod/Good - Poor - GL	CH6B Dry Sclerophyll Forests (Shrubby sub-formation)	New England Dry Sclerophyll Forests	159.2	2.7
MU 3	Hunter Floodplain Red Gum Woodland	- Listed TSC Act, E: Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions - Listed TSC Act, E: White Box Yellow Box Blakely's Red Gum Woodland - Listed EPBC Act, CE: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	42	HU599	95%	River Red Gum / River Oak riparian woodland wetland in the Hunter Valley	Mod/Good	CH 9 Forested Wetlands	Eastern Riverine Forests	39.4	10.9
MU 4	Hunter Floodplain Red Gum Woodland Derived Native Grassland	- Listed TSC Act, E: White Box Yellow Box Blakely's Red Gum Woodland - Listed EPBC Act, CE: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	42	HU599	95%	River Red Gum / River Oak riparian woodland wetland in the Hunter Valley	Mod/Good - Poor - GL	CH 9 Forested Wetlands	Eastern Riverine Forests	10.1	4.3
MU 5	Central Hunter Box-Ironbark Woodland	- Listed TSC Act, E: Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions	1691	HU905	79%	Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	Mod/Good	CH3 Grassy Woodlands	Coastal Valley Grassy Woodlands	477.4	150.9
MU 6	Narrabeen Footslopes Slaty Box Woodland	- Listed TSC Act, E: Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion	1176	HU618	40%	Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion	Mod/Good	CH6B Dry Sclerophyll Forests (Shrubby sub-formation)	Western Slopes Dry Sclerophyll Forests	98.8	97.0
MU 7	Central Hunter Bullock Forest Regeneration	Not listed	1692	HU906	53%	Bull Oak grassy woodland of the central Hunter Valley	Mod/Good	CH3 Grassy Woodlands	Coastal Valley Grassy Woodlands	43.0	25.9
MU 8	Hunter Valley River Oak Forest	Not listed	485	HU712	50%	River Oak riparian grassy tall woodland of the western Hunter Valley (Brigalow Belt South Bioregion and Sydney Basin Bioregion)	Mod/Good	CH 9 Forested Wetlands	Eastern Riverine Forests	2.2	2.2
MU 9	Coocha Scrub	Not listed	1691	HU905	79%	Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	Mod/Good - Other - Shrubby	CH3 Grassy Woodlands	Coastal Valley Grassy Woodlands	64.7	-
MU 10	Planted Vegetation	Not listed	n/a	n/a	n/a	n/a	n/a	N/A	N/A	8.3	-
MU 11	Other Grassland	Not listed	1691	HU905	79%	Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	Mod/Good - Poor - GL	CH3 Grassy Woodlands	Coastal Valley Grassy Woodlands	2,304.0	981.0
MU 12	Other Grassland	Not listed	1691	HU905	79%	Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	Low - GL	CH3 Grassy Woodlands	Coastal Valley Grassy Woodlands	1,264.8	159.4
TOTALS										4,565	1,438

*This is the percent cleared value of the PCT in the major catchment area
E = Endangered; CE = Critically Endangered

6.1.2 Drayton Mine

Vegetation units described for the minor additional mining areas at Drayton Mine (**Table 6.3** and **Figure 9**) are based on the vegetation map provided in the Drayton Mine Extension Flora and Fauna Impact Assessment (Hansen Bailey, 2007), which was updated using the latest survey results. The vegetation that occurs in the minor additional mining areas at Drayton Mine is dominated by rehabilitated exotic grasslands. The small areas of woody vegetation comprise planted trees and shrubs and very young regeneration.

The vegetation in the minor additional mining areas at Drayton Mine is highly modified and has been almost entirely cleared in the past. Infrastructure, such as a gravel-based erection pad and an industrial dam, and rehabilitated exotic grassland cover most of the minor additional mining areas and very little native vegetation remains. Much of the grassland areas are currently dominated by weeds and exotic pasture species.

A small area (0.4 ha) of woody regeneration conforms to *Hunter Lowland Redgum Forest*, which is a TEC listed under the TSC Act. This occurrence is highly modified and has little opportunities for recovery.

Table 6.3 Vegetation in the Minor Additional Mining Areas at Drayton Mine

Vegetation Community	Status		Area of Vegetation (ha)
	TSC Act	EPBC Act	
Acacia Revegetation Area	-	-	1.2
Other Grassland	-	-	7.4
Hunter Lowland Red Gum Forest	EEC	-	0.4
Exotic Grassland	-	-	10.2
TOTAL Vegetation			19
Industrial Dam	na	na	6.6
North Pit Erection Pad	na	na	2.6
Cleared Land	na	na	8.1
TOTAL Area			37

Key: EEC = Endangered Ecological Community

6.1.3 Vegetation Listed under the EPBC Act

This section summarises the likelihood of occurrence of threatened communities that are listed under the EPBC Act, regardless of whether they have been recorded in the Study Area during field surveys. Two communities, Box-Gum Woodland and Weeping Myall Woodlands (**Table 6.4**), were considered based on:

- The presence of suitable habitat; or
- Field survey results; or
- The EPBC Act PMST (DoE, 2015) search results; or
- Known occurrences in the locality of the Study Area.

As aforementioned, Box-Gum Woodland has been recorded within the Study Area. Weeping Myall Woodland has not been recorded within the Study Area. These communities are briefly discussed below.

A more comprehensive discussion is provided in **Appendix A**, which contains summary of assessment of MNES as required under the EPBC Act.

Table 6.4 Likelihood of Occurrence of TECs Listed under the EPBC Act in the Study Area

Common Name	EPBC Status	Occurrence in Study Area	Likelihood
Box-Gum Woodland	CE	Present. 303 ha (grassland and woodland) mapped, comprising: - approximately 94 ha MU 1: Upper Hunter White Box-Ironbark Grassy Woodland; - approximately 40 ha MU 3: Hunter Floodplain Red Gum Woodland; and - approximately 169 ha of MU 2 and 4: Derived Native Grassland	Present
Weeping Myall Woodlands	E	Not present. Unlikely to occur with current land practices. See explanation in text.	Not likely

Key: E = Endangered; CE = Critically Endangered

i. *Box-Gum Woodland*

Status: CEEC (EPBC Act) *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland*; EEC (TSC Act) *White Box Yellow Box Blakely's Red Gum Woodland*

Box-Gum Woodland is an open grassy woodland community (sometimes occurring as a grassy forest formation) that is dominated by one or more of the following canopy species *Eucalyptus albens* (White Box), *Eucalyptus melliodora* (Yellow Box) and *Eucalyptus blakleyi* (Blakely's Red Gum). Box-Gum Woodland is widely distributed and comprises a number of different vegetation types. It can be found from the Queensland border in the north, to the Victorian border in the south. It also occurs in the tablelands and western slopes of NSW (OEH, 2012c).

The Study Area supports known occurrences of the Box-Gum Woodland, which is present as MU 1: Upper Hunter White Box-Ironbark Grassy Woodland and MU 3: Hunter Floodplain Red Gum Woodland. Native grassland derived from the historical clearance of these communities (i.e. MU 2 and 4), are considered to be a part of the Box-Gum Woodland listing where they meet the minimum condition thresholds detailed in the EPBC Act listing advice (Threatened Species Scientific Committee, 2006).

Box-Gum Woodland is a CEEC that has been nominated in the SEARs as a Matter Requiring Further Consideration. Additional information has also been provided within this biodiversity assessment report as per Section 9.2.5.2 of the FBA (OEH, 2014b).

ii. *Weeping Myall Woodland*

Status: EEC (EPBC Act) *Weeping Myall Woodlands*; EEC (TSC Act) *Hunter Valley Weeping Myall Woodland of the Sydney Basin Bioregion*

Weeping Myall Woodlands is an ecological community that generally occurs on heavy soils of flats, floodplains and undulating, arable landscapes. Weeping Myall Woodlands occurs as a mosaic of sparse to open woodlands and treeless shrublands and grasslands where Weeping Myall (*Acacia pendula*) trees are the sole or dominant overstorey species in these landscapes (SEWPaC, 2011f). A disjunct population of Weeping Myall Woodland occurs in the Hunter Valley at the eastern distributional limit of the species' range (Threatened Species Scientific Committee, 2008; SEWPaC, 2011f). The Hunter Valley population of Weeping Myall (*Acacia pendula*) is fewer than 1000 individuals, from six locations - Jerrys Plains, Edderton, Wybong, Appletree Creek, Warkworth and Appletree Flat. Individuals were also recorded in the locality during ecological studies for the Mt Arthur Coal Underground Project (Umwelt Environmental Consultants, 2007) but subsequent studies for Mt Arthur Coal have not relocated any records nor identified any additional individuals.

The community typically comprises a relatively dense or open tree canopy up to about 15 m tall, sometimes with an open understorey of semi-sclerophyllous shrubs, and a variable groundcover dominated by grasses or herbs. In disturbed stands the canopy may consist of either scattered trees or dense regrowth and the understorey may comprise relatively few native species above ground (Threatened Species Scientific Committee, 2008).

A patch of Weeping Myall must conform to the following criteria to be included in the EPBC Act listed ecological communities:

- Tree canopy dominated (at least 50% of trees present) by living, dead or defoliated Weeping Myall trees; and
- The overstorey with at least 5% tree canopy cover or at least 25 dead or defoliated mature Weeping Myall trees / ha; and
- An area at least 0.5 ha in size; and
- Either two layers of regenerating Weeping Myall present; or, the tallest Weeping Myall trees is at least 4 m tall and vegetative cover present is comprised of 50% native species.

Weeping Myall Woodland has not been recorded in the Study Area. No mature *Acacia pendula* (Weeping Myall) trees were present. Small patches of regrowth (less than 3 m tall) *Acacia pendula* (Weeping Myall) has been recorded at two locations in grassland (see **Section 6.2.2**). The understorey at one of these patches was eroded and almost absent of understorey species, including grasses. The understorey at the second patch was continuous with the surrounding grassland understorey. There is unlikely to be any occurrences of Weeping Myall Woodlands as listed under the TSC Act within the Study Area.

The occurrences of *Acacia pendula* (Weeping Myall) recorded in the Study Area do not form a patch of at least 0.5 ha and less than 4 m in height. As such, the regrowth does not currently form a patch that could constitute the EPBC listing for Weeping Myall Woodlands. There is, however, potential for the community to regenerate within the Study Area if cattle are excluded, immature trees are allowed to mature, and any surviving soil seed bank left to regenerate.

6.2 Flora Species

6.2.1 General Assemblage

Over 250 plant species were recorded within the Study Area. The majority of flora species are components of the ground strata, primarily composed of herbs and grasses. A comprehensive species list has been compiled from data collected from surveys of the Study Area and is presented in **Appendix C**.

The flora species present in the minor additional mining areas at Drayton Mine are comprised largely of exotic grasses and broad-leaved pasture weeds because the majority of the additional mining areas have been cleared in the past and rehabilitated. Few trees species and shrubs were recorded; those that were present are immature regrowth or were planted for visual screening. No threatened species were recorded in these areas or are likely to occur. For this reason, the remainder of this Chapter is discussed in relation to the Study Area.

6.2.2 Threatened Flora Species Recorded in the Study Area

A total of four threatened flora species listed under the TSC Act were recorded within the Study Area are discussed below and shown in **Figure 10**. No threatened flora species listed under the EPBC Act were recorded.

i. *Acacia pendula* (Weeping Myall)

Status: Endangered Population in the Hunter catchment (TSC Act)

Acacia pendula (Weeping Myall) is an erect or spreading small to medium tree 5 to 13 m high (Harden, 2002). The tree typically has a pendulous habit with long silver-grey phyllodes and hard, dark and fissured bark (Botanic Gardens Trust, 2011). The species occurs in woodlands, shrublands and grasslands and often forms low open woodland in heavy loam soils. *Acacia pendula* (Weeping Myall) is found principally on the slopes and plains of western NSW where the tree has widespread distribution (Tame, 1992) but forms a disjunct and small coastal population in the Hunter catchment area.

In the Hunter catchment, *Acacia pendula* (Weeping Myall) is known to occur on heavy soils on the margins of floodplains or sometimes in gently undulating landscapes. The Hunter catchment population is recognised to be distinct from the inland population and is often referred to as the 'Hunter Valley form' of the species. The Hunter Valley form of *Acacia pendula* (Weeping Myall) has the following characteristics:

- Does not reliably produce seed;
- Appears to be functionally sterile but spreads via suckering from the root system;
- As a result of suckering habit, produces close-spaced clonal clumps as opposed to multiple clumps from multiple seed germination events; and
- Has a distinctly non-pendulous habit, sometimes with erect branchlets.

Regenerating *Acacia pendula* (Weeping Myall) was recorded in the Study Area in grassland at two locations near Saddlers Creek during surveys by Cumberland Ecology. The species has also been recorded from surveys of the Mt Arthur Coal Mine lease (Umwelt Environmental Consultants, 2007; Cumberland Ecology, 2009) and Mangoola Coal Mine lease (Umwelt Environmental Consultants, 2006a). There are 85 records of the species within the locality (OEH, 2015).

At the eastern location, approximately 15 plants are estimated to be present in a diffuse patch. The numbers of individual plants (i.e. clonal clumps) were estimated based on the clumping distribution of regeneration/suckering observed. At this location, the patch was characterised by the occurrence of a few shrub-sized individuals surrounded by very low and sparse regeneration/suckers (**Photograph 6.1**). The plants at this location appear to be frequently grazed, most likely by cattle.



Photograph 6.1 *Acacia pendula* clonal clump at the eastern patch in the Study Area

At the western location, approximately two individuals are estimated to be present as a tight patch occurring on the embankment of Saddlers Creek. The numbers of individual plants were estimated based on the clumping pattern of regeneration. The size and health of the regeneration of this patch is more vigorous than the first patch (**Photograph 6.2**).

The occurrence of regenerating *Acacia pendula* (Weeping Myall) suggests that a larger population existed prior to clearing. The regeneration does not currently conform to the TSC Act- and EPBC Act-listing for Weeping Myall Woodlands (see **Section 6.1.3ii**).



Photograph 6.2 *Acacia pendula* clonal clump at the western patch along Saddlers Creek

ii. *Eucalyptus camaldulensis* (River Red Gum)

Status: Endangered Population in the Hunter catchment (TSC Act)

Eucalyptus camaldulensis (River Red Gum) is the most widespread eucalypt in Australia and prior to European settlement formed extensive stands of woodland on floodplains (Botanic Gardens Trust, 2011). In NSW, the species is found along most western flowing rivers. The Hunter catchment is the only coastal catchment in which the species has been recorded. A disjunct population forms at the limit of range of the species. The Hunter population is approximately 100 ha comprised of 19 remnant stands. Regeneration of this community is low as a result of clearing, changes to hydrology, tree dieback, grazing and weed infestation (NSW Scientific Committee, 2005a).

Eucalyptus camaldulensis (River Red Gum) was recorded as a single individual along the southern portion of Saddlers Creek west of Edderton Road (**Photograph 6.3**). It is considered likely that seedlings and other individuals are present elsewhere along the creek and floodplain. There are 524 records of the species within the locality (OEH, 2015).



Photograph 6.3 *Eucalyptus camaldulensis* tree on Saddlers Creek, west of Edderton Road

iii. *Cymbidium canaliculatum* (Tiger Orchid)

Status: Endangered Population within the Hunter catchment (TSC Act)

Cymbidium canaliculatum (Tiger Orchid) is a large epiphytic orchid that grows in tree hollows in dry sclerophyll forests and woodlands of tablelands and western slopes of NSW. The Hunter catchment population is at the south eastern limit of the geographic range for this species (Peake, 2006).

Within the Hunter catchment, the species is commonly found in woodlands dominated by *Eucalyptus albens* (White Box), usually occurring singly or as a single clump between 2 and 6 m above the ground (NSW Scientific Committee, 2011a). The species has been found, less commonly, to grow on *Eucalyptus dawsonii* (Slaty Box), *Eucalyptus crebra* (Narrow-leaved Ironbark), *Eucalyptus moluccana* (Grey Box), *Angophora floribunda* (Rough-barked Apple) and *Acacia salicina* (Cooba) (Peake, 2005).

A single Tiger Orchid individual was recorded during the 2009 surveys of the Study Area in a tree on the edge of Narrabeen Foothills Slaty Box Woodland. This species has been recorded along a tributary of Saddlers Creek and within MU 7: Central Hunter Bullock Forest Regeneration in the southern extent of the Mt Arthur Coal Mine lease (Cumberland Ecology, 2009). It has also been recorded at Mangoola Mine (Umwelt (Australia) Pty Limited, 2010).

The species may be represented in the general area as scattered individuals in association with Saddlers Creek. There are 32 records of the species within the locality (OEH, 2015).

iv. *Diuris tricolor* (Pine Donkey Orchid)

Status: Vulnerable (TSC Act) and Endangered Population in the Muswellbrook LGA (TSC Act)

Diuris tricolor (Pine Donkey Orchid) is a deciduous (i.e. loses its leaves seasonally), terrestrial orchid with sparse distribution on the western slopes of NSW. Outside of flowering periods, *Diuris tricolor* is known to persist via tuber dormancy. The species is generally found in sclerophyll vegetation on flats or small rises, on a range of substrates including sandy or loamy soils. *Diuris tricolor* experiences short flowering events any time between early September to late October (Umwelt Environmental Consultants, 2008; Botanic Gardens Trust, 2011) and is unlikely to be readily detectable outside of flowering season.

The Muswellbrook population exists at the eastern limit of the species' range and comprises a number of occurrences ranging from scattered individuals to large colonies consisting of a few thousand individuals (NSW Scientific Committee, 2006). This population is disjunct from other populations and highly restricted in its geographic distribution, found within an area measuring less than 50 km². The population also has particularly large flowers relative to other populations of the species. There are 144 records of the species within the locality (OEH, 2015).

The Muswellbrook population occurs as individuals or localised colonies in open grassy woodland often associated with Box-Gum Woodland (DEC (NSW), 2005k). It has been recorded in Box-Gum Woodland within 10 km of the Study Area in the Mt Arthur Coal Mine lease near the Access Road, and also in the Drayton Wildlife Refuge. It has also been recorded at Mangoola Mine (Umwelt, 2010). In addition to woodland habitat, *Diuris tricolor* has also been found in derived native grassland near tracks or in areas of recent disturbance where there may be better access to resources such as light and space.

In the Study Area, two individuals of *Diuris tricolor* (Pine Donkey Orchid) were recorded during 2009 surveys. The plants were found in MU 3: Hunter Floodplain Red Gum Woodland at an advanced stage of flowering. Targeted searches conducted by Cumberland Ecology in November 2010 did not detect any individuals but at least 30 additional plants were recorded in peak flower during the 2011 spring surveys in the same general area. It is likely that more individuals are present. Photographs of the plants and the habitat they were recorded in are shown in **Photograph 6.4 – 6.6**.

Diuris tricolor (Pine Donkey Orchid) is a threatened species that has been nominated in the SEARs as a Matter Requiring Further Consideration. Additional information has been provided within this biodiversity assessment report as per Section 9.2.5.2 of the FBA (OEH, 2014b).



Photograph 6.4 **Threatened Orchid *Diuris tricolor* Recorded within the Study Area**



Photograph 6.5 ***Diuris tricolor* in Open Grassy Understorey**

Note: Diuris tricolor in open grassy understorey among a diversity of ground cover forbs and graminoids.



Photograph 6.6 **Open grassy Box-Gum Woodland Habitat where *Diuris tricolor* was Recorded**

6.2.3 *Potential Threatened Flora Species*

This section describes threatened flora species that have not previously been recorded within the Study Area but are considered to have the potential to occur due to the availability of suitable habitat and as indicated by the OEH Atlas of NSW Wildlife (OEH, 2015) records and/or the EPBC Act PMST (DoE, 2015).

For a comprehensive overview, threatened species known from and predicted for the locality have been analysed for their likelihood of occurrence in the Study Area. This analysis is presented in **Appendix D** and includes:

- TSC Act listed threatened flora species recorded from the locality (OEH, 2015);
- EPBC Act listed species predicted to occur based on availability of habitat in the locality (DoE, 2015).
- Threatened species recorded from multiple surveys of the Mt Arthur Coal Mine lease, which adjoins the Study Area and has similar vegetation and habitat features.

Two additional flora species with the potential to occur within the Study Area, namely *Prasophyllum* sp. Wybong (Leek-orchid) and *Thesium australe* (Austral Toadflax) are described in detail below.

i. *Prasophyllum* sp. Wybong (Leek-orchid)

Status: Critically Endangered (EPBC Act)

a. Record Details

Prasophyllum sp. Wybong (a leek orchid) has not been recorded within the Study Area. There are no records of the species from the locality on the Atlas of NSW Wildlife database (OEH, 2011a). However, the species is known from seven population locations including a Muswellbrook population to the north of the Study Area. The species was also recorded at Mangoola Mine (Eastcoast Flora Survey, 2009). These populations are highly localised.

b. Habitat and Ecology

Prasophyllum sp. Wybong is a terrestrial perennial orchid that grows to approximately 30 cm in height and appears as a single leaf and single flower spike with numerous fragrant flowers in winter and spring. The species dies back to a tuber over summer and autumn. The species is endemic to NSW and generally found in shrubby and grassy habitat on wet soils, as well as in open eucalypt woodland and grassland (Threatened Species Scientific Committee, 2009a; SEWPaC, 2011e).

The species has not been recorded within the Study Area; however it is considered to have a low potential to occur based on the availability of suitable habitat in the Study Area and the proximity of the Muswellbrook population.

ii. *Thesium australe* (Austral Toadflax)

Status: Vulnerable (EPBC Act) and Vulnerable (TSC Act)

a. Record Details

Thesium australe (Austral Toadflax) is a short-lived herbaceous shrub with long wiry stems up to 30 cm. It is parasitic on the roots of other plants, particularly kangaroo grass (*Themeda australis*) (Tas. DPIPWE, 2003). The species occurs in grassland and grassy woodlands, with strong associations with Kangaroo Grass.

b. Habitat and Ecology

The species is distributed along the coast and ranges regions of Queensland, NSW and Victoria. No records for the species are available from the Atlas of NSW Wildlife for the locality (OEH, 2015). *Thesium australe* (Austral Toadflax) has not been recorded in the Study Area. Despite the Study Area and its surrounds being extensively studied, the species is only known from two localised populations detected elsewhere in the Muswellbrook LGA; one at Mangoola Mine in recent years (Umwelt (Australia) Pty Limited 2010b); and another on a property to the north west of Muswellbrook in 2011. To date those small occurrences are the only recorded occurrences within the Upper Hunter Valley.

Thesium australe (Austral Toadflax) has a strong association with *Themeda australis* (Kangaroo Grass), which is not common in the Study Area; it is also relatively short-lived and

very sensitive to grazing, clearing for agriculture and trampling. As the Study Area has been extensively cleared, this species has been assessed as having a very low potential to occur in the Study Area.

6.2.4 Invasive Flora Species

More than 40 invasive flora species were recorded within the Study Area. Of these, two species, namely *Opuntia stricta* (Prickly Pear) and *Lycium ferocissimum* (African Boxthorn), are declared as noxious under the *Noxious Weeds Act 1993* for the Upper Hunter County Council, which incorporates the Muswellbrook and Singleton LGAs, while *Opuntia stricta* (Prickly Pear) also has an 'all of NSW' declaration (DPI Agriculture). *Opuntia stricta* (Prickly Pear) was found in low abundance in multiple quadrats across the Study Area, while a few individuals of *Lycium ferocissimum* (African Boxthorn) were recorded within one quadrat in Bulloak Forest. Both are Class 2 noxious weeds, meaning that their growth and spread must be controlled according to the measures specified in a management plan published by the local control authority. Sale, propagation or the intentional distribution of the species are also prohibited.

The majority of invasive weeds in woodland and grassland are typically restricted to perennial species such as pasture-derived groundcovers, including many Asteraceae species, grasses and thistles. A high proportion of weeds exist in all strata along the banks of the Hunter River, including *Salix babylonica* (Weeping Willows). Weeds are common due to a combination of the following disturbance factors: bank disturbance; surrounding cropping and grazing; increased shade, nutrients and moisture; and the spread of propagules by fauna and from upstream sources. In-stream vegetation along Saddlers Creek was dominated by exotic reeds and rushes such as *Juncus acutus* (Sharp Rush).

6.2.5 Flora Species listed under the EPBC Act

This section summarises the likelihood of occurrence of threatened flora species that are listed under the EPBC Act, regardless of whether they have been recorded in the Study Area during field surveys. The species discussed in **Table 6.5** below were included for consideration based on incidence of suitable habitat and as indicated by the EPBC Act PMST (DoE, 2015) and/or presence of records in the locality of the Study Area.

As described above, the Study Area has a low potential to support Leek-orchid (*Prasophyllum* sp. Wybong) and Austral Toadflax (*Thesium australe*). No other threatened flora species are considered likely to occur in the Study Area.

These species are discussed in greater detail in **Appendix A**, which contains summary of assessment of MNES as required under the EPBC Act.

Table 6.5 Likelihood of Occurrence of Flora Species Listed under the EPBC Act in Study Area

Common Name	EPBC Status	Occurrence in Study Area	Likelihood of Occurrence
Slaty Red Gum (<i>Eucalyptus glaucina</i>)	V	Not recorded. Low potential to occur. Suitable habitat is present in the Study Area but not detected in flora surveys.	Low likelihood
Rufous Pomaderris (<i>Pomaderris brunnea</i>)	V	Not recorded. Unlikely to occur. Not detected in flora surveys. The Study Area is likely to be just outside of the typical range of the species.	Unlikely
Leek-orchid (<i>Prasophyllum</i> sp. Wybong (C. Phelps ORG 5269))	CE	Not recorded. Low potential to occur. Suitable habitat available but outside of the 7 known populations.	Low likelihood
Illawarra Greenhood (<i>Pterostylis gibbosa</i>)	E	Not recorded. Unlikely to occur. Not detected in flora surveys, and outside of known range in the Hunter.	Unlikely
Austral Toadflax (<i>Thesium australe</i>)	V	Not recorded. Low potential to occur. Not detected during extensive flora surveys of the Study Area and generally not found in the Upper Hunter Valley. However, ostensibly suitable habitat is available and localised populations were detected elsewhere in the Muswellbrook LGA at Mangoola Mine in recent years and on another property to the north west of Muswellbrook in 2011. To date those small occurrences are the only recorded occurrences within the Upper Hunter Valley.	Low likelihood

Key: V = Vulnerable; E = Endangered; CE = Critically Endangered

6.3 Fauna Habitat

Fauna habitat is considered a species-specific concept (Fischer and Lindenmayer, 2007) and is broadly defined as the range of environments that a particular species utilises. What constitutes suitable habitat depends on the requirements of a given species to successfully maintain a viable population. Notwithstanding this, there are general environment types and landscape features that have been long recognised as providing habitat for a range of fauna species. These will be discussed in further detail in this section.

6.3.1 *Extant Habitat*

Extensive vegetation clearing has removed much of the original habitat that was present in the Study Area. Most of the Study Area now comprises open areas of grassland. Remaining woodland vegetation has either regenerated from clearing and is very young and structurally simple; or has been modified from its original state through degradation by fragmentation, ongoing agriculture and structural simplification (i.e. by clearing or thinning activities). Clearance and grazing have removed the majority of ground habitat features such as logs and rocks from grassland, while a lack of large old growth trees has limited the number and size of hollows available in the Study Area. Despite the modified nature, the Study Area still provides habitat for fauna. The key habitat types in the Study Area are:

- Remnant forest and woodland;
- Regenerating shrubland (e.g. Cooba Scrub) and forest (e.g. Bulloak Forest Regeneration);
- Grassland;
- Planted trees;
- Riparian habitat; and
- Aquatic habitat (e.g. farm dams and creeklines such as Saddlers Creek)

The minor additional mining areas at Drayton Mine also predominantly comprise open areas of grassland that are largely exotic or have been rehabilitated for soil stabilisation. A small proportion of the vegetation is represented by immature woody regeneration or shrub plantings that are structurally very simple. These woody regrowths and plantings provide no hollows or other significant habitat features. The key habitat types in the minor additional mining areas at Drayton Mine are:

- Regenerating forest (i.e. regrowth Hunter Lowland Redgum Forest);
- Grassland;
- Planted trees; and
- Aquatic habitat (i.e. the industrial dam).

Although the industrial dam in one of the additional mining areas is an artificial water body, it could potentially provide limited aquatic habitat for some native species.

A description and general discussion of the various habitat types available is provided below.

6.3.2 Remnant Forest and Woodland

Remnant forest and woodland across the eastern portion of the Study Area are generally open with a grassy groundcover and feature deep beds of leaf litter. Although young, these vegetated areas are mature and at a later stage of regeneration such that they represent mixed-aged stands, which support a reasonably complex understorey and overstorey structure to make them valuable to a range of fauna species. For more mobile species, the remnant woodland patches within the Study Area provide good connectivity to surrounding remnant patches outside of the Study Area (pers. comm. Stojanovic, 2011). Other habitat values that are associated with these remnant stands include the following:

- Mixed-age trees and understorey vegetation that provides breeding habitat, foraging habitat and refuge sites for woodland birds, bats, other small mammals and reptiles;
- Ground cover, leaf litter, fallen timber, and limited rocky outcrops suitable as shelter for small arboreal and terrestrial fauna species;
- Tree hollows in stags and mature trees that provide shelter and breeding habitat for a range of hollow-dependant fauna (see **Section 6.3.2i**);
- Blossom-producing trees suitable as forage habitat for a range of nectarivores (see **Section 6.3.2ii**); and
- Woodland margin habitat at the woodland-grassland interface, which provide a combination of foraging habitat and refuge for ground-foraging fauna (see **Section 6.3.2iii**);

A number of the woodland patches were comprised of mature remnant trees, many with various sized hollows, scattered amongst younger regenerating trees and some small shrubs that provide habitat for a range of commonly-occurring and threatened arboreal mammals, bats and birds. Cover and densities of habitat features such as stags, fallen logs, woody debris including bark, and thick leaf litter varied between patches but overall offer shelter and forage habitat for small terrestrial fauna and birds.

Signs of mammal activity included scats and scratch marks on the older trees, while macropods and possums were commonly observed. Various common woodland bird species were recorded nesting in hollows and foraging on the ground or in the canopy of trees. A number of threatened avifauna species, including the Speckled Warbler (*Chthonicola sagittata*) and Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*) were detected in this habitat type as well as hollow-dependent bat species (**Figure 10**).

A general assessment of the value of the remnant forest and woodland habitat present in the Study Area for various faunal groups is summarised in **Table 6.6**. It shows that the Study Area supports woodland and forest patches that represent a mixture of moderately valuable to highly valuable habitat for bats, and woodland and nectar-feeding birds. The woodland and forest habitats are also moderately valuable for arboreal mammals and reptiles but do not provide much habitat for amphibians and terrestrial mammals.

Table 6.6 Qualitative Assessment – Remnant Forest and Woodland Habitat

Faunal Group	Low Value	Moderate Value	High Value
Amphibians	X		
Birds- nectarivorous		X	X
Birds- woodland		X	X
Birds- raptors		X	
Mammals- arboreal		X	
Mammals- terrestrial	X	X	
Microbats			X
Reptiles		X	

There is no remnant forest or woodland habitat in the minor additional mining areas at Drayton Mine. The woody vegetation in the minor additional mining areas are regenerating woodland or plantings and do not provide multi-aged stands, sizable tree hollows, woodland margin habitats or significant feed trees.

i. Hollow Resources

During general habitat assessments, the presence of tree hollows was observed in many of the more mature woodland habitats and was noted as being more abundant in box canopy species than other tree species. Some examples are shown in **Photograph 6.7 to 6.10**.

Hollows are a limiting resource for many fauna species and would thus be an important habitat resource in the Study Area. Considering that hollow abundance is typically overestimated in ground-based assessments (Gibbons *et al.*, 2000; Harper *et al.*; Koch, 2008; Rayner *et al.*, 2010), the number of hollows that is likely to be present in the Study Area is expected to be much lower than that observed during habitat assessments. Therefore, the availability of tree hollows in the Study Area is likely to be very limited and in high demand by hollow-using fauna.



Photograph 6.7 A Large Tree Hollow in the Study Area



Photograph 6.8 Australian Kestrel in a Tree Hollow (Photo: D. Stojanovic, 2011)



Photograph 6.9 Stag Providing Valuable Large Hollows



Photograph 6.10 A Typical Hollow-bearing Tree in the Study Area

Note the ground debris, which provides valuable habitat for ground-dwelling fauna

Hollow specificity is also likely to increase the pressure on the remaining hollows in the Study Area for hollow-using fauna because the number of serviceable hollows for any individual species is much less than the number that is actually present. Different fauna species typically have specific hollow requirements that depend on surrounding vegetation community; tree species; habit; height; diameter at breast height (dbh); crown spread and

fire scars; number and height of hollows from the ground; minimum entrance width and depth; and landscape factors such as aspect, topographic position and slope (Lindenmayer *et al.*, 1990b; Gibbons *et al.*, 2002; Remm *et al.*, 2008). Competition for remaining functional hollows would thus place more pressure on this resource.

ii. *Feed Trees*

Nectarivorous bird species require habitat containing suitable feed trees that allows foraging throughout the year. Flowering times for trees found in forest and woodland communities within the Study Area are shown in **Table 6.7**.

During winter surveys, *Eucalyptus albens* (White Box), *Eucalyptus moluccana* (Grey Box) and planted *Eucalyptus sideroxylon* (Mugga Ironbark), which are valuable blossom trees for wintering migrant bird species, were found to be in flower and to have abundant blossoms. Psyllid lerps were also observed in a range of eucalypt species across the Study Area (Stojanovic, 2011).

Table 6.7 Flowering Periods for Dominant Tree Species

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<i>Angophora floribunda</i>	X	X										X
<i>Eucalyptus albens</i>			X	X	X	X						
<i>E. blakelyi</i>								X	X	X	X	X
<i>E. crebra</i>	X				X	X	X	X	X	X	X	X
<i>E. dwyeri</i>							X	X	X	X	X	
<i>E. melliodora</i>	X	X							X	X	X	X
<i>E. moluccana</i>	X	X	X	X								
<i>E. punctata</i>	X	X	X									X
<i>E. tereticornis</i>						X	X	X	X	X	X	

(Source: Boland *et al.*, 1984; Brooker and Kleinig, 1990)

iii. *Woodland Margins*

Woodland margins are mentioned because they provide limited habitat for ground-foraging fauna, such as small woodland birds, that tend to forage in lightly wooded areas amongst scattered native grass tussocks and timber debris under an open canopy but within proximity of the protective cover of trees and shrubs (**Photograph 6.11**). Threatened birds such as the Diamond Firetail (*Stagonopleura guttata*) and Hooded Robin (*Melanodryas cucullata cucullata*) often occur and forage on the margins of woodland or in open forests near clearings. These species use the proximity of the woodland to provide quick access to shelter (Pizzey and Knight, 2003). Woodland margin habitat in the Study Area was generally considered to provide low to moderate fauna habitat (refer to **Table 6.8**).

Ground habitat features, such as logs and other timber debris, have largely been removed at the fringes of woodland for the establishment of grazing pastures and other agricultural activities. However, the progression of woodland regeneration, which is present and most noticeable at woodland margins due to the availability of light and space, is restoring some habitat complexity to these areas.

Table 6.8 Qualitative Assessment – Woodland Margins

Faunal Group	Low Value	Moderate Value	High Value
Amphibians	X		
Birds- nectarivorous	X		
Birds- woodland	X		
Birds - raptors		X	
Mammals- arboreal	X		
Mammals- terrestrial		X	
Microbats	X		
Reptiles	X		



Photograph 6.11 Woodland Margins and Scattered Trees

Note: Woodland margins and scattered trees provide low to moderate habitat for a range of fauna

6.3.3 *Regenerating Shrubland and Forest*

Regenerating shrublands and forests, such as the regenerating Cooba Scrub and the Central Hunter Bullock Forest Regeneration areas, have limited habitat value because they are largely even-aged stands, have simple structures, little ground cover, limited species diversity and contain few stags or hollows that are typical of older stands of vegetation. Nevertheless, the regenerating vegetation in the Study Area is mature enough to provide additional flowering resources as well as sheltering sites for woodland birds. These shrublands and regenerating forests also provide “stepping stone” connections among larger vegetated patches, which facilitate the movement of such species that have limited mobility like most of the threatened woodland birds recorded in the Study Area.

The regenerating area of Hunter Lowland Redgum Forest and the acacia plantings in the minor additional mining areas at Drayton Mine are too small and of an unsuitable configuration (being linear and possessing no significant width) to provide sheltering sites for fauna like woodland birds. They are also too isolated from larger vegetated patches to be an effective “stepping stone” connection. Foraging resources for microbats, birds and arboreal mammals is also limited as the canopy trees present are relatively immature and if able to flower, are unlikely to produce flowers reliably or abundantly compared with mature trees. The trees are also not old enough to provide substantial hollows.

6.3.4 *Grassland*

Grassland habitat generally provides low fauna habitat due to a lack of woody vegetation and ground debris for cover (refer to **Table 6.9**). Most native fauna species are found in treed habitats, however, native tussock grasslands can provide sparse habitat for native fauna species because they provide a degree of groundstorey complexity and seed resources, even where the grasslands are still used for light grazing.

Grassland vegetation is the most widespread habitat type in the Study Area (**Photograph 6.12**). A range of native and naturalised grass and forb species dominate this community, and upper storey layers are generally non-existent except for a few scattered trees that do not conform to woodland. The composition and diversity of native species varies as a result of ongoing grazing; however a large portion of grassland is derived from the understorey of woodland and forest communities that have been cleared in the past and so still retain a proportion of native groundcover species. Some areas of grassland include woody debris and leaf litter cover; however, other areas that were cropped or grazed are devoid of such habitat features.

The open grasslands in the Study Area generally provide suitable foraging habitat for large mammals, including macropods like the Eastern Grey Kangaroo (*Macropus giganteus*) and Red-necked Wallaby (*Macropus rufogriseus*). The grassland can also provide shelter and forage habitat for small mammals in areas where there is an adequate layer of tussock grass, and microhabitats exist under timber and rocks for reptiles. Large open areas provide ample foraging habitat for insectivorous and granivorous birds, and hunting resources for raptors, owls and some bat species.

Table 6.9 Qualitative Assessment – Grassland Habitat

Faunal Group	Low Value	Moderate Value	High Value
Amphibians	X		
Birds- nectarivorous	X		
Birds- woodland			X
Birds- raptors		X	
Mammals- arboreal	X		
Mammals- terrestrial			X
Microbats	X		
Reptiles	X		

Rehabilitated grasslands are the most widespread habitat in the minor additional mining areas at Drayton Mine (**Photograph 6.13**). Due to the proximity of these grasslands to existing mining and associated disturbances, much of these areas are degraded by mat-forming pasture grasses and broad-leaved weeds, and cleared of woody ground debris and leaf litter. All of these elements limit the habitat amenity of the grassland in the minor additional mining areas for species such as woodland birds and ground-dwelling fauna.

i. Scattered Paddock Trees in grassland

Scattered paddock trees in grassland can be a typical feature of the agricultural matrix. An abundance of mature trees are present throughout the Study Area, particularly in the eastern sections of the Study Area where agricultural use is less intensive than in the western sections. In fragmented agricultural landscapes like the Hunter Valley region, scattered paddock trees are considered important keystone features critical for the viability of various fauna populations because they:

- Offer roosting and nesting habitat for some bird and bat species;
- Provide hollows or the potential for hollows that supply nesting and roosting sites for microbats, small arboreal mammals, some woodland and forest birds, and larger birds of prey;
- Supply food such as seasonal flowering resources for nectarivorous birds and bats;
- Provide “stepping stones” among larger vegetated patches (if occurring in high enough densities) that facilitates the movement of species of limited mobility;
- Provide shade for terrestrial fauna such as macropods;
- Provide refugia for ground-dwelling mammals, microbats and small birds; and
- Provide sheltering sites for reptiles and amphibians.



Photograph 6.12 **Grassland Habitat in the Study Area Containing Scattered Paddock Trees**



Photograph 6.13 **Grassland Habitat in the Minor Additional Mining Areas at Drayton Mine**

6.3.5 Planted Trees

Eight (8) hectares of planted vegetation occurs along Edderton Road as a thin, linear strip of same-age and evenly spaced tree plantings that acts as a visual barrier and windbreak. It includes non-endemic species, such as *Eucalyptus sideroxylon* (Mugga Ironbark), *Corymbia maculata* (Spotted Gum), *Eucalyptus tereticornis* (Forest Red Gum), *Eucalyptus nicholii* (Narrow-leaved Black Peppermint) and a number of wattle species. There is no mid-storey vegetation and the ground stratum is generally bare with limited ground cover, leaf litter or debris (see detailed description in **Appendix B**).

The planted vegetation provides foraging and some nesting habitat for threatened bird species such as the Grey-crowned Babbler (*Pomatostomus temporalis*), which prefer a more structurally open habitat and has been observed to have active nests in this vegetation; and nectarivorous and winter migrant bird species such as the Swift Parrot (*Lathamus discolor*), which depend on winter flowering eucalypt species and has been observed to feed on blossoms of *Eucalyptus sideroxylon* (Mugga Ironbark) within this planted area.

6.3.6 Riparian Vegetation

Riparian vegetation represents valuable habitat as it contains mature trees with hollows, a grassy understorey and fallen timber and rocks in relatively close proximity to creeks and other water sources. Riparian vegetation can also represent movement corridors if they are extensive enough and connect large patches of vegetation in the wider locality.

The riparian forest vegetation present within the Study Area occurs along Saddlers Creek and its tributaries. Canopy species along the length of Saddlers Creek are highly variable and include *Eucalyptus melliodora* (Yellow Box), *Eucalyptus tereticornis* (Forest Red Gum), *Angophora floribunda* (Rough-barked Apple) and *Casuarina* species. The riparian vegetation in the Study Area has been highly modified from its original state and typically persists as very narrow and interrupted corridors along the creeklines.

Riparian habitat was generally considered to provide low to moderate fauna habitat (refer to **Table 6.10**). If riparian vegetation along Saddlers Creek were to be restored and rehabilitated, it can provide good quality seasonal flowering resources, foraging habitat, movement corridors and roosting and nesting habitat for small arboreal mammals and birds.

Table 6.10 Qualitative Assessment – Riparian Habitat

Faunal Group	Low Value	Moderate Value	High Value
Amphibians	X		
Birds- nectarivorous	X		
Birds- woodland	X		
Birds- raptors		X	
Mammals- arboreal	X		
Mammals- terrestrial	X		
Microbats	X		

Table 6.10 **Qualitative Assessment – Riparian Habitat**

Faunal Group	Low Value	Moderate Value	High Value
Reptiles	X		

6.3.7 ***Aquatic Habitat***

The water bodies in the Study Area are predominantly dry and channels are severely eroded from cattle grazing. Most creek beds and banks have a grassy and weedy understorey; where water is present, the in-stream habitat is typically choked by rushes (**Photograph 6.14**). A systematic assessment of the condition of the aquatic habitat in the Study Area is provided in **Section 6.7**.



Photograph 6.14 **Aquatic Habitat along and within Saddlers Creek**

An industrial dam in one of the minor additional mining areas at Drayton Mine potentially provides some artificial habitat for fauna such as common turtles, eels, foraging water birds and bats as it contains permanent water. There is also a small potential that the dam supports hardy and invasive fish species (see **Section 6.7.3**). However, its habitat value is very limited due to the lack of fringing vegetation, its industrial use and the quality of the water, and its location within an existing mine landscape (**Photograph 6.15**).

The lack of fringing vegetation around the dam limits its ability to provide sheltering sites for native aquatic species and the quality of the water is generally very poor since the dam is located within an active mine site and receives dirty mine water. The dam is turbid, has experienced silt-laden runoff and is potentially slightly acidic as a result of dust and run off pollutants. The surrounding land use, proximity of infrastructure and the lack of permanent watercourses and ephemeral drainage lines would also limit fauna movement to and from the dam through the surrounding grassland landscape.



Photograph 6.15 **Industrial Dam at Drayton Mine**

Note: Lack of fringing vegetation.

6.4 Fauna Species

6.4.1 General Assemblage

More than 175 fauna species have been recorded within the Study Area, of which 21 are listed under State and/or Commonwealth environmental legislation. A large proportion of recorded species are represented by avifauna and microbats, which are highly mobile species. Reptiles, arboreal mammals and terrestrial mammals, which are less mobile, are not as well represented. Many of the mammals recorded are represented by stock and exotic species such as cattle, horses, rabbits and mice.

The assemblage of fauna within the Study Area is reflective of the history of vegetation clearance and prolonged grazing, which is typical of the Hunter Valley area. These practices have resulted in a simplified and fragmented landscape that has subsequently altered faunal assemblages by encouraging more mobile and adaptive species to thrive.

A comprehensive list of fauna species is provided in **Appendix E**. It is a cumulative list of survey results since 2000 and comprises fauna recorded (observed, trapped or identified from scats or call playback) by Ecotone (2000), Cumberland Ecology (2010) and OEH Atlas of NSW Wildlife records (OEH, 2015).

As discussed in the previous sections, the minor additional mining areas at Drayton Mine constitute poor habitat for native fauna. These areas are dominated by exotic grassland and to a lesser extent, degraded native pastures. Woody vegetation is very limited and comprises immature regrowth vegetation or small patches of roadside plantings. The patches of woody vegetation that occur are small in size and so provides little interior habitat, lack understorey complexity, have limited connectivity to surrounding woodland, provide little foraging resources and lacks important habitat features such as logs, hollows and bush rock.

There is unlikely to be any resident native fauna in the minor additional mining areas, with the exception of the industrial dam which may potentially contain common turtles or eels. It is unlikely that there are any native visitors that make regular use of the land within the minor additional mining areas except water birds and bats that may potentially forage over the industrial dam. No threatened species were recorded in these areas or are likely to occur, with the exception of one bat species, namely the Southern Myotis (*Myotis macropus*), which may forage over the dam and is known from the surrounding locality. For this reason, the remainder of this Chapter is focussed on discussions of the fauna of the Study Area.

Below is a summary of the fauna of the Study Area.

i. Amphibians

Approximately eight amphibian species have been recorded across the Study Area from various surveys. All were recorded in close proximity to farm dams. The most common frog species recorded were the Eastern Common Toadlet (*Crinia signifera*) and Spotted Grass Frog (*Limnodynastes tasmaniensis*). The amphibian species recorded are widely distributed non-threatened species that are well represented within the locality. They are predicted to recolonise the Study Area following rehabilitation of water courses, particularly along Saddlers Creek.

ii. Reptiles

Approximately 13 reptile species have been recorded across the Study Area from various surveys. Commonly recorded species include the Tree Skink (*Egernia striolata*) and Bearded Dragon (*Pogona barbata*), and the Lace Monitor (*Varanus varius*) in remnant woodland areas. These non-threatened reptile species are widespread and well represented within the locality and many are predicted to recolonise rehabilitated areas.

iii. Birds

Approximately 115 bird species have been recorded across the Study Area from various surveys. Most bird species were recorded in or on the margins of the woodland areas, however the raptors and some grassland species were observed across the extensive open grassland areas.

Frequently recorded species include the Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*), Weebill (*Smicromis brevirostris*), Grey Fantail (*Rhipidura albiscapa*) and Superb Fairywren (*Malurus cyaneus*). Other species consistently recorded include common urban-adapted birds such as the Galah (*Eolophus roseicapillus*), Australian Raven (*Corvus coronoides*), Australian Magpie (*Gymnorhina tibicen*) and Pied Currawong (*Strepera graculina*). The Project will progressively remove habitat for a range of non-threatened birds. These species are well represented within the locality and many are predicted to recolonise rehabilitated areas.

iv. Mammals

Approximately 39 mammal species have been recorded across the Study Area from various surveys.

Mammal species commonly recorded include macropods; Eastern Grey Kangaroo (*Macropus giganteus*) and Red-necked Wallaby (*Macropus rufogriseus*); a suite of bat species including White-striped Freetail-bat (*Austronomus australis*), Gould's Wattled Bat (*Chalinolobus gouldii*), Chocolate Wattled Bat (*C. morio*) and Little Forest Bat (*Vespadelus vulturnus*); and feral animals including rabbits (*Oryctolagus cuniculus*). The non-threatened mammalian species mentioned are well represented within the locality and many are predicted to recolonise rehabilitated areas.

6.4.2 Threatened Fauna Species Recorded in the Study Area

Twenty-one (21) threatened fauna species have been recorded within the Study Area since surveys conducted in 2000 and all are represented by highly mobile bird and microbat species (**Table 6.11**).

The cumulative results of fauna surveys conducted over the Study Area show that threatened species were generally restricted to areas of remnant vegetation (**Figure 10**). No threatened species were recorded in grassland habitat.

Descriptions of threatened species recorded within the Study Area and/or the Mt Arthur Coal Mine lease are provided below, along with a brief summary of their preferred habitats.

Table 6.11 Threatened Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status ¹		Ecology Study	
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009, 2011)
BIRDS						
Apodidae	<i>Hirundapus caudacutus</i>	White-throated Needletail		Mi, Ma	X	
Accipitridae	<i>Circus assimilis</i>	Spotted Harrier	V			X
	<i>Hieraaetus morphinoides</i>	Little Eagle	V			X
Psittacidae	<i>Lathamus discolor</i>	Swift Parrot	E	E; Ma		X
Strigidae	<i>Ninox connivens</i>	Barking Owl	V		X	
Meropidae	<i>Merops ornatus</i>	Rainbow Bee-eater		Mi, Ma	X	X
Climacteridae	<i>Climacteris picumnus</i>	Brown Treecreeper	V			X
Acanthizidae	<i>Chthonicola sagittata</i>	Speckled Warbler	V		X	X
Meliphagidae	<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater (eastern subspecies)	V		X	
Pomatostomidae	<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler (eastern subspecies)	V		X	X
Petroicidae	<i>Petroica boodang</i>	Scarlet Robin	V			X
	<i>Melanodryas cucullata</i>	Hooded Robin	V		X	
Estrildidae	<i>Stagonopleura guttata</i>	Diamond Firetail	V		X	X
BATS						
Emballonuridae	<i>Saccolaimus flaviventris</i>	Yellow-bellied Shearwater	V			X

Table 6.11 Threatened Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status ¹		Ecology Study	
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009, 2011)
Molossidae Vespertilionidae	<i>Mormopterus norfolkensis</i>	Eastern Freetail-bat	V		X	X
	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V		X
	<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing-bat	V		X	X
	<i>Myotis macropus</i>	Southern Myotis	V		X	?
	<i>Nyctophilus corbeni</i>	Greater Long-eared Bat	V	V	X	
	<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V		X	
	<i>Vespadelus troughtoni</i>	Eastern Cave Bat	V			?

¹As listed under the Schedules of the TSC Act and EPBC Act.

Key: V = Vulnerable; E = Endangered; Mi = Migratory; Ma = Marine; ? = call not positively identified

Threatened Nectarivorous Birds

i. Black-chinned Honeyeater (eastern subspecies) (Melithreptus gularis gularis)

Status: Vulnerable (TSC Act)

a. Record Details

The Black-chinned Honeyeater was tentatively recorded within the Study Area in 2000 (Ecotone, 2000). There are four records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Black-chinned Honeyeater is a blossom-dependent species. It is a resident species with a widespread distribution across mainland Australia (Birds Australia, 2014). The species prefers the upper levels of drier open forests or woodlands dominated by Box-Ironbark eucalypts, especially *Eucalyptus sideroxylon* (Mugga Ironbark), *Eucalyptus albens* (White Box), *Eucalyptus microcarpa* (Grey Box), *Eucalyptus melliodora* (Yellow Box) and *Eucalyptus tereticornis* (Forest Red Gum) (DEC (NSW), 2005a). It can also be found in riparian woodland with a patchy or dense understorey. The species has local movements that follow flowering trees where it forages among the canopy for nectar and honeydew. Nests are commonly suspended from the upper branches, high up in the crown of the canopy (NSW Scientific Committee, 2001a).

c. Threats

The primary threat to this species is the loss of habitat, including remnant vegetation as a result of ongoing woodland and forest clearing (Birds Australia, 2014). The species cannot survive in remnants less than 200 ha (DECC (NSW), 2007a). Fragmentation may also increase competition from generalist and urban-aggressive species such as the Noisy Miner, which can occur in high densities in remnant vegetation (Clarke and Oldland, 2007). Low density populations and a loss of habitat increase the species' vulnerability to genetic isolation and may lead to local extinction.

ii. Swift Parrot (Lathamus discolor)

Status: Endangered and Marine (EPBC Act); Endangered (TSC Act)

a. Record Details

The Swift Parrot was recorded within the Study Area in 2011. An individual was observed foraging on mistletoe and *Eucalyptus moluccana* (Grey Box) for lerps and another individual was heard calling (Stojanovic, 2011) (**Photograph 6.16**). There are no records of the species within the locality although it is known to visit the locality in the winter in very low numbers and very infrequently (OEH, 2015).



Photograph 6.16 **Swift Parrot (Photo: D. Stojanovic, 2011)**

b. Habitat and Ecology

The Swift Parrot is a predominantly nectarivorous, migratory species endemic to south eastern Australia (Birds Australia, 2014). The species breeds in Tasmania and migrates to the mainland in winter, where it is most commonly found in dry, open eucalypt forests and woodlands containing Grey Box, White Box and Yellow Gum, all of which occurs in the Study Area (Garnett and Crowley, 2011). The species is reliant on Box-Ironbark communities for winter foraging, and movement is strongly associated with the availability of lerps and winter-flowering eucalypt species such as *Eucalyptus sideroxylon* (Mugga Ironbark). Swift Parrots often occur in urban areas, including farmland with remnant patches of eucalypt woodland (DEC (NSW), 2005p; Saunders and Heinsohn, 2008).

The Study Area supports winter-forage habitat for Swift Parrots in the form of mature and old regenerating eucalypt species that produce nectar and support lerps. Habitat available in the Study Area is considered locally significant for the species as it facilitates dispersal and foraging behaviour (pers. comm. Stojanovic, 2011). The occurrence of this species is likely to be sporadic and be highly dependent on flowering events and abundance of resources across the region. Hence, it is not expected that this species would be a regular visitor to the Study Area.

c. Threats

The primary threat to this species is the loss and fragmentation of habitat as a result of ongoing woodland and forest clearing. Breeding habitat has been extensively cleared by forestry operations in Tasmania (Birds Australia, 2014), while on the mainland, agriculture and residential development has destroyed forage habitat, including over 70% of Box-Ironbark forests (Garnett and Crowley, 2011). The species is also highly susceptible to climate change which impacts on the availability of flowering eucalypts and lerps.

Threatened Woodland Birds

i. *Brown Treecreeper (eastern subspecies) (Climacteris picumnus victoriae)*

Status: Vulnerable (TSC Act)

a. Record Details

The Brown Treecreeper has been recorded within the Study Area on multiple occasions. The Study Area supports at least one territory for a pair of Brown Treecreepers based on consistent detection in mature box woodland and in scattered mature paddock trees during 2011 surveys (Stojanovic, 2011) (**Photograph 6.17**). There are 28 records of the species within the locality (OEH, 2015).



Photograph 6.17 **Brown Treecreeper (Photo: D. Stojanovic, 2011)**

b. Habitat and Ecology

The Brown Treecreeper is an insectivorous woodland species endemic to eastern NSW. It is a sedentary species most commonly found in open grassy box woodlands, dry forest, and in grasslands with scattered mature trees (Birds Australia, 2014).

Suitable nesting and foraging habitats such as fallen timber, hollows in stags and live trees are available within the Study Area (DEC (NSW), 2005b; Garnett and Crowley, 2011). The species is dependent on the availability of small tree hollows for nesting, and as such, prefers patches of remnant vegetation which contain trees of hollow-bearing age of at least 150 years old. The abundance of scattered paddock trees adjacent to the remnant vegetation is likely to facilitate some dispersal for the resident pair.

c. Threats

The primary threat to the Brown Treecreeper is the loss of habitat as a result of ongoing woodland and forest clearing, particularly the removal of hollow-bearing trees, stags and fallen timber. The species' sedentary nature and limited capacity for dispersal means it is generally unable to move across open country greater than 100 m, making it susceptible to genetic isolation through habitat fragmentation (Cooper *et al.*, 2002; Doerr *et al.*, 2011). The species requires fragments that are at least 300 ha. Once a subpopulation is lost from a remnant patch, recolonisation is unlikely without assistance. In the absence of human intervention, local extinction of the species could occur (DECC (NSW), 2007a; Garnett and Crowley, 2011).

ii. *Diamond Firetail (Stagonopleura guttata)*

Status: Vulnerable (TSC Act)

a. Record Details

The Diamond Firetail has been recorded in the Study Area on multiple occasions (Ecotone, 2000). Two individuals, including a juvenile, were recorded in remnant box woodland during the 2011 survey (Stojanovic, 2011) (**Photograph 6.18**). The species has also been recorded from surveys of the Mt Arthur Coal Mine lease and Drayton Mine (Cumberland Ecology, 2010). There are 18 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Diamond Firetail is a woodland species endemic to south eastern Australia with scattered distribution in NSW (DEC (NSW), 2005c). It is a mainly sedentary, ground-foraging species most commonly found in or on the edge of lightly timbered open eucalypt forest and woodlands including Box-Ironbark and *Casuarina* associations (NSW Scientific Committee, 2001b). The species also occurs in farmland and grassland with remnant trees and a sparse understorey, and along watercourses (Birds Australia, 2014).



Photograph 6.18 **Diamond Firetail (Photo: D. Stojanovic, 2011)**

Note: Adult (left) and juvenile (right)

Suitable breeding and forage habitat exists in the Study Area. The species breeds from August to December in small colonies and nests in shrubby understorey, preferentially in mistletoe (Cooney and Watson, 2005). A juvenile was observed being fed by an adult during surveys. This strongly suggests that breeding took place onsite, rather than immigration, as the capacity for a dependent juvenile to disperse is limited (Higgins *et al.*, 2006).

c. Threats

The primary threat to the Diamond Firetail is the loss of habitat as a result of ongoing woodland and forest clearing, and the modification and removal of ground forage habitat features. While population trends are not well known (Lindenmayer and Cunningham, 2011), the species is considered to be intolerant of habitat fragmentation and do not survive in remnants smaller than 200 ha (DECC (NSW), 2007a). The species is also adversely affected by egg predation by native predators such as the Pied Currawong (Birds Australia, 2014), and invasion by exotic grasses which result in the loss of key food plants.

iii. *Hooded Robin (Melanodryas cucullata cucullata)*

Status: Vulnerable (TSC Act)

a. Record Details

The Hooded Robin was recorded within the Study Area in 2000, in remnant open woodland (Ecotone, 2000). The species has also been recorded from surveys of the Mt Arthur Coal Mine lease (Cumberland Ecology, 2009). There are 14 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Hooded Robin is a woodland species endemic to the mainland and commonly found in south eastern Australia. It is a mostly sedentary species that prefers open and lightly timbered acacia or eucalypt woodlands, particularly Box-Ironbark, that are structurally diverse and often at the edges of clearings and grassland (Birds Australia, 2014). The species forages on the ground, perching on fallen timber and low-lying branches to feed on insects. The species breeds between July and November, building nests in tree forks, hollows or crevices at heights between 1 to 5 m (DEC (NSW), 2005i).

c. Threats

The primary threat to the Hooded Robin is the loss of habitat as a result of ongoing woodland and forest clearing. Understorey clearing and modification adversely impacts their foraging and nesting success. The species is highly susceptible to habitat fragmentation as even large remnant patches are unable to sustain populations in the long term, which can lead to local extinctions (Birds Australia, 2014).

iv. *Grey-crowned Babbler (eastern subspecies) (Pomatostomus temporalis temporalis)*

Status: Vulnerable (TSC Act)

a. Record Details

The Grey-crowned Babbler has been recorded within the Study Area on multiple occasions (Ecotone, 2000; Cumberland Ecology, 2010). A number of individuals were recorded in a stand of remnant *Eucalyptus moluccana* (Grey Box) and in planted vegetation during the 2011 survey session (**Photograph 6.19**). The species has also been recorded from surveys of the Mt Arthur Coal Mine lease where it tends to occur along Saddlers Creek and its tributaries. There are 101 records of the species within the locality (OEH, 2015).



Photograph 6.19 **Adult Grey-crowned Babbler (Photo: D. Stojanovic, 2011)**

b. Habitat and Ecology

The Grey-crowned Babbler is a woodland insectivorous species widespread from northern to eastern Australia. It is a ground-dwelling, sedentary species most commonly found in open forest and woodland dominated by acacias or eucalypt Box-Ironbark associations (NSW Scientific Committee, 2011b). The species forages for insects on trunks and branches of eucalypts and other woodland trees, and on the ground amongst litter and tussock grasses.

The species is only found in habitat containing all of the following elements: woodland or open forest on fertile or heavy soils; abundant trees, with a high proportion of large, mature eucalypts with a trunk measuring >90 cm diameter at breast-height (dbh); an understorey of shrubs with dbh of 10 to 30 cm, for nesting and sheltering; and an open ground layer with much leaf litter and fallen timber debris, and sparse grass cover (Birds Australia, 2014).

Suitable breeding and forage habitat exists in the Study Area and supports at least two separate groups of Grey-crowned Babblers. The species were recorded in a remnant linear patch of *Eucalyptus moluccana* (Grey Box) with an open, grazed understorey, and in a linear, planted windbreak along Edderton Road. Active nests were observed at both sites in young and mature eucalypts.

c. Threats

The primary threat to the Grey-crowned Babbler is the loss of habitat as a result of ongoing woodland and forest clearing. The species is adversely affected by the degradation or removal of any of the above critical habitat elements, particularly ground and midstorey strata that simplify habitat structure. The species is highly susceptible to habitat fragmentation and is unable to undertake laboured flight and cross large open areas greater than 900 m (Blackmore *et al.*, 2011). This combined with a lack of habitat connectivity and decrease in territory size can disrupt dispersal and increase the population's vulnerability to inbreeding depression and thus local extinction (Stojanovic, 2011; Birds Australia, 2014). Once lost from a fragment, natural recolonisation is unlikely (Garnett and Crowley, 2011).

v. *Scarlet Robin (Petroica boodang)*

Status: Vulnerable (TSC Act)

a. Record Details

The Scarlet Robin has previously been recorded within the Study Area by Cumberland Ecology (Cumberland Ecology, 2010). The species was also detected in regenerating box and sheoak woodland with some scattered mature trees during the 2011 survey session (**Photograph 6.20**). There are two records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Scarlet Robin is an insectivorous, woodland species endemic to south eastern NSW and south western Western Australia. It is a mainly sedentary species that does not undertake movements greater than 10 km (Higgins and Peter, 2002). The species is most commonly found in drier open woodland and forest of mature and regrowth eucalypts with an open understorey. The species may also use paddocks with scattered remnant trees (Birds Australia, 2014). Abundant logs and fallen timber are critical habitat features, allowing the species to forage for insects on the ground. In NSW, the species breeds between July and January and builds nests in tree forks (NSW Scientific Committee, 2010b).

Suitable breeding and forage habitat exists in the Study Area, particularly in regenerating and remnant sheoak and Box-Gum Woodland woodland in the eastern portion of the Study Area (Stojanovic, 2011). Scarlet Robins were detected twice in the Study Area, by the territorial song of male birds, at distant locations. It is thus possible that two separate, permanent territories are present in the Study Area.

c. Threats

The primary threat to the Scarlet Robin is the loss of habitat as a result of ongoing woodland and forest clearing. Due to low recruitment rates and short distance movements (Debus, 2006) habitat fragmentation will increase the species' vulnerability to genetic isolation by restricting dispersal, which can lead to local extinctions.



Photograph 6.20 **Male Scarlet Robin (Photo: D. Stojanovic, 2011)**

vi. *Speckled Warbler (Chthonicola sagittata)*

Status: Vulnerable (TSC Act)

a. Record Details

The Speckled Warbler has been recorded in the Study Area on multiple occasions (Ecotone, 2000; Cumberland Ecology, 2010). Speckled Warblers were consistently detected in regenerating sheoak and box woodland at four locations during the 2011 survey session, suggesting the species lives in discrete and stable social groups throughout winter (Gardner, 2004). The species has also been consistently recorded in woodland and open forests in and near the Mt Arthur Coal Mine lease (Cumberland Ecology, 2009) in Central Hunter Bulloak Forest Regeneration. There are 83 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Speckled Warbler is a woodland species endemic to south eastern Australia (Garnett and Crowley, 2011). It is a territorial, sedentary species most commonly found in eucalypt-dominated dry sclerophyll forest and woodland with a grassy understorey (NSW Scientific Committee, 2001c; Higgins and Peter, 2002). The species forages on the ground for seeds and insects around tussocks and under shrubs and trees, and nests on the ground in undergrowth and thick litter.

c. Threats

The primary threat to the Speckled Warbler is the loss of habitat and connectivity for dispersal as a result of ongoing woodland and forest clearing. The species currently exists as small isolated groups and requires large, relatively undisturbed patches of remnant vegetation greater than 100 ha to persist in an area (DEC (NSW), 2005m). Further habitat fragmentation will place them at high risk of local extinction as the species is unlikely to recolonise due to poor dispersal abilities across open land (Garnett and Crowley, 2011), thus also impacting on genetic viability of subpopulations (Stojanovic, 2011; Birds Australia, 2014). As a ground-dwelling species, it is adversely affected by invasion of habitat by exotic grasses and weed cover and the modification of ground habitat structure and complexity, particularly from the removal of nesting debris and foraging substrates (Tzaros, 1996; DEC (NSW), 2005m).

Threatened Owls

i. Barking Owl (*Ninox connivens*)

Status: Vulnerable (TSC Act)

a. Record Details

The Barking Owl was tentatively recorded during nocturnal bird surveys within the Study Area in 2000 (Stojanovic, 2011). There are three records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Barking Owl is a sedentary, medium-sized owl widespread on the mainland. The species is most commonly found in dry open sclerophyll woodland and open forest dominated by eucalypts such as red gums (Birds Australia, 2014). It also inhabits fragmented remnant patches, partly cleared farmland and casuarinas along watercourses which contain large roost trees (NSW NPWS, 2003b). The species roosts in shaded portions of dense tree canopies, including tall mid-storey trees with dense foliage such as *Acacia* and *Casuarina* species. It nests in hollows of large, old eucalypt trees and requires very large permanent territories in most habitats due to sparse prey densities. Monogamous pairs hunt over as much as 6000 ha, with 2000 ha being more typical in NSW habitats (NSW Scientific Committee, 2004a).

c. Threats

The primary threat to this species is the loss and degradation of habitat as a result of ongoing woodland and forest clearing. The species is not found in regenerating forest and relies on habitat with mature trees older than 60 years (Birds Australia, 2014), thus limiting the amount of suitable habitat available within the Study Area. The species is adversely affected by a decline in remnant patches which contain large, remnant hollow-bearing trees suitable for roosting. Loss of structural complexity and agricultural practices such as grazing also reduces habitat for prey species (Garnett and Crowley, 2011).

Threatened Raptors

i. Little Eagle (Hieraetus morphnoides)

Status: Vulnerable (TSC Act)

a. Record Details

The Little Eagle was recorded in the Study Area during the 2011 survey session. An individual was observed feeding on a rabbit carcass within mature riparian vegetation. There are seven records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Little Eagle is a small, territorial raptor, uncommon but with widespread distribution across mainland Australia (Birds Australia, 2014). The species is considered partly migratory, with adults generally resident and sedentary, while the juvenile birds tend to disperse. The species is most commonly found in open eucalypt forest and woodland with abundant prey availability, Sheoak or acacia woodlands and riparian woodlands (NSW Scientific Committee, 2011c). The species require a tall living tree within a remnant patch for nesting.

c. Threats

The threats to this species are likely to be from a combination of factors, including reduction in habitat quality, prey abundance and the species' low breeding productivity (NSW Scientific Committee, 2011c). Populations may benefit from clearing, which may open new feeding grounds and thus small mammal availability, but they do not respond well to urbanisation.

ii. Spotted Harrier (Circus assimilis)

Status: Vulnerable (TSC Act)

a. Record Details

The Spotted Harrier was recorded within Central Hunter Box-Ironbark Woodland in the central north and in planted vegetation in the south of the Study Area. The species has also been recorded from surveys of the Mt Arthur Coal Mine lease. There are 14 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Spotted Harrier is a partly nomadic raptor with widespread but sparse distribution across mainland Australia (Pizzey and Knight, 2003). The species is most commonly found in grassy open woodland including remnant vegetation, riparian woodland and native grassland. The species nests in live trees in open or remnant woodland, often close to food sources such as crops (NSW Scientific Committee, 2010c).

The species is irruptive in response to local availability of key prey species such as terrestrial grassland birds, including quail, pipits and larks.

c. Threats

The primary threat to this species is the loss of breeding and forage habitat as a result of ongoing woodland and forest clearing; particularly the degradation of ground cover by grazing which impacts on prey densities (Marchant and Higgins, 1993).

Migratory Birds

i. *Rainbow Bee-eater (Merops ornatus)*

Status: Marine - Migratory (EPBC Act)

a. Record Details

The Rainbow Bee-eater has been recorded in the Study Area on multiple occasions (Ecotone, 2000; Cumberland Ecology, 2010), including in riparian Central Hunter Box-Ironbark Woodland in the south east of the Study Area. The species has also been recorded from surveys of the Mt Arthur Coal Mine lease (Cumberland Ecology, 2009). There are 40 records of the species within the locality (OEH, 2015).

b. Habitat Description

The Rainbow Bee-eater is an insectivorous migratory species widespread through mainland Australia (Birds Australia, 2014). The species is most commonly found in open forests and woodlands in open, cleared or lightly-timbered areas with sandy soils that are often, but not always, located in close proximity to permanent water. The species has also been known to occur in grasslands, cleared and semi-cleared habitats; in towns and suburbs and around homesteads; and in other disturbed habitats including roadside vegetation, quarries, mines or gravel pits, where they often breed (Higgins, 1999). Southern populations of the species migrate north in winter and may fly over the top of non-preferred habitats such as rainforest or treeless plains. The species breeds in burrows constructed in sand or earth river banks (Boland, 2004a; SEWPaC, 2011c).

c. Threats

The species is considered to be impacted by predation, particularly by introduced fauna such as foxes, dingoes, cane toads and feral dogs, all of which can easily access ground burrows and feed on eggs and nestlings (Boland, 2004b). Rainbow Bee-eaters are presumably also susceptible to predation, flooding and trampling because of their location on the ground and in banks. No other threats to the species have been identified, and the species is not considered globally threatened (SEWPaC, 2011c).

ii. *White-throated Needletail (Hirundapus caudacutus)*

Status: Marine - Migratory (EPBC Act)

a. Record Details

The White-throated Needle-tail was recorded within the Study Area in 2000 (Ecotone, 2000). The species has also been recorded from surveys of the Mt Arthur Coal Mine lease. There are six records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The White-throated Needle-tail is a regular non-breeding, summer migrant to eastern Australia from the northern hemisphere. The species are insectivorous, tree roosting swifts that are almost exclusively aerial in Australia (Pizzey and Knight, 2003). The species commonly forages on insects in the airspace above forests, woodland, farmland and lakes (DEWHA, 2009b).

c. Threats

The key threat to individual birds is the risk of collision, but there are few threats to the species overall.

Threatened Microbats

Several threatened species of microbats have been recorded within the Study Area:

- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) (Vulnerable under the TSC Act);
- Eastern Freetail-bat (*Mormopterus norfolkensis*) (Vulnerable under the TSC Act).
- Large-eared Pied Bat (*Chalinolobus dwyeri*) (Vulnerable under the EPBC and TSC Acts);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) (Vulnerable under the TSC Act); and
- Southern Myotis (*Myotis macropus*) (Vulnerable under the TSC Act);
- Greater Long-eared Bat (*Nyctophilus corbeni*) (Vulnerable under the EPBC and TSC Acts);
- Greater Broad-nosed Bat (*Scoteanax rueppellii*) (Vulnerable under the TSC Act); and
- Eastern Cave Bat (*Vespadelus troughtoni*) (Vulnerable under the TSC Act).

Most of the microbat species recorded are insectivorous and foraging behaviour is typically separated into major foraging guilds (Hall, 1981; Churchill, 2009). While microbats have

extensive foraging ranges, the presence of these species suggests the Study Area contains a suite of habitat types that support their various distinctive living and foraging requirements. A description of the foraging guilds, and the placement of the above species within these guilds, is provided in **Table 6.12** below.

Table 6.12 Foraging Guilds of Microbat Species Recorded in the Study Area

Foraging Guild	Description
Open Space Aerial Foragers	Typically freetail and sheath-tail bats such as the Yellow-bellied Sheath-tail-bat and Eastern Freetail-bat which were recorded in the Study Area. These species fly very fast across large, open and empty areas away from vegetation to intercept and catch insects.
Edge Space Aerial Foragers and Trawlers	The majority of 'ordinary' vespertilionid microbats are considered edge space aerial foragers and trawlers, including the Eastern Cave Bat, Greater Broad-nosed Bat, Southern Myotis, Eastern Bentwing-bat and Large-eared Pied Bat. These agile species catch insects while flying along the edges of vegetation in gaps. The Southern Myotis pinpoints prey using echolocation directed at calm water surfaces such as pools.
Gleaning Foragers	The Greater Long-eared Bat is a gleaning forager. Prey is caught by gleaning from the ground or from vegetation, often within densely vegetated environments such as woodland.

The roosting habits of many of the microbat species recorded in the Study Area are typically tree-roosting or cave-roosting. The Greater Long-eared Bat (*Nyctophilus corbeni*), Yellow-bellied Sheath-tail-bat (*Saccolaimus flaviventris*), Eastern Freetail-bat (*Mormopterus norfolkensis*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*) are all tree roosting species that forage in or around the canopies of forest and woodland trees.

The Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*), Large-eared Pied Bat (*Chalinolobus dwyeri*) and Southern Myotis (*Myotis macropus*) are predominantly cave-roosting species, though have been known to roost in mines, culverts and other artificial structures such as building roof cavities. No caves or other suitable roosting habitat exist within the Study Area; the closest suitable caves are small outcrops within the Mt Arthur Coal Mine lease and near Mt Ogilvie. These species forage in forest and woodland and typically frequenting the Study Area while foraging at night, and returning to roost sites each morning.

i. Yellow-bellied Sheath-tail-bat (Saccolaimus flaviventris)

Status: Vulnerable (TSC Act)

a. Record Details

The Yellow-bellied Sheath-tail Bat was recorded within the Study Area by Cumberland Ecology in 2011. It has also been recorded from surveys of the Mt Arthur Coal Mine lease

(Cumberland Ecology, 2009). There are seven records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Yellow-bellied Sheath-tail Bat is a tree-hollow roosting species with wide-ranging distribution through tropical Australia, although is considered rare in south eastern Australia (Churchill, 2009). It is an insectivorous species that primarily forages above the tree canopy in almost all habitats (NSW Scientific Committee, 2004q). Most records in NSW have been obtained between January and May, leading to speculation that the species may be migratory in the southern portion of its range, although very little is currently known about seasonal movements. This species roosts in large tree-hollows in groups of between two and 30 (Van Dyck and Strahan, 2008).

c. Threats

The primary threat to the species is habitat clearance and displacement from tree hollows by invasive European honeybees (Oldroyd *et al.*, 1997). The species also has the highest prevalence of lyssavirus in Australian microbat species, though it is not known whether this is a problem for the species as a whole (Churchill, 2009).

ii. Eastern Freetail-bat (*Mormopterus norfolkensis*)

Status: Vulnerable (TSC Act)

a. Record Details

The Eastern Freetail-bat (*Mormopterus norfolkensis*) has been recorded within the Study Area in 2000 (Ecotone, 2000) and by Cumberland Ecology in 2011. It has also been recorded from surveys of the Mt Arthur Coal Mine lease (Cumberland Ecology, 2009). There are 38 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Eastern Freetail-bat is a solitary, insectivorous bat (Churchill, 2009) most commonly found in open spaces in dry sclerophyll forests, woodland and swamp forests in eastern NSW (NSW Scientific Committee, 2004c).

The species mainly roost in spout hollows of large mature trees and sometimes under bark or in man-made structures (DEC (NSW), 2005e). It is also known to forage in gaps in upper-slope vegetation and over larger waterways.

c. Threats

The primary threat to the species is the loss and fragmentation of habitat as a result of ongoing woodland and forest clearing. The removal of large, mature trees may impact on roost site availability.

iii. *Large-eared Pied Bat (Chalinolobus dwyeri)*

Status: Vulnerable (EPBC Act; TSC Act)

a. Record Details

The Large-eared Pied Bat was recorded within the Study Area by Cumberland Ecology in 2011. Analysis of bat calls recorded in 2011 surveys showed activity throughout the night suggesting the species feeds around the Study Area. Known populations occur in Wollemi National Park (DEC (NSW), 2005j) and it has also been recorded from surveys of the Mt Arthur Coal Mine lease. There are 20 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Large-eared Pied Bat is an insectivorous species with poorly known population densities and distribution. It is considered to be patchily distributed from mid-Queensland to southern NSW (DEC (NSW), 2005j). Little is known about the habitat requirements of the species, but natural roosts are typically dependent on extensive sandstone outcrops, cliffs and caves, and old mine workings. The species appears to prefer low to mid-elevation grassy box and alluvial woodland close to these roost features, particularly areas containing gullies. The Large-eared Pied Bat typically exists in small colonies consisting of less than 50 individuals (NSW NPWS, 2004c; SEWPaC, 2011a).

c. Threats

The primary threat to this species is habitat loss and fragmentation which restricts the species' capacity for dispersal, thus making them highly susceptible to local extinctions due to loss of genetic variability in small breeding colonies (Hoye and Dwyer, 1995). The species is also vulnerable to impacts on subterranean roost sites, such as mining-induced subsidence (DECC (NSW), 2007a) which are used for shelter and breeding, particularly as up to 100 individuals may share the same site (SEWPaC, 2011a).

iv. *Eastern Bentwing-bat (Miniopterus schreibersii oceanensis)*

Status: Vulnerable (TSC Act)

a. Record Details:

The Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) has been recorded within the Study Area on multiple occasions (Ecotone, 2000; Cumberland Ecology, 2010). The species has also been recorded from surveys of the Mt Arthur Coal Mine lease, primarily around Saddlers Creek and Mt Arthur (Cumberland Ecology, 2009). This species is well documented and has been consistently detected in surveys within the locality. There are 47 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Eastern Bentwing-bat is an insectivorous species that almost exclusively roost in caves and artificial constructions such as mines along the east coast of Australia (Churchill, 2009).

The species occurs in large colonies of up to 150,000 individuals and forages above the canopy over forested areas for insects. In south eastern Australia the species hibernates in underground sites, usually large caves with a constant microclimate, during winter. It requires very specific conditions in terms of temperature and humidity for maternity sites. The species changes roosts in response to seasonal needs, and in turn long-distance movements occur (DECC (NSW), 2005c). The species can travel up to 65 km a night (DECC (NSW), 2007a).

Analysis of bat calls recorded in 2011 surveys showed a peak in Eastern Bentwing-bat activity in the middle of the night. This suggests that an individual flew in from a cave roost some distance away to forage around the Study Area.

c. Threats

The primary threat to the species is the disturbance or removal of summer breeding habitat and damage to nursery caves which can lead to significant population declines. Disturbance of hibernating colonies in winter torpor sites can lead to a loss of energy reserves and starvation. Ongoing woodland and forest clearing may also impact on the availability of forage habitat.

v. *Southern Myotis (Myotis macropus)*

Status: Vulnerable (TSC Act)

a. Record Details

The Southern Myotis was recorded within the Study Area in 2000 (Ecotone, 2000). There are 18 records of the species within the locality, some of which have been recorded from surveys of the Mt Arthur Coal Mine lease (Umwelt Environmental Consultants, 2003; Umwelt Environmental Consultants, 2005; Umwelt Environmental Consultants, 2006b; Umwelt Environmental Consultants, 2006c; Umwelt (Australia) Pty Limited, 2007).

b. Habitat and Ecology

The Southern Myotis is a cave-dwelling, fishing bat that was formerly known as *Myotis adversus*. It has a primarily coastal distribution along the east coast to the Kimberley, and along major rivers in south eastern Australia (Churchill, 2009). The species typically lives in colonies of less than 15 to hundreds, in caves, mine shafts, hollow-bearing trees, storm-water channels, buildings, under bridges and in dense foliage (Van Dyck and Strahan, 2008). The primary force driving roost selection is the proximity of suitable day-roost sites to suitable waterways. Roosting sites are often close to water as the species forages over streams and pools catching insects, prawns and small fish by raking their feet across the water surface (NSW Scientific Committee, 2004i; DEC (NSW), 2005l).

Analysis of echolocation data recorded by Cumberland Ecology in 2011 could not positively identify the species, which is difficult to differentiate from *Nyctophilus* spp. calls. As the recordings were not made over still water-bodies, it is considered highly probable that 2011 survey calls were *Nyctophilus* spp.

The Southern Myotis could potentially forage for insects over the industrial dam in the minor additional mining areas at Drayton Mine. Although no records for the species is currently known on Drayton Mine, it has been recorded in the surrounding locality of Drayton Mine and could use the dam from time to time.

c. Threats

The primary threat to the species is changes to water flow regimes and deteriorating water quality, including increased turbidity that reduces the availability of aquatic prey for the species. The species is also impacted by a lack of suitable tree and cave roost sites in the vicinity to watercourses.

vi. *Greater Long-eared Bat (Nyctophilus corbeni)*

Status: Vulnerable (EPBC and TSC Acts)

a. Record Details

The Greater Long-eared Bat (south eastern form) (*Nyctophilus corbeni*) was recorded within the Study Area in 2000 (Ecotone, 2000). There are three records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Greater Long-eared Bat is an insectivorous species with rare distribution around south eastern Australia, including the Hunter Valley (Churchill, 2009). The species is most commonly found in inland woodland vegetation types including Box-Ironbark dominated communities and mallee. In the Hunter Valley the species is found in national parks, including Wollemi National Park, where it has primarily been recorded in moister woodland of various eucalypt species with a distinct shrub layer frequently adjacent to watercourses.

Little is known about the species, but it is expected to roost solitarily in tree crevices and shedding bark, and forage in flight, on the ground or around patches of trees (DEC (NSW), 2005h).

c. Threats

There is a lack of data available to determine past and current threats; however, the species is likely to be impacted by woodland clearing as a result of agriculture, open cut coal, natural gas and mineral sand mining proposals (SEWPaC, 2011d). The species is also affected by fragmentation, as they show a preference for larger habitats, and clearance of hollow-bearing trees of any size. It is considered extremely important that any hollow, no matter how small, may provide habitat for this species (DEC (NSW), 2005h), and it is the smaller more obscure hollows rather than the larger more obvious hollows that are important to this species.

vii. *Greater Broad-nosed Bat (Scoteanax rueppellii)*

Status: Vulnerable (TSC Act)

a. Record Details

The Greater Broad-nosed Bat was recorded within the Study Area in 2000 (Ecotone, 2000). It has also been recorded from surveys of the Mt Arthur Coal Mine lease (Cumberland Ecology, 2009). There are six records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Greater Broad-nosed Bat is a large insectivorous species with limited distribution along the east coast of Australia (Churchill, 2009). The species is found in a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest. This species mainly roosts in tree hollows and cracks or fissures in trunks and branches. The species flies slowly and directly along creek and river corridors in open woodland habitat and dry open forest at low altitudes of up to 6 m, foraging for beetles and other large, slow-flying insects after sunset (NSW Scientific Committee, 2004e). It is also known to prey on other microbat species (Churchill, 2009).

c. Threats

The primary threat to the species is the loss and fragmentation of suitable forest roost and forage habitat, including hollow-bearing trees (Duncan *et al.*, 1999).

viii. Eastern Cave Bat (*Vespadelus troughtoni*)

Status: Vulnerable (TSC Act)

a. Record Details

The Eastern Cave Bat (*Vespadelus troughtoni*) has not been positively identified within the Study Area. Results of analysis of echolocation data recorded by Cumberland Ecology was inconclusive; however the calls are considered highly likely to be from the Eastern Cave Bat (*Vespadelus troughtoni*) due to call frequency range and pulse characteristics, and are included in mapping of threatened fauna (**Figure 10**). It has also been recorded from surveys of the Mt Arthur Coal Mine lease. There are 14 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Eastern Cave Bat is a cave-roosting species typically found in dry open forest and woodland. It generally roosts near cave entrances in moderately well-lit areas or in crevices of cliffs and overhangs. It has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals (NSW Scientific Committee, 2004b).

Analysis of bat calls recorded in 2011 surveys showed the calls are mainly clustered near the beginning and end of the recording session, i.e. close to dusk and dawn. This suggests the species utilises a roost site closer to the Study Area than the Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*).

6.4.3 Potential Threatened Fauna

This section describes threatened flora and fauna species that have not previously been recorded within the Study Area but are considered to have potential to occur due to the incidence of suitable habitat and as indicated by OEH Atlas of NSW Wildlife (OEH, 2015) records and/or the EPBC Act PMST (DoE, 2015).

A likelihood of occurrence assessment was conducted for threatened species known or predicted to occur within the Study Area and locality. Species that could potentially be impacted by the Project are presented within **Appendix F**. This table shows all records of TSC Act listed threatened fauna species recorded from the locality and all EPBC Act listed species predicted to occur based on availability of habitat in the locality.

Many of the following species have been recorded during surveys of the Mt Arthur Coal Mine lease. The site adjoins the Study Area to the north and is part of the same topographic and vegetation landscape. The close proximity and availability of similar habitat makes it likely that fauna species would use vegetation corridors such as along Saddlers Creek to move between the two sites.

Threatened Avifauna

i. Little Lorikeet (*Glossopsitta pusilla*)

Status: Vulnerable (TSC Act)

a. Record Details

The Little Lorikeet (*Glossopsitta pusilla*) has not been recorded within the Study Area. It has been recorded from surveys of the Mt Arthur Coal Mine lease. There are 14 records of the species within the locality (OEH, 2015).

b. Habitat Description

The Little Lorikeet (*Glossopsitta pusilla*) mostly occurs in dry, open eucalypt forests and woodlands and is distributed in NSW from the coast to the western slopes of the Great Dividing Range (Barrett *et al.*, 2003). The species is considered to be nomadic (Higgins, 1999), with irregular large or small influxes of individuals occurring at any time of year, apparently related to food availability where there is some tree-flowering in the vicinity (NSW Scientific Committee, 2009b).

The species has not been recorded within the Study Area; however it is considered to have potential to occur as suitable habitat is available and it has previously been recorded in the Mt Arthur Coal Mine lease.

ii. *Turquoise Parrot (Neophema pulchella)*

Status: Vulnerable (TSC Act)

a. Record Details

The Turquoise Parrot (*Neophema pulchella*) has not been recorded within the Study Area. It has been recorded from surveys of the Mt Arthur Coal Mine lease. There are three records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Turquoise Parrot (*Neophema pulchella*) lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland (NSW Scientific Committee, 2004o). The species feeds on seeds of grasses and herbaceous plants, or browses on vegetable matter, all of which are available within grassland and open woodland of the Study Area. It nests in tree hollows, logs or posts, from August to December (DEC (NSW), 2005q).

The species has not been recorded within the Study Area; however it is considered to have potential to occur as suitable habitat is available and it has previously been recorded in the Mt Arthur Coal Mine lease.

iii. *Flame Robin (Petroica phoenicea)*

Status: Vulnerable (TSC Act)

a. Record Details

The Flame Robin (*Petroica phoenicea*) has not been recorded within the Study Area. There is one record of this species within the locality (OEH, 2015).

b. Habitat and Ecology

The Flame Robin (*Petroica phoenicea*) is a small, insectivorous bird found in a broad coastal band across the south east corner of the Australian mainland and in Tasmania (Birds Australia, 2014). In NSW it breeds in upland moist eucalypt forests and woodlands, often on ridges and slopes, in areas of open understorey. It migrates in winter to more open lowland habitats such as grassland with scattered trees and open woodland on the inland slopes and plains. The species forages on the ground for insects and arthropods and forages in scattered flocks in non-breeding seasons. It constructs small cup nests in tree cavities or rock faces.

The species has not been recorded within the Study Area; however it is considered to have potential to fly over during winter migrations due to various sightings within the locality.

iv. *Gang-gang Cockatoo (Callocephalon fimbriatum)*

Status: Vulnerable (TSC Act)

a. Record Details

The Gang-gang Cockatoo (*Callocephalon fimbriatum*) has not been recorded within the Study Area. There is one record of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Gang-gang Cockatoo (*Callocephalon fimbriatum*) is endemic to south eastern Australia. In NSW they are widely distributed from the central slopes and tablelands, including the lower Hunter Valley, to the south coast. The species typically inhabits and forages in eucalypt open forest and woodland such as Box-Ironbark assemblages, with an acacia understorey. In winter Gang-gang Cockatoo (*Callocephalon fimbriatum*) undergo seasonal altitudinal migrations to lower altitudes into drier, more open forests and woodlands (NSW Scientific Committee, 2005b). The species requires tree hollows in tall old growth living trees, often near water, for nesting. It forms close monogamous pairs with high nest fidelity and often breed semi-colonially where densities are high. Densities of nest territories range from 7 to 22 km² (DEC (NSW), 2005f)

The species has not been recorded within the Study Area; however it is considered to have potential to occur as suitable forage and nesting habitat is available.

v. *Glossy Black-Cockatoo (Calyptorhynchus lathami)*

Status: Vulnerable (TSC Act)

a. Record Details

The Glossy Black-Cockatoo (*Calyptorhynchus lathami*) has not been recorded within the Study Area. There are 24 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Glossy Black-Cockatoo (*Calyptorhynchus lathami*) was previously widely distributed across most of south eastern Australia. In NSW the species now has patchy distribution along the coast and tablelands in eucalypt open forest and woodland with hollow-bearing trees and stands of she-oak species. The species tends not to live in country where extensive clearing has taken place rather it prefers to fly over intact habitat rather than open country (Birds Australia, 2014).

The species feeds almost exclusively on the seeds of several species of she-oak (*Casuarina* and *Allocasuarina* species). It generally nests in tree hollows of approximately 26cm wide by 1.4cm deep in live trees or stags. Pairs defend the immediate area surrounding the nest hollow and have extensive forage ranges. Glossy Black-Cockatoo (*Calyptorhynchus lathami*) is highly mobile and can disperse up to 12 to 60 km (NSW NPWS, 1999a; NSW Scientific Committee, 2004d).

The species has not been recorded within the Study Area; however it is considered to have potential to occur as some forage and nesting habitat is available. Given the local abundance of the species it is likely that the Glossy Black-Cockatoo (*Calyptorhynchus lathami*) use wooded areas in the locality, including the Study Area, as habitat 'stepping stones' to forage during long-distance commutes.

vi. *Powerful Owl (Ninox strenua)*

Status: Vulnerable (TSC Act)

a. Record Details

The Powerful Owl (*Ninox strenua*) has not been recorded within the Study Area. There are three records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Powerful Owl (*Ninox strenua*) occurs in the eastern quarter of NSW, from the coast to the inland slopes where it inhabits eucalypt forests and woodlands and inland riverine woodland (Barrett *et al.*, 2003). The species requires large hollows up to 1 m wide and 2 m deep in large remnant trees for nesting (NSW Scientific Committee, 2004k; Soderquist and Gibbons, 2007). The species is considered unlikely to roost or nest in the Study Area as very few trees have hollows of that size. However, individuals may visit the Study Area to forage due to an abundance of both arboreal and terrestrial prey.

vii. *Masked Owl (Tyto novaehollandiae)*

Status: Vulnerable (TSC Act)

a. Record Details

The Masked Owl (*Tyto novaehollandiae*) has not been recorded within the Study Area. It has been recorded from surveys of the Mt Arthur Coal Mine lease. There are three records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Masked Owl (*Tyto novaehollandiae*) occurs in dry eucalypt forests and woodlands. The species is distributed along the east coast where it is most abundant to the western plains. Overall records for this species fall within approximately 90% of NSW, excluding the most arid north western corner. There is no seasonal variation in its distribution. Pairs have a large home range of 500 to 1000 ha (Debus and Rose, 1994; NSW Scientific Committee, 2004j).

The species has not been recorded within the Study Area; however it is considered to have potential to occur and it has previously been recorded in the Mt Arthur Coal Mine lease. This species is unlikely to roost or breed in the Study Area as no large tree hollows in moist forested gullies or caves occur. There is potential for the species to forage in the Study Area for tree-dwelling and terrestrial mammals

viii. *Varied Sittella (Daphoenositta chrysoptera)*

Status: Vulnerable (TSC Act)

a. Record Details

The Varied Sittella (*Daphoenositta chrysoptera*) has not been recorded within the Study Area. It has been recorded from surveys of the Mt Arthur Coal Mine lease. There are 17 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Varied Sittella (*Daphoenositta chrysoptera*) is sedentary and inhabits eucalypt forests and woodlands across most of mainland Australia except the treeless deserts and open grasslands, with a nearly continuous distribution in NSW from the coast to the far west (Higgins and Peter, 2002; Barrett *et al.*, 2003). The species prefers rough-barked tree species and mature smooth-barked gums with dead branches to feed on arthropods.

The species has not been recorded within the Study Area; however it is considered to have potential to occur as suitable habitat is available and it has previously been recorded in the Mt Arthur Coal Mine lease.

ix. *Regent Honeyeater (Anthochaera phrygia)*

Status: Critically Endangered (TSC Act); Endangered (EPBC Act);

a. Record Details:

The Regent Honeyeater (*Anthochaera phrygia*) has not been recorded within the Study Area. There is one record of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Regent Honeyeater (*Anthochaera phrygia*) is a winter migrant confined to Victoria and NSW and is strongly associated with the western slopes of the Great Dividing Range (Garnett and Crowley, 2011). The species is found in temperate eucalypt forests and woodlands, particularly in blossoming trees and mistletoe (DEC (NSW), 2006). The Regent Honeyeater is strongly nomadic and follows blossoming trees (Franklin *et al.*, 1989; NSW Scientific Committee, 2004). The species uses patches of vegetation as 'stepping stones' to travel across landscapes.

The species has not been recorded within the Study Area; however it is considered to have potential to occur as suitable forest and woodland habitat, containing winter-flowering trees, is available. Habitat available in the Study Area is considered locally significant for the species; however, the occurrence of this species is likely to be sporadic and be highly dependent on flowering events and abundance of resources across the region. Hence, it is not expected that this species would be a regular visitor to the Study Area.

Threatened Mammals

i. Grey-headed Flying Fox (*Pteropus poliocephalus*)

Status: Vulnerable (EPBC Act; TSC Act)

a. Record Details

The Grey-headed Flying Fox (*Pteropus poliocephalus*) has not been recorded within the Study Area. An individual was recorded during surveys of the Drayton Mine lease. There are four records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Grey-headed Flying Fox (*Pteropus poliocephalus*) is endemic to eastern Australia where it is common, but limited in distribution across a narrow strip of the east coast (NSW Scientific Committee, 2004f). This highly mobile nocturnal species mates and breed in 'camps' within dense riparian vegetation, which are often used over many years. It forages within 20 km of camp 75% of the time, but can travel up to 50 km in some cases to find a productive food source (Tidemann and Nelson, 2004; Van Dyck and Strahan, 2008).

The species has not been recorded within the Study Area and is considered to have low potential to occur based on low LGA records and the lack of suitable riparian vegetation for breeding and camp habitat. As such, the Grey-headed Flying Fox (*Pteropus poliocephalus*) is not considered likely to be impacted by the Project and no further impact assessments have been conducted.

ii. Spotted-tailed Quoll (*Dasyurus maculatus*)

Status: Endangered (EPBC Act); Vulnerable (TSC Act)

a. Record Details

The Spotted-tailed Quoll (*Dasyurus maculatus*) has not been recorded within the Study Area. An individual was recorded during surveys of the Mt Arthur Coal Mine lease. There are 21 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Spotted-tailed Quoll (*Dasyurus maculatus*) has been recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest. This is a nocturnal species with a large home range; females occupy home ranges up to about 750 ha and males up to 3500 ha. The species usually traverse their ranges along densely vegetated creeklines (DEC (NSW), 2005n).

The species has not been recorded within the Study Area; however it has been recorded in the Mt Arthur Coal Mine lease. Due to proximity, the species is considered to have potential to utilise vegetation corridors and habitat in the Study Area. Despite the fragmented and

modified nature of vegetation in the Study Area, some suitable habitat is available in the form of habitat features such as large hollow logs.

iii. *Squirrel Glider (Petaurus norfolcensis)*

Status: Vulnerable (TSC Act)

a. Record Details

The Squirrel Glider (*Petaurus norfolcensis*) has not been recorded within the Study Area. It has been recorded from surveys of the Mt Arthur Coal Mine lease. There are 13 records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Squirrel Glider (*Petaurus norfolcensis*) is widely, but sparsely distributed in eastern Australia. It commonly inhabits mature or old growth Box-Gum, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range. The species live in family groups and nest in tree hollows and prefer eucalypt stands with a shrubby or an *Acacia* midstorey. The species requires abundant tree hollows for refuge and nest sites (NSW Scientific Committee, 2004m; DEC (NSW), 2005o).

The species has not been recorded within the Study Area; however it is considered to have high potential to occur as suitable habitat is available. It has previously been recorded in the Mt Arthur Coal Mine lease on a number of occasions. The species was recorded along Saddlers Creek, the south western extent of the mine lease and the north western slopes of Mt Arthur (Cumberland Ecology, 2009). Thus, it is likely that the species utilises surrounding areas, including the Study Area, particularly along Saddlers Creek.

iv. *Yellow-bellied Glider (Petaurus australis)*

Status: Vulnerable (TSC Act)

a. Record Details

The Yellow-bellied Glider (*Petaurus australis*) has not been recorded within the Study Area. There are no records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Yellow-bellied Glider (*Petaurus australis*) has sparse distribution along the east coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria (NSW NPWS, 2003a; NSW Scientific Committee, 2004p). The nocturnal species commonly inhabits open forest where it lives in family groups up to six individuals which share a tree hollow. Group size varies depending on the availability of food and habitat quality, and territories are aggressively defended against trespassing gliders within the 30 to 60 ha geographic range (Van Dyck and Strahan, 2008). The majority of time (90%) is spent outside of dens engaged in foraging-related activities for eucalypt nectar, pollen, sap and

insects. It is common for gliders to travel over 2 km to forage (Menkhorst and Knight, 2004) and V-shaped scars on tree trunks are indicative of sap-feeding.

The species has not been recorded within the Study Area and is considered to have low potential to occur based on the fragmented nature of forest and woodland. The large exclusive area required by single groups and patchy distribution of forage resources means that very large expanses of forest habitat (>15,000 ha) are required to conserve viable populations of this species (Van Dyck and Strahan, 2008). The species may use larger tracts of more intact habitat within Wollemi National Park.

As such, the Project is unlikely to impact on the species and no further impact assessments have been conducted.

Migratory Species

The following EPBC Act-listed bird species are seasonal migrants to Australia with widespread distributions across the mainland.

The Study Area is within each species migration range; however with low or non-existent records for the LGAs, each species is considered to have low potential to overfly the Study Area and low potential to forage in the locality. As such, the Project is unlikely to impact on the species and no further impact assessments have been conducted.

i. Satin Flycatcher (Myiagra cyanoleuca)

Status: Marine, Migratory (EPBC Act)

a. Record Details

The Satin Flycatcher (*Myiagra cyanoleuca*) has not been recorded within the Study Area. There are no records of this species within the locality (OEH, 2015). The species has previously been recorded within the Mt Arthur Coal Mine lease.

b. Habitat and Ecology

The Satin Flycatcher (*Myiagra cyanoleuca*) is a widely distributed insectivore in eastern Australia; in NSW the species is widespread on and east of the Great Divide and sparsely scattered on the western slopes, with very occasional records on the western plains (Morris *et al.*, 1981; Blakers *et al.*, 1984; Cooper and McAllan, 1995). The species has erratic migration movements but are generally recorded in passage between September and October. It is commonly found singly or in pairs or up to groups of four, in tall, moist eucalypt forests, often near wetlands or watercourses, or in mature eucalypt woodlands with open understorey and grass ground cover. The Satin Flycatcher (*Myiagra cyanoleuca*) prefers to nest in a fork of outer branches of trees, such as paperbarks, eucalypts, and banksias and tend to nest in the same locality each year, and sometimes in the same tree.

The species has not been recorded within the Study Area; however it is considered to have potential to occur as some forage and nesting habitat is available. This species has the potential to overfly the Study Area infrequently during migrations.

ii. *Fork-tailed Swift (Apus pacificus)*

Status: Marine, Migratory (EPBC Act)

a. Record Details

The Fork-tailed Swift (*Apus pacificus*) has not been recorded in the Study Area. There are no records for this species within the locality (OEH, 2015); however, it has been predicted to occur on the basis of available habitat (DoE, 2015).

b. Habitat and Ecology

The Fork-tailed Swift (*Apus pacificus*) is a non-breeding visitor to all states and territories of Australia (Higgins, 1999). The species is common in NSW from October to March, and most records in NSW are east of the Great Divide. The species is exclusively aerial and commonly occurs over inland plains; dry or open habitats including riparian woodland; treeless grassland and coastal sand dunes (DEWHA, 2009a).

iii. *Great Egret (Ardea alba)*

Status: Marine, Migratory (EPBC Act)

a. Record Details

The Great Egret (*Ardea alba*) has not been recorded within the Study Area. There are no records of the species within the locality (OEH, 2015).

b. Habitat and Ecology

The Great Egret (*Ardea alba*) is distributed throughout the world and commonly occurs in all areas of Australia except the most arid regions (Birds Australia, 2014). The species prefers shallow, flowing water where it typically feed alone on fish, aquatic invertebrates, reptiles and crustaceans. The species breeds in colonies and build nests in trees overhanging water (SEWPaC, 2010a).

iv. *Latham's Snipe (Gallinago hardwickii)*

Status: Marine, Migratory (EPBC Act)

a. Record Details

Latham's Snipe (*Gallinago hardwickii*) has not been recorded within the Study Area. There are no records of the species in the locality (OEH, 2015).

b. Habitat and Ecology

Latham's Snipe (*Gallinago hardwickii*) is a non-breeding migratory wader that travels to south eastern Australia in the warmer months, typically around September (Birds Australia, 2014). The species is commonly found singly or in small groups in freshwater wetlands or near the

coast in dense wetland or riparian vegetation cover. The species is omnivorous and generally feeds on aquatic molluscs, insects and plant seeds.

v. *White-bellied Sea Eagle (Haliaeetus leucogaster)*

Status: Marine, Migratory (EPBC Act)

a. Record Details

The White-bellied Sea Eagle (*Haliaeetus leucogaster*) has not been recorded in the Study Area. There are seven records for this species within the locality (OEH, 2015).

b. Habitat and Ecology

The White-bellied Sea Eagle (*Haliaeetus leucogaster*) is a large raptor distributed along the coastlines of mainland Australia and Tasmania (SEWPaC, 2011b). The species is not globally threatened but has seen declines across Australia. Distribution varies depending on local climatic conditions, but can extend inland along some larger watercourses. The White-bellied Sea-Eagle is generally seen singly or in pairs, though it may occasionally congregate around sites where food is abundant (Marchant and Higgins, 1993).

6.4.4 Invasive Fauna Species

Feral animals are a major environmental and economic issue in the Upper Hunter region, particularly as the region supports an abundance of agricultural-based industries (Fitzgerald and Wilkinson, 2009; Gong *et al.*, 2009). Feral animals prey on native species and increase competition for resources; selectively feed on particular plant communities; create drainage channels in swamps; erode soil and channel banks; foul waterbodies; and spread weeds and possibly disease. Landholders, both public and private, are obligated to eradicate and manage pests under the *Rural Lands Protection Act 1998*. Trapping and baiting are the most effective methods of reducing feral animal numbers.

Rabbits were the most abundant feral species observed during surveys of the Study Area. The species is common and densities are reportedly increasing on pastoral farming 'red soil' country and in mine leases. They are considered to occur in low to medium densities in the Upper Hunter, mainly on alluvial flats and foothills (West and Saunders, 2007).

No feral foxes or dogs were recorded during surveys of the Study Area; however they are likely to occur within the locality and are therefore a risk. These feral species have been recognised to be a major contributor to the decline of ground-nesting birds, small to medium mammals and reptiles by preying on fauna and degrading habitats (SEWPaC, 2010b).

Invasive aquatic fauna such as Common Carp (*Cyprinus carpio*) and Mosquito Fish (*Gambusia holbrooki*) were also recorded during aquatic surveys. These are discussed in **Section 6.7.3**. These aquatic species may also potentially be present in the industrial dam in the minor additional mining areas at Drayton Mine, although the water quality is expected to be very low (see **Section 6.3.7**). As the industrial dam is offline (not on an existing drainage system) the introduction of fish species would depend on the source of water that is released to the dam.

6.4.5 Fauna Species Listed under the EPBC Act

This section summarises the likelihood of occurrence of threatened fauna species that are listed under the EPBC Act, regardless of whether they have been recorded in the Study Area during field surveys. The threatened species discussed in **Table 6.13** below were included for consideration based on incidence of suitable habitat and as indicated by the EPBC Act PMST (DSEWPC, 2011a) and/or presence of records in the locality of the Study Area.

The Study Area provides foraging resources for known occurrences of Swift Parrot (*Lathamus discolor*) and Greater Long-eared Bat (*Nyctophilus corbeni*). The Study Area may also support occurrences of Regent Honeyeater (*Anthochaera phrygia*) on occasions when there is abundant flowering but these occurrences are likely to be rare.

Spotted-tailed Quoll (*Dasyurus maculatus maculatus*) has a low potential to be present within the Study Area; the species may visit or travel through on occasion but these occasions are likely to be infrequent to rare. No other terrestrial fauna species, including the Koala (*Phascolarctos cinereus*) and Green and Golden Bell Frog (*Litoria aurea*) are considered likely to occur in the Study Area.

These species are discussed in greater detail in **Appendix A**, which contains summary of assessment of MNES as required under the EPBC Act.

Table 6.13 Likelihood of Occurrence of Fauna Species Listed under the EPBC Act in Study Area

Common Name	EPBC Status	Occurrence in Study Area	Likelihood
Birds			
Regent Honeyeater (<i>Anthochaera phrygia</i>)	E	Not recorded. Suitable foraging habitat present. The species may forage in dry open forest, woodland and riparian forests within the Project area during migratory movements.	Low likelihood (very infrequently)
Swift Parrot (<i>Lathamus discolor</i>)	E, Ma	Recorded in the Study Area. Likely to occur occasionally and in very low numbers but unlikely to visit regularly every year.	Present (very infrequently)
Spotted-tail Quoll (<i>Dasyurus maculatus maculatus</i>)	E	Not recorded. Potential to visit occasionally and in low numbers but unlikely to visit regularly every year.	Low likelihood
Koala (<i>Phascolarctos cinereus</i>)	V	Not recorded. Unlikely to occur. Study Area does not support core habitat. Likely to occur in the wider area in low densities. The Study Area is unlikely to provide good movement corridors because of surrounding land use and poor connectivity	Unlikely

Table 6.13 Likelihood of Occurrence of Fauna Species Listed under the EPBC Act in Study Area

Common Name	EPBC Status	Occurrence in Study Area	Likelihood
Grey-headed Flying-fox (<i>Pteropus poliocephalus</i>)	V	to significant areas of habitat offsite. Not recorded. Low potential to occur. Not detected in fauna surveys. Previously recorded from the Drayton mine lease; however no suitable habitat is considered to exist in the Study Area for the species.	Low likelihood
Greater Long-eared Bat (<i>Nyctophilus corbeni</i>)	V	Recorded in the Study Area. Suitable roosting and foraging habitat available.	Present
Large-eared Pied Bat (<i>Chalinobus dwyeri</i>)	V	Recorded in the Study Area. Suitable foraging habitat available although no roosting or breeding habitat is available.	Present
Amphibians			
Green and Golden Bell Frog (<i>Litoria aurea</i>)	V	Not recorded. Unlikely to occur. Some suitable summer habitat is available along sections of Saddlers Creek; however there is no suitable winter shelter habitat.	Unlikely

Key: V = Vulnerable; E = Endangered; Mi = Migratory; Ma = Marine

6.5 Credit Species

The FBA uses native vegetation as a surrogate to assess a number of threatened species. For these species (which are largely fauna species strongly associated with vegetated habitats), the assessment of impacts to native vegetation (and the associated Ecosystem Credits required to address impacts on such vegetation) includes consideration of impacts to these threatened species. These species are referred to as “Ecosystem Credit species”.

Some species cannot be assessed using native vegetation as a surrogate. These species are referred to as “Species Credit species” and are largely comprised of threatened plant species. The assessment of Project impacts on Species Credit species generates a credit requirement for each species.

The identified Ecosystem Credit species associated with Project PCTs are listed in **Table 6.14**. The Species Credit species identified for the Project are listed in **Table 6.15**.

Table 6.14 Predicted "Ecosystem Credit" Species Associated with Onsite PCTs

Common Name	Scientific Name	Offset Multiplier
Black-chinned Honeyeater (eastern subspecies)	<i>Melithreptus gularis</i> subsp. <i>gularis</i>	1.3
Brown Treecreeper (eastern subspecies)	<i>Climacteris picumnus</i> subsp. <i>victoriae</i>	2
Bush Stone-curlew	<i>Burhinus grallarius</i>	2.6
Corbans Long-eared Bat	<i>Nyctophilus corbeni</i>	2.1
Diamond Firetail	<i>Stagonopleura guttata</i>	1.3
Flame Robin	<i>Petroica phoenicea</i>	1.3
Freckled Duck	<i>Stictonetta naevosa</i>	1.3
Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>	2
Glossy Black-Cockatoo	<i>Calyptorhynchus lathami</i>	1.8
Grey-crowned Babbler (eastern subspecies)	<i>Pomatostomus temporalis</i> subsp. <i>temporalis</i>	1.3
Hooded Robin (south-eastern form)	<i>Melanodryas cucullata</i> subsp. <i>cucullata</i>	1.7
Little Eagle	<i>Hieraaetus morphnoides</i>	1.4
Little Lorikeet	<i>Glossopsitta pusilla</i>	1.8
Masked Owl	<i>Tyto novaehollandiae</i>	3
Painted Honeyeater	<i>Grantiella picta</i>	1.3
Powerful Owl	<i>Ninox strenua</i>	3
Scarlet Robin	<i>Petroica boodang</i>	1.3
Speckled Warbler	<i>Chthonicola sagittata</i>	2.6
Spotted Harrier	<i>Circus assimilis</i>	1.4
Squirrel Glider	<i>Petaurus norfolcensis</i>	2.2
Swift Parrot	<i>Lathamus discolor</i>	1.3
Turquoise Parrot	<i>Neophema pulchella</i>	1.8
Varied Sittella	<i>Daphoenositta chrysoptera</i>	1.3
Yellow-bellied Sheath-tail-bat	<i>Saccolaimus flaviventris</i>	2.2

Table 6.15 Identified "Species Credit" Species

Common name	Scientific name	Identified From
Pine Donkey Orchid	<i>Diuris tricolor</i>	Survey
Pine Donkey Orchid population in the Muswellbrook LGA	<i>Diuris tricolor</i> population in the Muswellbrook LGA	Survey
Tiger Orchid population in the Hunter Catchment	<i>Cymbidium canaliculatum</i> population in the Hunter Catchment	Survey
Weeping Myall population in the Hunter Catchment	<i>Acacia pendula</i> population in the Hunter Catchment	Survey

6.6 Groundwater Dependent Ecosystems

The occurrence of GDEs in the Study Area has been assessed as likely to be represented by two communities:

- Hunter Floodplain Red Gum Woodland; and
- Hunter River Oak Forest.

As explained in **Section 5.3.6**, the identification of GDEs in the Study Area was determined on the basis of the presence of species such as *Eucalyptus camaldulensis* (River Red Gum), *Eucalyptus tereticornis* (Forest Red Gum) and *Casuarina cunninghamiana* (River Oak). This is because floodplain and creekline communities dominated by such canopy species as *Eucalyptus camaldulensis* (River Red Gum), *Eucalyptus tereticornis* (Forest Red Gum) and *Casuarina cunninghamiana* (River Oak) are likely to have some root access to deep watertables and thus comprise a GDE. The areas of these GDEs in the Study Area has been estimated and is shown in **Table 7.1**.

The degree of dependence of the GDEs within the Study Area has not been empirically measured using isotopes and/or borehole investigations. However, Hunter Floodplain Red Gum Woodland and Hunter River Oak Forest in the Study Area is likely to be partially dependent upon groundwater, as the community mostly occurs in association with the gullies and creeks where it may be flooded on occasion and where there is a presence of shallow groundwater within Quaternary sediments (see EIS groundwater impact assessment).

As vegetation will primarily extract water from sources where the combination of soil moisture content, root density and hydraulic connectivity requires the least amount of energy, vegetation will use shallow soil water before seeking deeper soil water or groundwater (Serov *et al.*, 2012). Therefore these vegetation types are unlikely to be completely dependent on groundwater as the canopy trees such as *Eucalyptus tereticornis* (Forest Red Gum), *Angophora floribunda* (Rough-barked Apple) and *Casuarina cunninghamiana* (River Oak) are likely to draw on surface flows in streams and gullies and

shallow soil water before accessing groundwater. The understorey of these communities is similar to the surrounding grassy understorey of non-GDE vegetation and is unlikely to be groundwater-dependent.

The now partially cleared valley floor and floodplain areas to the north of the Study Area would have historically supported GDEs, consisting of floodplain vegetation such as Hunter Floodplain Red Gum Woodland. These areas are now largely dominated by derived native grasslands and in some areas exotic grassland.

6.7 Aquatic Results

6.7.1 *Habitat Assessment*

Habitat assessments were conducted along Saddlers Creek and at the confluence with the Hunter River. General habitat assessment results are shown in **Table 6.16**. Both water bodies provide habitat for a range of macroinvertebrates and possibly amphibians. Results of the 2000 aquatic study of the Study Area (The Ecology Lab Pty Ltd, 2000) indicated that Saddlers Creek was unlikely to support significant freshwater fish communities but that it potentially provides some degree of refuge for aquatic fauna during periods of higher flow and would benefit from rehabilitation measures.

i. Saddlers Creek

Saddlers Creek is considered a “typical small, enlarged rural stream” (Rutherford *et al.*, 2000) and has little prospect for natural, unassisted recovery. Characteristics of these watercourses include:

- Small, with occasional flow;
- Cleared to the banks;
- Accessed by livestock;
- Channel erosion at the outer banks and possible deepening by up to 0.5 m;
- Removal of large snags and rocks;
- Contamination of coarse sediments with fine-grained sediment;
- Limited aquatic fauna, typically restricted to carp;
- Little shading from riparian vegetation; and
- Nutrient-enriched pools.

Saddlers Creek experiences minimal flows and its tributaries are generally ephemeral. Upstream, the creek is characterised by low, or no flows and steep, eroded and exposed clay banks. Pre-agriculture, these channels were likely to have been meandering watercourses (NSW Department of Planning, 2005), subject to fluctuating flow regimes and

the nature of the soil. Meandering creeks and channels are sensitive ecosystems that rely on riparian vegetation and woody debris such as logs to provide stability and prolong the availability of water in 'chains of ponds' (Eyles, 1977; Rutherford *et al.*, 2000). As these features do not exist along large sections of Saddlers Creek, this increases its susceptibility to significant erosion (NSW Department of Planning, 2005).

Chains of ponds are important ecological and landscape features that provide permanent water sources for native fauna. These are typically discrete ponds of varying size (approximately 6 to 60 m in length) that appear along drainage lines and small to medium streams of broad open valleys, large flats or floodplains (Eyles, 1977; Rutherford *et al.*, 2000). This morphology is common in south eastern Australia, most likely due to climatic variability in which infrequent high flows gouge sediment and form ponds. These events are interspersed with long periods of low flow that allow in-stream vegetation to establish between ponds (Eyles, 1977).

Post-European settlement, these watercourse features have generally been replaced by severely incised channels on the floodplain and gullies with vertical walls (Wasson *et al.*, 1998; Brooks *et al.*, 2003) which have formed as a result of clearing to the banks, erosion and heavy rainfall events and a lack of stabilising vegetation. Some small, disjointed, semi-permanent ponds do exist along Saddlers creek; however, these are in poor condition due to the lack of flooding events, stagnation, trampling by cattle and colonisation by invasive species such as the rush *Juncus acutus* (Sharp Rush). These ponds are also at risk of becoming unstable and draining due to further channel widening or incision (Rutherford *et al.*, 2000).

Four locations were surveyed and are referred to as S1, S2, S3 and S4 (see **Figure 7**). The sites have experienced high levels of disturbance and are degraded (**Photographs 6.21** and **6.22**). At the time of survey, these locations were little more than small, disjointed ponds that contained very little water. The watercourse provides somewhat simplified habitat with little or no in-stream vegetation, or rocks and snags for aquatic fauna. Few macroinvertebrates can colonise and survive on bare substrates, even if water quality is suitable (Chessman, 1995; Chessman and McEvoy, 1998).

Macrophyte diversity was low; *Typha* sp. (Cumbungi), *Juncus acutus* (Sharp Rush) and *Phragmites australis* (Common Reed) are abundant and choking the in-stream of these sections of Saddlers Creek. Sharp Rush is an indication of a saline environment. This vegetation provides some suitable refuge for amphibians and birds and with proposed rehabilitation can create an extensive habitat corridor along the whole creek length.



Photograph 6.21 **Low-value Habitat at Site S1 along Saddlers Creek**



Photograph 6.22 **Low-value Habitat at Site S2 along Saddlers Creek**

ii. Hunter River

The Hunter River is a larger watercourse with constant flow. The river is characterised by a narrow band of riparian vegetation and wide floodplain cleared of vegetation for agricultural purposes, which is the typical landscape all along the Hunter River banks. The limited native riparian vegetation that does exist is in poor condition, impacting on bank stability and currently reducing its potential use as a fauna habitat corridor.

In 2002, the NSW Stressed Rivers Assessment Report assessed the health of the Hunter River catchment and determined that it was not ecologically sustainable in its current capacity. It found that a number of watercourses were under environmental stress as a consequence of pressures from surrounding agriculture, industry and urban development (Healthy Rivers Commission, 2003). Water quality was variable, and nearly two thirds of streams were considered to be in degraded condition. Approximately 10% of streams were considered unstable, with highly modified pool and riffle substrate and severely eroded and structurally unstable banks. At the time of survey, macroinvertebrate results indicated that between 40 and 70% of sampled sites were in poor condition and only 70% of native fish species were still present in the catchment.

Seasonal surveys conducted in the Hunter River from 2005 to 2006 showed the improvement of river health and abundant and diverse aquatic macroinvertebrate assemblages (Harris and Gehrke, 1997; Healthy Rivers Commission, 2003), (Hanquet *et al.*, 2004; Robson *et al.*, 2005; Marshall *et al.*, 2006; Sharpe and Downes, 2006; Sheldon and Thoms, 2006).

At survey locations at the confluence with Saddlers Creek and the proposed water intake/discharge outlets, the Hunter River is characterised by steep banks and shows evidence of bank erosion and severe weed infestation. The river ranges in width from 20 to 50 m. At the time of survey, the river was fairly deep and river flow was moderately fast, as a result of heavy rainfall experienced the previous week (refer to **Photographs 6.23** and **6.24**).

Depending on the survey location, the substratum ranges from rocks and pebbles to sand, silt and clay, providing suitable habitat for a variety of macroinvertebrates and amphibians. Other habitat features include logs, dense reeds and rushes along the bank, and overhanging canopy vegetation in the form of *Casuarina glauca* (Swamp Oak) and the exotic tree species *Salix babylonica* (Weeping Willow).



Photograph 6.23 **Habitat Upstream of the Confluence of the Hunter River and Saddlers Creek**



Photograph 6.24 **Habitat at site H3 (Proposed Water Outflow Pipeline) along the Hunter River**

Table 6.16 Summary of Aquatic Habitat Assessment

Site	Surrounding land use	Dominant Substrate	Rocks/snags	Riparian trees >10 m	Other riparian vegetation	Macrophytes*	Water quality	In-stream Vegetation	Riparian Vegetation
H1	Agriculture (cropping)	Gravel	Limited	Present	Native reeds and exotic grasses and rushes	Absent	2	2	2
H2	Livestock grazing	Sand- Cobbles	Present	Absent	Absent	Limited	2	2	2
H3	Livestock grazing	Sand - Silt	Limited	Present	Exotic vines	Limited	2	2	3
H4	Livestock grazing	Silt	Absent	Present - limited	Exotic rushes and grasses	Limited	4	4	3
S1	Livestock grazing	Silt	Absent	Present	Exotic grasses	Present	3	3	3
S2	Livestock grazing	Silt	Absent	Absent	Exotic rushes	Present	3	3	3
S3	Livestock grazing	Silt	Absent	Absent	Native reeds and exotic rushes	Present	3	3	3
S4	Livestock grazing & cropping	Silt	Absent	Present - limited	Native reeds and exotic grasses	Absent	2	3	2

* = Absence of aquatic macrophytes is indicative of erosion or instability, turbidity or carp impact.

AUSRIVAS Visual Assessment Ranking:

0 = no evidence of human disturbance

1 = little disturbance

2 = moderate disturbance

3 = high disturbance

4 = extreme disturbance

6.7.2 Site Condition and Ecological Integrity

The current condition and degree of ecological integrity of the aquatic sites was determined by inputting survey data into the AUSRIVAS macroinvertebrate predictive model (Turak and Waddell, 2001b), and SIGNAL macroinvertebrate scoring system (Chessman, 2003). Water quality was compared to published guidelines for lowland rivers in south eastern Australia to determine the levels of disturbance affecting each site (ANZECC, 2000). Guideline trigger values are concentrations (or loads) of the key performance indicators (KPIs), below which there is a low risk of adverse biological effects. These may have direct or indirect, toxic or non-toxic effects on the ecosystem or biota (von der Ohe and Liess, 2004).

Based on input data, most aquatic survey locations were classified as AUSRIVAS band C (severely impaired). One site (S3) had relatively high macroinvertebrate diversity which gave it an AUSRIVAS band A rating, and one site (S2) was rated band D (extremely impaired) (Turak *et al.*, 2004). River health results show that all sites are severely altered or affected by surrounding land practices and do not support a diverse assemblage of aquatic invertebrate fauna. At these sites, up to 75% of expected biodiversity has been lost.

AUSRIVAS-determined bands for river health at each site are summarised in **Table 6.17** and the AUSRIVAS band keys are presented in **Table 6.18**. Input components and results are explained in further detail in the subsections below.

Table 6.17 Health of Aquatic Sites According to AUSRIVAS Bands

Site	AUSRIVAS Band	Band Description
H1	C	Severely Impaired
H2	C	Severely Impaired
H3	C	Severely Impaired
H4	C	Severely Impaired
S1	C	Severely Impaired
S2	D	Extremely Impaired
S3	A	Reference condition
S4	C	Severely Impaired

Table 6.18 AUSRIVAS Band Keys

AUSRIVAS Band	Description	Macroinvertebrate Biodiversity Status	Comments
X	More biologically diverse than reference sites	Over 112% more biodiversity than reference sites	More macroinvertebrate families found than expected. Potential biodiversity 'hot spot'. Possible mild nutrient enrichment.
R	Reference Site	Natural or near-natural levels of biodiversity	Presumed to be in a reference condition
A	Reference condition	Similar levels of biodiversity to reference sites	Most or all of the expected families were found at the sample site. Water quality and / or habitat condition roughly equivalent to reference sites.
B	Significantly impaired	Approximately 16-45% of macroinvertebrate biodiversity has been lost	Several expected families not found. Water quality and/or habitat condition significantly impaired. Significant loss of macroinvertebrate biodiversity.
C	Severely impaired	Approximately 46-75% of macroinvertebrate biodiversity has been lost	Many expected families not found. Water quality and/or habitat condition severely impaired. Severe loss of macroinvertebrate biodiversity.
D	Extremely impaired	Approximately 66-100% of macroinvertebrate biodiversity has been lost	Extremely few of the expected families found. Extremely poor water quality and/or habitat condition. Extreme loss of macroinvertebrate biodiversity. Highly degraded
?	Beyond the capacity of current AUSRIVAS models	Could not be assessed using current AUSRIVAS models	Could not be assessed using current AUSRIVAS models

i. *Physical and Chemical Stressors*

Trigger values or target loads are used to provide an indicative assessment of water quality and ecosystem health using conservative threshold values assigned to various water components. Desirable ranges may vary depending on local conditions (DEC (NSW), 2004a). Trigger values, including those specified in the ANZECC guidelines (ANZECC, 2000), indicate:

- Low risk that adverse biological (ecological) effects will occur where values are below the trigger value or within the desirable range; or
- High risk that adverse biological (ecological) effects will occur where values are higher than the trigger value or outside the desirable range. If exceeded, these values should 'trigger' some action, either further ecosystem specific investigations or implementation of management/ remedial actions.

Physical and chemical data collected that was used to determine the overall condition of each survey site is shown in **Table 6.19**. A brief explanation of the impact of these stressors in relation to ANZECC trigger values and AUSRIVAS bands is listed below (ANZECC, 2000; Turak and Waddell, 2001b). The watercourses are considered 'lowland' rivers under the ANZECC guidelines as altitude is below 150 m.

- **Alkalinity (mg/L):** Alkalinity levels at all sites were extremely high, ranging from 160 to 970ppm. Watercourses can be naturally alkaline if minerals derived from the underlying geology leach out of the soil. Levels of at least 20 ppm are considered the minimum required to protect aquatic organisms against any changes in pH.
- **Conductivity (µS/cm):** Electrical conductivity varied widely between sites. Conductivity levels can fluctuate greatly depending on flow rates, groundwater input, surrounding geologies and land use. The variability of conductivity of the water at the sample sites is likely to be the result of a combination of factors such as flow regime, evaporation, runoff and the minerals within underlying geology and soil. Hunter River readings are well within ANZECC guidelines.
- **Dissolved oxygen (DO) (ppm):** levels varied between sites, with some sites well below the ANZECC minimum criteria values, indicating poor water quality that is not suitable to sustain diverse invertebrate and vertebrate populations. Numerous studies suggest that fish cannot survive when DO levels drop below 3 ppm. While DO levels can fluctuate daily and ongoing monitoring would be required to determine long-term trends, sites S1 and S4 were particularly poor during surveys due to pools of stagnant water. DO can vary depending on factors such as time of day, temperature, photosynthetic activity, amount of decaying organic matter, aeration and stream flow and animal and human activities.
- **pH:** While S2 had unusually high readings (10.16), pH levels were fairly similar across the remaining sites but toward the ANZECC upper limit trigger values.

Higher pH levels can damage metabolic function or directly kill aquatic organisms. It may also increase the toxicity of metals and substances such as ammonia.

- **Turbidity (NTU):** The sample sites generally had mid-range levels, as specified by ANZECC guidelines, of suspended particulate matter. H4 had very high turbidity levels (74.4 NTU). A lack of macrophyte and riparian vegetation along the banks at H4 allows fine clay and silt sediment to erode into the watercourses. The sediment was observed to be easily disturbed and remained suspended in the water column for a long time before settling to the substrate.

Table 6.19 Aquatic Physical and Chemical Data

	Units	ANZECC trigger values*	S1	S2	S3	S4	H1	H2	H3	H4
Chemical Properties										
Calcium (C)	mg/L		160	56	110	110	34	34	35	73
Magnesium (Mg)	mg/L		400	210	420	360	25	25	25	80
Mercury (Hg)	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorus (P)	mg/L	0.05 mg/L	0.11	0.27	0.095	0.088	0.064	0.083	0.067	0.1
Potassium (K)	mg/L		11	18	7.7	10	2.6	2.7	2.8	8.1
Sodium (Na)	mg/L		1180	970	1390	1640	44	45	45	480
Chloride	mg/L		2200	1800	2500	2900	66	67	68	510
Alkalinity (as CaCO ₃)	mg/L		970	210	800	760	160	170	170	680
Nitrogen Total	mg/L	0.5 mg/L	1.3	6.6	0.86	0.45	0.31	0.34	0.35	0.79
NOx	mg/L	0.04 mg/L	0.01	<0.01	<0.01	<0.01	0.11	0.11	0.12	0.025
Sulphate	mg/L		510	470	530	180	24	23	23	75
Physical Properties										
Temperature	°C		14.4	18.6	16.2	15.8	17.3	16.9	16.8	16.3
Turbidity	NTU	6-50 NTU	22.5	26.7	28	4.2	14.5	19.2	20.4	74.4
Dissolved Oxygen	mg/L		1.08	11.64	4.26	2.52	9.47	9.41	7.86	4.67
pH	pH	6.5-8	7.71	10.16	7.95	8.21	8.13	7.68	7.03	7.79
Conductivity	µS/cm	125-2200	-	-	-	-	566	590	505	-

*Chemical and physical trigger values for lowland rivers in SE Australia for slightly disturbed ecosystems. The values are used to assess the risk of adverse effects due to nutrients, biodegradable organic matter and pH in various ecosystem types.

ii. *Macroinvertebrates*

Using SIGNAL and AUSRIVAS scores, the assemblage of macroinvertebrates at each site was used to determine how degraded the survey sites are.

Twenty-nine macroinvertebrate taxa were identified across the eight aquatic survey locations. The majority of taxa are regarded as tolerant to very tolerant of environmental stresses, with SIGNAL grades under 5. S3 had the highest macroinvertebrate diversity, with 19 taxa collected. S2 had the lowest number of taxa, with four taxa collected, most likely due to a lack of flowing water and limited habitat availability. SIGNAL results of macroinvertebrate sampling are summarised in **Table 6.20** below.

Table 6.20 SIGNAL Macroinvertebrate Scores

Site	Number of Taxa	SIGNAL score
H1	7	7.2
H2	7	8
H3	7	1.3
H4	6	4.7
S1	5	7.1
S2	4	2.6
S3	19	2.4
S4	6	2.3

< 4 – severe pollution;

4 - 5 – moderate pollution;

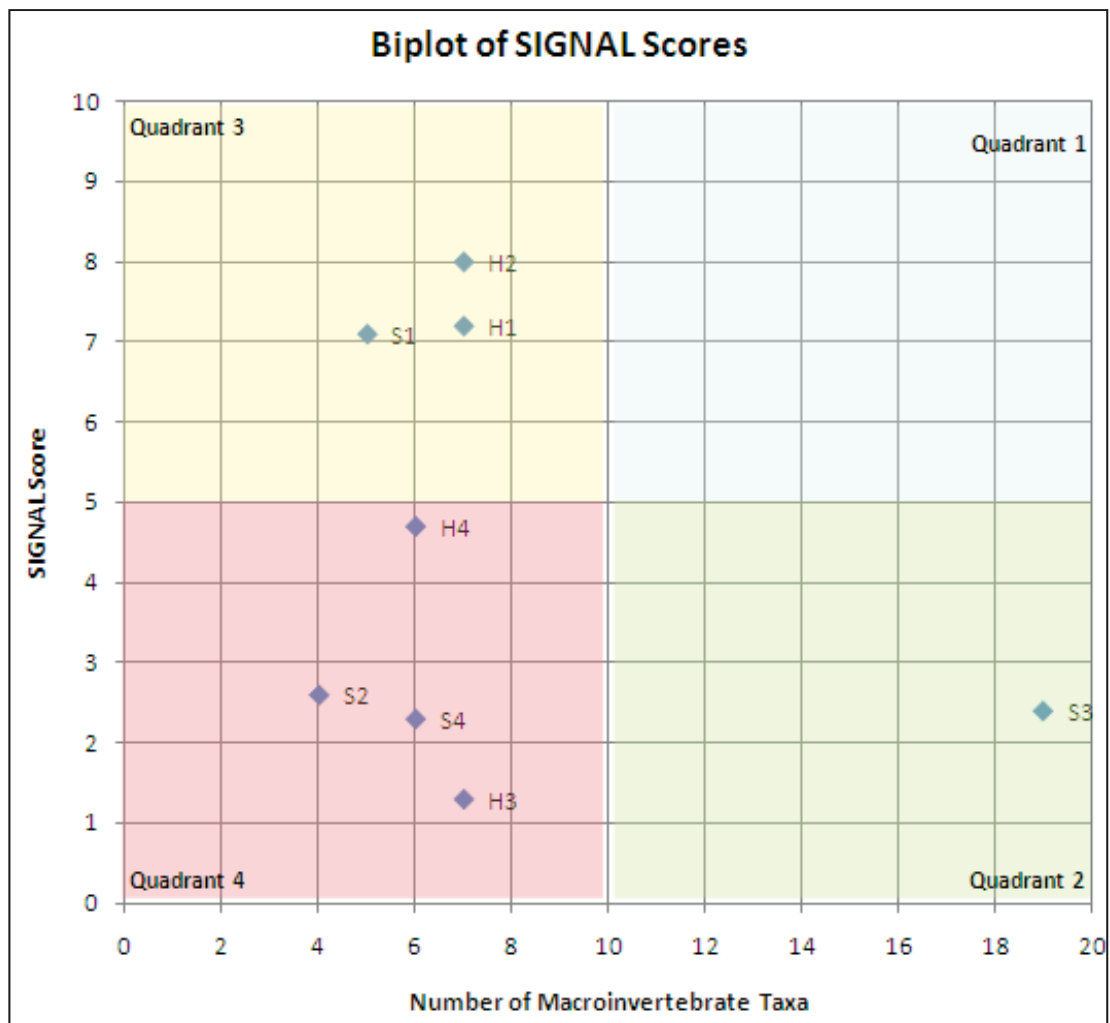
5 - 6 – fair water quality; and

> 6 – good water quality

The most common taxa included fly, bug, dragonfly, caddisfly and beetle larvae; generally those with low SIGNAL grades indicating their tolerance of a range of environmental conditions, including poor water quality and common forms of water pollution. In general, the Hunter River sites had a greater number of invertebrates with high SIGNAL grades, indicating greater sensitivity to environmental stressors, and thus indicating somewhat better water quality or habitat availability.

SIGNAL scores for order-class-phylum taxa have been plotted in a basic quadrant diagram, displayed in **Graph 6.1** and explained below. The scores represent general environmental conditions based on the abundance and diversity of taxa collected at each site. The graph shows that the majority of sites fall in quadrant 4 and are affected by one or more human impacts, which are typically from urban, industrial or agricultural pollution, or downstream effects of dam.

Sites H2 and H3 were expected to be similar in condition and have similar SIGNAL results as they are located relatively close together, near the pipeline locations, and physical and chemical attributes and taxa abundance were very similar. However, they have been placed in separate quadrants based on the specific taxa recorded; each site recorded completely different taxa, each with different environmental sensitivity grades. As other site attributes are comparable this could be a result of the substrate, cobbles versus silt, respectively, which provided different habitat conditions for macroinvertebrates.



Graph 6.1 **Biplot of the Condition of Each Aquatic Survey Site According to SIGNAL Scores**

a. Quadrant 1: (none)

Quadrant 1 represents high values for SIGNAL scores and the number of macroinvertebrate taxa. The presence of large number of taxa suggests that the diversity of physical habitats is high and that stress factors like toxic chemicals and harsh physical conditions are not present. The high SIGNAL scores suggest that turbidity, salinity and nutrient concentrations are low.

b. Quadrant 2: S3

Quadrant 2 represents lower SIGNAL scores and a high diversity of macroinvertebrate types. Sites falling in this quadrant are likely to have higher levels of turbidity, salinity or nutrients than those in quadrant 1. These levels may be high either naturally, because of local geology and soil types, or as a result of human activities. The high number of macroinvertebrate types suggests that physical conditions are still benign and toxic chemicals are not present in large amounts. Many agricultural streams without severe impacts fall into this quadrant.

c. Quadrant 3: S1, H1 and H2

Quadrant 3 represents high values of SIGNAL scores but few macroinvertebrate types. Sites with toxic pollution, such as those below old mine sites where acidic drainage can result in low pH and high concentrations of trace metals usually fall either in this quadrant or in quadrant 4. This occurs because the tolerances of some macroinvertebrate types differ according to the type of pollution.

Harsh physical conditions can also result in sites falling in quadrant 3. A very simple habitat structure, such as occurs on mobile sand beds or bare muddy beds, can result in few macroinvertebrate types being able to colonise and survive, even if water quality is suitable for them. Extreme floods can wash macroinvertebrates away, so that few types are collected if sampling occurs soon after the flood has receded.

d. Quadrant 4: S2, S4, H3 and H4

Quadrant 4 represents low values of both the SIGNAL scores and the number of invertebrate types. Most sites falling into this quadrant will be suffering from one or more forms of human impact. This is not surprising as all sites are located within a highly degraded region in which native vegetation has been removed, grazing still occurs, and watercourses are not protected or fenced off.

6.7.3 Aquatic Vertebrate Species

Sampling of vertebrates in the Hunter River, particularly fish, communities was not included in the 2011 survey scope of works as the Hunter River is outside of the Study Area and proposed activities are not likely to impact on the river. However, a literature review of the larger Hunter Valley catchment determined it unlikely that the river system would support abundant or diverse fish communities (The Ecology Lab Pty Ltd, 2000; Marine Pollution Research Pty Ltd, 2009; Howell and Creese, 2010).

Studies of the catchment includes results from a State-wide assessment of fish populations conducted for the NSW Stressed Rivers Assessment Report in which four sites in the Hunter Valley were sampled (Harris and Gehrke, 1997). **Table 6.21** summarises the survey results from a study spanning 30 years that identified 18 native freshwater fish species and five alien species in the Hunter Valley catchment (Howell and Creese, 2010). This number accounts for approximately 70% of the native fish species estimated to occur in the catchment (Healthy Rivers Commission, 2003).

Table 6.21 Vertebrate Fauna Recorded in the Hunter River

Scientific Name	Common Name	Native/ Introduced	Most recent record
<i>Anguilla australis</i>	Short-finned Eel	Native	2010
<i>Anguilla reinhardtii</i>	Long-finned Eel	Native	2010
<i>Craterocephalus amniculus</i>	Darling River Hardyhead	Species of concern- locally threatened	2010
<i>Potamalosa richmondia</i>	Freshwater Herring	Native	2010
<i>Cyprinus carpio</i>	Common Carp	Introduced	2009
<i>Gobiomorphus australis</i>	Striped Gudgeon	Native	2010
<i>Gobiomorphus coxii</i>	Cox's Gudgeon	Native	2010
<i>Hypseleotris klunzingeri</i>	Western Carp Gudgeon	Native	1971
<i>Hypsiliotris compressa</i>	Empire Gudgeon	Native	2010
<i>Philypnodon grandiceps</i>	Flathead Gudgeon	Native	2009
<i>Philypnodon macrostomus</i>	Dwarf Flathead Gudgeon	Native	2009
<i>Galaxias brevipinnis</i>	Climbing galaxias	Native	2001
<i>Galaxias olidus</i>	Mountain galaxias	Native	2001
<i>Mugil cephalus</i>	Sea Mullet	Native	2010
<i>Trachystoma petardi</i> (syn. <i>Myxus petardi</i>)	Freshwater Mullet/ Pink-eye Mullet	Native	2010
<i>Macquaria novemaculeata</i>	Australian Bass	Native (Stocked)	2009
<i>Tandanus tandanus</i>	Freshwater Catfish / Eel-tailed Catfish	Native	2009
<i>Gambusia holbrooki</i>	Plague Minnow/ Mosquito Fish	Introduced	2009
<i>Retropinna semoni</i>	Australian Smelt	Native	2009
<i>Oncorhynchus mykiss</i>	Rainbow Trout	Introduced (Stocked) 2010	2010
<i>Salmo trutta</i>	Brown Trout	Introduced (Stocked)	2010
<i>Notesthes robusta</i>	Bullrout	Native	2010

Table 6.21 Vertebrate Fauna Recorded in the Hunter River

Scientific Name	Common Name	Native/ Introduced	Most recent record
<i>Chelodina longicollis</i>	Eastern Snake-necked Turtle/ Long-necked Tortoise	Native	2008

Source: (Howell and Creese, 2010)

The decline in expected abundances of fish species has been attributed to habitat degradation; disruption of spawning and migration pathways; disease, competition from alien species and predation; fishing; reduced water quality and pollution (Llewellyn, 1983; Gehrke and Harris, 1996; Howell and Creese, 2010). A major factor of habitat degradation is the removal of instream woody structures such as snags which are recognised as important habitat features for native fish in lowland sections of inland rivers (Erskine and Bell, 1982; Rutherford *et al.*, 2000; Arthur Rylah Institute). Snags encourage oxygenation of water; slow and alter stream flow and direction; provide shelter, feeding and shaded habitat, spawning sites and nursery areas for fauna; and substrates for biofilm and algae colonisation at different heights in the water column. The loss of snags has also been linked to the successful establishment of invasive species such as Common Carp (*Cyprinus carpio*) and Mosquito Fish (*Gambusia holbrooki*) in the Hunter and other NSW rivers (CRC for Freshwater Ecology). Mosquito Fish were caught at all four Hunter River sites and at some of the Saddlers Creek sites, despite the lack of flowing water.

6.7.4 Aquatic Threatened Species

No threatened aquatic species were recorded during vertebrate surveys of Saddlers Creek and the Hunter River (The Ecology Lab Pty Ltd, 2000). Other surveys conducted in the Hunter River catchment have not found any threatened species. The Hunter River catchment is not considered to provide suitable habitat for threatened species and communities that are listed under the FM Act or EPBC Act (The Ecology Lab Pty Ltd, 2000; Umwelt (Australia) Pty Ltd, 2008)

Chapter 7

Project Impacts

7.1 Direct Impacts on Native Terrestrial Vegetation

The total Project Disturbance Footprint area is approximately 1,441 ha in size. Within this area, approximately 1,438 ha of vegetated land will be cleared for the mine pits, the active spoil fill areas, haul road, mine site facilities, a mine dam and the Edderton Road realignment (**Figure 11**). No ground disturbance is required for the lay down of the water pipeline but some clearance of woody vegetation is assumed (where the alignment crosses woodland and forest patches) to maintain a clearway for construction and maintenance access.

The largest direct impact of the Project is the removal of native vegetation from the Study Area that, in addition to providing habitat for native flora and fauna, also performs an important role in regulating ecosystem health (McIntyre *et al.*, 2002). Approximately 1,438 ha of vegetation comprising remnant and regenerating forest and woodland and large areas of open grassland with scattered trees will be removed from the Study Area over the life of the Project. These vegetation communities provide habitat for a range of flora and fauna, including species listed as threatened or migratory under the EPBC Act and/or TSC Act.

The direct removal of approximately 291 ha of forest and woodland communities and approximately 1,447 ha of grassland vegetation will reduce their overall extent in the Study Area. This includes various communities that conform to the EPBC Act and TSC Act listed Box-Gum Woodland; and other threatened woodland communities. Areas of vegetation to be removed from the Study Area by the Project are shown in **Table 7.1** and **Figure 12**.

The direct removal of vegetation communities from the Study Area is likely to result in the following impacts to remaining habitat by:

- Removing or reducing the availability of important habitat features that may offer forage, shelter or breeding opportunities for fauna, thus putting more pressure on remaining habitat to provide these features (**Section 7.1.1**);
- Exacerbating fragmentation and isolation in already patchy woodland areas. Although the remnant vegetation is already fragmented within the Study Area, the Project is likely to exacerbate the degree of fragmentation and isolation of woodland areas (**Section 7.1.3**);

- Reducing connectivity by removing areas of woodland and forest that would serve as “stepping stones” for mobile fauna in an otherwise cleared landscape (**Section 7.1.4**);
- Increasing edge effects, particularly along linear patches (**Section 7.1.5**);
- Reducing nutrient and water cycling through the system;
- Loss of soil to wind or water erosion as a result of the lack of groundcover shelter; and
- Removing important pollinators such as birds, bats and insects critical for the pollination of native plants.

Mitigation and offset measures have been developed to address and counter such predicted impacts. Mitigation measures are discussed in **Chapter 8** and offsetting strategies are detailed in the EIS biodiversity offset strategy report.

The Project will also clear a total area of 37 ha from the minor additional mining areas at Drayton Mine. This area includes approximately 19 ha of vegetation that comprises less than 2 ha of immature forest regeneration and shrub plantings; as well as larger areas of rehabilitated exotic grassland and low diversity native grasslands (see **Table 6.3**). This vegetation holds little conservation significance in its current form because:

- It represents poor quality vegetation;
- It does not have good prospects for recovery;
- It does not represent good habitat for flora and fauna species, particularly threatened species; and
- The woody vegetation present is too small and isolated to provide effective stepping stone connectivity between more significant habitats in the locality.

Table 7.1 Areas of Vegetation to be Removed by the Project

Map Unit (MU)	Vegetation Community	Legal Status ¹		Area of Vegetation (ha)		Proportion to be Disturbed
		TSC Act	EPBC Act	Within Study Area	Within Disturbance Footprint	
MU 1	Upper Hunter White Box-Ironbark Grassy Woodland	EEC	CEEC	93.6	3.8	4%
MU 2	Upper Hunter White Box-Ironbark Grassy Woodland Derived Native Grassland	EEC	CEEC	159.2	2.7	2%
MU 3	Hunter Floodplain Red Gum Woodland	EEC	CEEC	39.4	10.9	28%
MU 4	Hunter Floodplain Red Gum Woodland Derived Native Grassland	EEC	CEEC	10.1	4.3	42%
MU 5	Central Hunter Box-Ironbark Woodland	EEC	-	477.4	150.9	32%
MU 6	Narrabeen Footslopes Slaty Box Woodland	VEC	-	98.8	97.0	98%
MU 7	Central Hunter Bullock Forest Regeneration	-	-	55.6	25.9	60%
MU 8	Hunter Valley River Oak Forest	-	-	2.2	2.2	100%
MU 9	Cooba Scrub	-	-	52.1	0	0%
MU 10	Planted Vegetation	-	-	8.3	0	0%
MU 11	Other Grassland – moderate/good condition	-	-	2304.0	981.0	43%
MU 12	Other Grassland – low condition	-	-	1264.8	159.4	13%
TOTAL (to nearest whole hectare)				4565	1,438	31%

¹As listed under the Schedules of the TSC Act and EPBC Act.

Key: EEC = endangered ecological community; CEEC = critically endangered ecological community; VEC = vulnerable ecological community

7.1.1 *Impacts on Threatened Ecological Communities*

The Project will result in a reduction in the local and regional abundance and distribution of various vegetation communities, including TECs. Assessments of Significance have been prepared to assess the impact of the Project on each TEC (see **Appendix G**).

i. Box-Gum Woodland

The Project will remove the following Box-Gum Woodland communities from the Study Area:

- Approximately 4 ha of MU 1: Upper Hunter White Box-Ironbark Grassy Woodland and 3 ha of native grassland derived from this community (MU 2), which represent a respective 4% and 2% of the total extent of these communities in the Study Area; and
- Approximately 11 ha of MU 3: Hunter Floodplain Red Gum Woodland and 4 ha of native grassland derived from this community (MU 4); which represent a respective 28% and 42% of the total extent of these communities in the Study Area.

The total area of Box-Gum Woodland that will thus be directly impacted by the Project is likely to be in the order of approximately 22 ha, which would represent approximately 4% of the onsite extent of the community (*c.f.* **Figure A.1** and **Figure A.5**). In the larger context of the Central Hunter Valley, the onsite distribution of each of the above Box-Gum Woodland communities to be disturbed by the Project would represent about 0.07% of the Central Hunter distribution estimated for Upper Hunter White Box-Ironbark Grassy Woodland; and 2.5% for Hunter Floodplain Red Gum Woodland (Peake, 2006). When considering the total extant extent over NSW, the proportion of Box-Gum Woodland to be cleared for the Project would comprise less than 0.01% of the estimated State-wide distribution (Threatened Species Scientific Committee, 2006).

Notwithstanding the above, Box-Gum Woodland is a TEC that has received particular attention from government agencies and conservationists as a high extinction-risk community and is generally considered to be of very high conservation significance. It was once a geographically wide-spread community spanning three different states and covering an estimated pre-European area of several million hectares but has since declined quickly and dramatically across its range. As a consequence of the decline of Box-Gum Woodland, many flora and fauna species have been directly and indirectly affected by the removal of forage, breeding, and/or roosting habitat that is provided by this community and are now listed as threatened under State and/or Commonwealth legislation (DECCW, 2011). Approximately 10% of its pre-European extent is estimated to remain today; the decline is primarily attributed to the community being situated largely on fertile, arable land in prime agricultural areas (DECCW, 2011).

In NSW, Box-Gum Woodland has suffered a large decline; less than 10% of its original extent is estimated to remain (DECCW, 2011). Much of the community across the state now exist as paddock trees or isolated and fragmented remnant patches with reduced structural complexity and little evidence of regeneration (DECCW, 2011). Remaining remnants of Box-Gum Woodland are recognised to be under continued threat from further land clearing due

to ongoing land use for agriculture, horticulture, mining, urban expansion and public infrastructure (DECCW, 2011). Furthermore, as remnant patches become more fragmented and isolated, they become even less resilient to degradation and require active management to counter the effects of these processes.

In the Central Hunter region, Box-Gum Woodland is considered to be regionally significant as it is rare, highly cleared, restricted in its distribution and poorly conserved in the formal reserve system (Peake, 2006). The patterns of decline mirror those recorded state-wide. Much of the community has been extensively cleared throughout its original distribution and remaining areas are highly fragmented; for instance, the majority of remaining woodland areas persist largely as remnant patches of less than 10 ha (Peake, 2006). Only 11% of the original distribution of Box-Gum Woodland in the Central Hunter remains today and the community continues to be at risk as a result of various land practices that promote ongoing degrading processes (e.g. suppressed regeneration caused by ongoing livestock grazing, low connectivity, edge effects, erosion and significant weed invasion). The threat from land clearing for industry and urban expansion are considered to be so high that the Key Threatening Processes (KTP) “*Clearing of native vegetation*” (TSC Act) and “*Land clearance*” (EPBC Act) have been named as the most prevalent threats to this community (NSW DECCW, 2010).

Since Box-Gum Woodland remains poorly represented in the national conservation reserve system, the conservation of remaining remnants is critical to the recovery of the community. Recovery of the ecological community can also be expected to directly benefit the recovery of threatened species reliant on Box-Gum Woodland (NSW DECCW, 2010).

In consideration of all of the above, the Project is likely to result in a significant impact to Box-Gum Woodland as the removal of approximately 22 ha will contribute to the cumulative loss of what is considered to be an over-cleared vegetation community and exacerbate the KTPs identified as prevalent threats to this community. This TEC has been nominated within the SEARs to be a Matter Requiring Further Consideration. Additional information is presented in **Section 9.2** as required by Section 9.2.5.2 of the FBA (OEH, 2014b).

There is a good opportunity to redress the anticipated loss of Box-Gum Woodland by implementing appropriate amelioration measures (see **Chapter 8**). Anglo American is committed to avoiding impacts on Box-Gum Woodland as much as possible through the Project design and will implement a number of mitigation measures. Residual impacts that cannot be addressed through mitigation or avoidance will be compensated. Anglo American has proposed a substantial offsets package to compensate for the loss of this community (see EIS biodiversity offset strategy report). With the implementation of the proposed avoidance, mitigation and compensation measures, the Project is likely to avoid a significant impact on Box-Gum Woodland.

ii. *Central Hunter Box – Ironbark Woodland*

The Project will remove approximately 151 ha of MU 5: Central Hunter Box – Ironbark Woodland from the Study Area. This represents approximately 32% of the total extent in the Study Area and approximately 1% of the estimated extent in the Central Hunter region.

Central Hunter Box – Ironbark Woodland is considered to be over-cleared in the Central Hunter region and is currently highly fragmented, with the majority of extant patches persisting as small remnants of less than 10 ha in size (Peake, 2006). It is also considered to be regionally significant, being threatened and poorly reserved (Peake, 2006). As a consequence of the decline of Central Hunter Box – Ironbark Woodland, many flora and fauna species that rely on this community for habitat, such as *Cymbidium canaliculatum* (Tiger Orchid) and *Diuris tricolor* (Pine Donkey Orchid) are now listed as threatened under State and/or Commonwealth legislation.

Without appropriate mitigation and amelioration measures, the Project will contribute to the loss of MU 5: Central Hunter Box – Ironbark Woodland on both a local and regional scale and exacerbate existing threatening processes. The Project will be designed with the aim to avoid impacts on this TEC as much as practicable. In addition, a substantial offsets package has been prepared to compensate for the residual impacts. Recovery of this community can also be expected to directly benefit the recovery of a number of threatened flora and fauna species. With the implementation of avoidance, mitigation and compensation measures, the Project is likely to avoid a significant impact on Central Hunter Box – Ironbark Woodland.

iii. *Narrabeen Foothills Slaty Box Woodland*

The Project will remove approximately 97 ha of MU 6: Narrabeen Foothills Slaty Box Woodland, which represents approximately 98% of the total extent in the Study Area and 3.7% of the estimated extent in the Central Hunter region.

Narrabeen Foothills Slaty Box Woodland is considered to be over-cleared in the Central Hunter region and is highly fragmented, with the majority of extant patches persisting as small remnants of less than 10 ha in size (Peake, 2006). Narrabeen Foothills Slaty Box Woodland is also considered to be regionally significant, being threatened and poorly reserved (Peake, 2006). As a consequence of the decline of Narrabeen Foothills Slaty Box Woodland, many flora and fauna species that rely on these for habitat, such as *Acacia pendula* (Weeping Myall), are now listed as threatened under State and/or Commonwealth legislation.

Without appropriate mitigation and amelioration measures, the Project will contribute to the loss of Narrabeen Foothills Slaty Box Woodland on both a local and regional scale and exacerbate existing threatening processes. Anglo American will aim to avoid impacts on this community as much as possible through the Project design and has proposed a substantial offsets package to compensate for the residual impacts. Recovery of this community can also be expected to directly benefit the recovery of a number of threatened flora and fauna species. With the implementation of avoidance, mitigation and compensation measures, the Project is likely to avoid a significant impact on Narrabeen Foothills Slaty Box Woodland.

iv. *Hunter Lowland Redgum Forest*

The Project will also remove approximately 0.4 ha of regrowth Hunter Lowland Redgum Forest from the minor additional mining areas at Drayton Mine. Although this community type is also considered to be over-cleared in the Central Hunter region, the occurrence of the community in the minor additional mining areas holds little conservation significance in its current form. This patch represents immature regrowth that has little prospects for recovery. Its occurrence is of low quality due to its size, proximity to existing infrastructure and level of isolation from other patches of significant woodland and forest. It holds minimal value as habitat for flora and fauna species due to its young age, lack of habitat features and lack of structural integrity. It has little to no understorey and what is present in the ground stratum comprises many exotic flora species. The removal of this patch of TEC is therefore not considered to be significant.

It is also noted that approximately 130 ha of this woodland community will remain elsewhere within the immediate locality, including within the Drayton Mine Northern Offset Area and Drayton Wildlife Refuge (see **Figure 13**). These areas of Hunter Lowland Redgum Forest are of higher quality and are substantially larger than that to be removed from the minor additional mining areas. They are to be conserved in the long term, which will ensure that the local occurrence of the community will not be placed at risk of extinction. Active management of these areas to maintain and increase their conservation value will also provide important habitat for native flora and fauna, including threatened species. Notwithstanding this, Hunter Lowland Redgum Forest species are proposed to be included in the forest and woodland rehabilitation effort at Drayton Mine to address the loss of this small patch from Drayton Mine (see **Section 8.2.3**).

7.1.2 Loss of Important Habitat Features

Fauna habitats supply various resources for species to survive. Examples of resources include sufficient territory for a home range; macro- and micro-physical habitat features; and the availability of food, water, nest and/or den sites (Bookhout, 1996). The quality of these resources is dependent upon location and past land use. Remnant woodland patches support a higher diversity and abundance of habitat features than regrowth areas which generally lack many habitat features. This is mainly due to the age of the regrowth areas, which are too young to support features like hollows and stags that require a lot of time to form. Regrowth areas also suggest that the habitat site was relatively recently cleared.

Although condition and nature of the habitats within the Study Area are greatly altered by existing and historical land uses, it is evident that they still retain some value for the resident and visiting native fauna that were recorded in the Study Area. Important fauna habitat features that will most likely be removed by the Project include:

- **Mature woodland** – loss of structural diversity from mature vegetation that provide more niche habitats for various animals to shelter, forage and nest;
- **Understorey vegetation** – loss of shelter and foraging habitat for amphibians, reptiles, small birds and terrestrial mammals;

- **Fallen logs, woody debris and leaf litter** – loss of shelter habitat for amphibians, reptiles and terrestrial mammals, and forage habitat for woodland bird species;
- **Hollow-bearing living trees and stags** – loss of habitat for a range of fauna species which may rely on them for shelter, breeding or roosting. Loss of mature remnant hollow-bearing trees will have important implications for threatened species such as reptiles, birds, arboreal mammals and microbats;
- **Nectar-producing trees and shrubs** – loss of food resources for blossom-dependant birds, arboreal mammals and megachiropteran bats (flying-foxes);
- **Shrubs and grasses** – loss of food for a range of passerine birds and herbivorous mammals;
- **Ecotonal (edge) communities** – loss of foraging habitat for many species, particularly birds such as raptors;
- **Ephemeral drainage lines** – loss of foraging, shelter and breeding habitat for amphibians, aquatic reptiles, wetland birds and aquatic mammals; and
- **Constructed farm dams with aquatic vegetation** – loss of foraging and breeding habitat for amphibians, aquatic reptiles and wetland birds.

Remnant paddock trees and the hollow resources provided by these trees are valuable characters that are often in high demand in fragmented landscapes such as that of the Study Area and are discussed in further detail below.

i. Remnant Trees and Associated Hollows

Scattered remnant trees are considered to be keystone habitat features that can promote natural regeneration of native woodland, facilitate fauna dispersal and provide some connectivity between remnant habitat patches within over-cleared landscapes (Manning *et al.*, 2006; Rawlings *et al.*, 2010). Larger, older eucalypts are more dependable forage habitat as they flower more regularly, intensely and for longer than smaller regrowth and regenerating trees (Lindenmayer *et al.*, 2005). They also provide habitat in the form of fallen woody debris, hollows and stags. However, this does not reduce the importance of younger trees as they secure habitat, seed and other habitat resources for the future and replace older remnant trees as they begin to die (Rawlings *et al.*, 2010).

Hollow formation generally develops as a tree ages and is exposed for longer, and eventually becomes vulnerable to natural decay and weakening processes (Gibbons and Lindenmayer, 2002). The likelihood of a tree bearing hollows is therefore strongly associated with trunk girth and the habit of the tree species (Gibbons and Lindenmayer, 2002; Harper *et al.*, 2004). In Box-Ironbark communities, hollows are more likely in old trees with a dbh of at least 60cm, which is generally equivalent to a tree that is 120 to 150 years old, or of pre-European settlement age (ECC, 2001; Gibbons *et al.*, 2008).

Over 300 Australian fauna species are reliant on hollows, and at least 40 species are commonly found within a given geographical region (Gibbons *et al.*, 2002). As such, hollows

are a resource in disproportionately high demand compared to the availability of suitable cavities (Lindenmayer *et al.*, 1990a; Newton, 1994; Gibbons and Lindenmayer, 2002; Heinsohn *et al.*, 2003). This is a consequence of the low occurrence of remnant trees, age requirements, and the prolonged and energy intensive processes of natural decay and primary excavation that produce hollows (Aitken and Martin, 2007; Murphy and Legge, 2007; Aitken and Martin, 2008). The distribution, diversity and abundance of hollow-dependent fauna is constrained by hollow density and specific characteristics of cavities (Remm *et al.*, 2008). Many available hollows in an area are unlikely to be usable or 'functional' for many species, which increases the demand on remaining suitable hollows (Newton, 1994; Cockle *et al.*, 2010).

In spite of the history of tree clearing, the Study Area contains numerous scattered paddock trees of varying ages. Many remnant trees have hollows and in particular, box eucalypts. Of these, it is possible that only a small proportion of available hollows are likely to be functional (Cockle *et al.*, 2008) and so the importance of this limited resource in the Study Area is likely to be quite high. The isolated and scattered nature of hollow-bearing remnant trees in the Study Area increases their value and significance in providing an extremely limiting resource for many threatened fauna species. For example, the Powerful and Barking Owls have shown to be negatively impacted by the loss of remnant trees (ECC, 2001) due to the nature and size of hollow requirements. Loss of large trees and associated nectar resources has also been identified as a significant threat to several hollow-specialist bird species including the EPBC Act listed winter migrants Regent Honeyeater and Swift Parrot (ECC, 2001; Gibbons and Lindenmayer, 2002; Gibbons *et al.*, 2002).

Due to paucity of habitat features and mature trees in the minor additional mining areas at Drayton Mine, the clearance of these areas is unlikely to significantly reduce the availability of important habitat resources for fauna. The industrial dam, which potentially provides habitat for common aquatic fauna such as eels, turtles and water birds, is unlikely to be an important wetland or aquatic habitat for most fauna, particularly threatened species. Nevertheless, a dam clearance protocol is proposed to be implemented to mitigate any possible impacts on fauna caused by the drainage process (see **Section 8.2.3**).

7.1.3 *Habitat Fragmentation and Patch Size*

The impacts of direct habitat loss can be exacerbated by fragmentation of nearby vegetation that is not cleared (Lindenmayer *et al.*, 1999). In many cases, fragmentation and diminishing patch sizes can have similar impacts to that caused by direct habitat removal (Bennett, 1990; Reid, 1999). Fragmentation is the process whereby once continuous areas of habitat are divided into multiple smaller and discrete patches that are usually isolated from each other by significantly different environment. The latter is typically non-woodland or forest land such as grass or agricultural land, or artificial infrastructure (Primack, 1993; Fahrig, 2003; Manning *et al.*, 2006).

The habitat within the Study Area is currently reasonably fragmented as it largely comprises patches of woodland surrounded by grassland. However, some patches of habitat, particularly the woodland areas in the central portion of the Study Area, are fairly large and as such provide reasonable interior habitat for threatened flora and fauna in their own right. The Project is likely to exacerbate the existing effects of fragmentation in the Study Area and

add stress to residual vegetation by removing an extensive area of woodland and grassland habitat within the central portion of the Study Area. Potential impacts due to increasing fragmentation include:

- *Change in existing flora and fauna assemblages.* Flora and fauna assemblages can be affected by changes to fragment size and shape. No remnant fragments are the same; they vary in size, shape, isolation, age, forest type, age and type of surrounding vegetation, topography, level of disturbance and level of connectivity (Lindenmayer *et al.*, 1999; Peake, 2006). Increases in fragmentation can make habitat unsuitable for some species and encourage more invasive species;
- *Isolation of remaining patches and loss of habitat connectivity.* Habitat isolation and barrier effects can adversely impact on daily movements of species, particularly if they are unable or unwilling to move between suitable areas of fragmented habitat; disrupt the successful dispersal of juveniles (Cooper and Walters, 2002); and in extreme circumstances, affect large-scale migratory patterns (Lindenmayer *et al.*, 1999; Fischer and Lindenmayer, 2002). Habitat connectivity and the extent and magnitude of impacts of isolation depend on the movement and dispersal capabilities of specific species. Those most vulnerable to barrier effects include smaller ground-dwelling species, individuals with low mobility and rare species as even a small reduction in movements can negatively affect genetic continuity within a population. Threatened woodland birds (such as Grey-crowned Babbler, Diamond Firetail, Speckled Warbler and Brown Treecreeper that have been recorded in the Study Area) are particularly susceptible to fragmentation, reduction in habitat size and distance between habitat patches as these processes impact on their dispersal capabilities;
- *Reduction of interior habitat due to decrease in patch sizes.* Patch size is an important determinant of the number of species and density of individuals or populations within an area. For many woodland birds, the minimum area of habitat required to support and maintain viable populations of a species and prevent population declines is approximately 100 ha (Higgins and Peter, 2002). This minimum number is also influenced by the availability of suitable habitat features and associated forage, breeding or nesting resources, and the structural complexity of remaining habitat. Notwithstanding this, small patches of remnant woodland and forest can be very valuable for biodiversity conservation within a cleared agricultural landscape such as the Study Area (ECC, 2001; Fischer and Lindenmayer, 2002);
- *Increase in stress on existing native flora and fauna by increasing intraspecific and interspecific competition.* Plants and other sessile organisms are usually directly destroyed, while mobile animals (especially birds and mammals) retreat into remnant patches of habitat (Fischer and Lindenmayer, 2007). This can lead to crowding and increased competition between individuals and species for space and resources in areas of remaining habitat; and
- *Genetic isolation*, which can lead to inbreeding and genetic drift problems for populations isolated within a fragment and reduce the effective population size

(Primack, 1993). Species least vulnerable to barrier effects tend to be those that are highly mobile (e.g. birds and bats), although even these species can vary in their response to barriers (Bennett, 1990).

Within the minor additional mining areas at Drayton Mine, the small patch of regenerating Hunter Lowland Redgum Forest and the planted strip of acacias are so limited in size and are fragmented and isolated to such a degree that their removal is unlikely to exacerbate any existing fragmentation impacts.

7.1.4 Reduction or Loss of Habitat Connectivity

Habitat connectivity refers to the connectedness between patches of suitable habitat (Franklin, 1993; Taylor *et al.*, 1993; Keitt *et al.*, 1997). The determination of 'suitable' habitat can vary significantly between individual species and is highly dependent on the landscape (Beier and Noss, 1998; Lindenmayer *et al.*, 1999; Fahrig, 2003). Connectivity of habitat does not necessarily require that patches be continuous; rather, connectivity is more likely to be a function of the gap distance between patches.

Although the vegetation within the Study Area is largely discontinuous (i.e. fragmented), remnant patches are still relatively connected and provide a local-scale corridor of stepping stones that less mobile fauna species can use to travel across the landscape. As a whole, vegetation within the Study Area may function as a landscape-scale 'stepping stone', allowing highly mobile species to migrate in a north-south fashion through the fragmented landscape to large, protected national parks to the south.

The Project will increase the isolation of the existing vegetation patches, and reduce their function as a stepping stone corridor. Affected species will most likely include sedentary birds and threatened mammals with potential to occur in the Study Area, such as the Yellow-bellied Glider, Squirrel Glider and Spotted-tailed Quoll.

Sparse, narrow, linear remnants such as those lining Saddlers Creek and its tributaries are currently not well connected to vegetation outside of the Study Area. Since these areas are not within the proposed Project Disturbance Footprint, there is some opportunity to mitigate the impacts on habitat connectivity by restoring and rehabilitating the creekline to improve its habitat value.

Within the minor additional mining areas at Drayton Mine, the small patch of regenerating Hunter Lowland Redgum Forest and the planted strip of acacias are so limited in size and disconnected from other areas of habitat in the locality that they provide no function as a movement corridor. The disturbance to the minor additional mining areas is unlikely to add to the loss of habitat connectivity in the locality.

7.1.5 Edge Effects

Edge effects refer to changes in physical and biological conditions at an ecosystem boundary or interface between adjacent ecosystems (Fischer and Lindenmayer, 2007), particularly between natural habitats such as forests and disturbed or developed land (Yahner, 1988). Edge effects are related to the degree of fragmentation (i.e. patch

configuration, interior areas) and the relative isolation of patches from other patches (gap distance).

The size and shape of a remnant patch determines its susceptibility to further degradation as fragmentation increases the ratio of disturbed “edge” habitat to more intact “interior” habitat (Manu *et al.*, 2007). Edges are typically warmer, drier and exposed to more wind than remnant interiors (Yahner, 1988; Murcia, 1995). Long, narrow, linear patches are most vulnerable to edge effects by increasing the area of exposure to invasion by exotic and invasive flora and fauna (Bryson and Carter, 2004), fire, erosion (Pimentel and Kounang, 1998), loss of structural diversity, increased nutrient loading and pollution (Yahner, 1988; Fischer and Lindenmayer, 2007). Small fragments are therefore unfavourable for species such as the Black-chinned Honeyeater which require interior habitat. Also several small, isolated forest patches will be unable to maintain a larger number of species than a single intact forest of the same total area.

Edge effects can also refer to abiotic microhabitat changes in light, temperature, moisture and nutrient levels; and biotic changes such as alterations in the composition and relationships between various flora and fauna species (Chen *et al.*, 1990; Fischer and Lindenmayer, 2007). The depth of penetration of edge effects within vegetation varies depending on the structural contrast between ecosystems, but can extend from between tens to hundreds of metres from the edge (Yahner, 1988). These include microclimatic changes in light, temperature, humidity and wind, which can favour a suite of different species, including exotics, and therefore cause significant changes to the ecology of the patch (Lindenmayer and Fischer, 2006).

The habitat within the Study Area is currently reasonably fragmented and is currently subject to variable levels of edge effects. However, as aforementioned, some patches of habitat, particularly the woodland areas in the central portion of the Study Area, are fairly large and as such provide reasonable interior habitat for threatened flora and fauna. The Project is likely to result in limited increases in “edge effects” in residual vegetation, particularly where edges are created between the Project and areas of forest (Peake, 2006). The Project is also predicted to increase the levels of disturbance activities in the Study Area, which can inadvertently exacerbate the effects of edge impacts on residual vegetation, through possible introduction of pathogens like *Phytophthora cinnamomi*, spread of weeds, facilitation of feral fauna and nutrient movement.

Within the minor additional mining areas at Drayton Mine, the small patch of regenerating Hunter Lowland Redgum Forest and the planted strip of acacias are so limited in size that they are currently subject to very high levels of edge impacts. The complete removal of these areas is unlikely to increase edge impacts to any other remnant vegetation in the surrounding locality.

7.2 Direct Impacts on Threatened Species

The potential impacts upon threatened species are discussed below. This discussion is made with particular reference to flora and fauna that are known to occur but also applies to the species discussed in **Chapter 6** that, although not confirmed as being present onsite, are regarded to have potential to occur.

Assessments of Significance have been prepared to assess the impact of the Project on threatened flora and fauna (listed under the TSC Act) that have a high potential to occur within the Study Area and are considered to be most at risk from the Project (see **Appendix G**).

No threatened species were recorded in the minor additional mining areas at Drayton Mine, and only one threatened fauna species has potential to forage over the industrial dam (i.e. Southern Myotis, *Myotis macropus*). The Assessment of Significance indicates that no significant impacts to threatened flora and fauna species are likely as a result of the clearance of the minor additional mining areas.

Four threatened flora species and 21 threatened fauna species have been recorded in the Study Area (see **Figure 10**). The Assessments of Significance indicate that without additional mitigation or compensation measures, the Project will have a significant impact upon a selection of these species. Without mitigation or compensatory measures, the Project will result in a net loss of forest and woodland habitat (approximately 291 ha) for threatened species; exacerbate KTPs such as native vegetation removal and tree hollow loss; and permanently degrade remaining habitat by increasing the degree of isolation between existing patches of habitat.

In consideration of this, the Project will include ameliorative measures to mitigate the potential impacts on biodiversity. Rehabilitation and ongoing management of vegetation within the Project Boundary will take place to reduce the net loss of habitat for threatened species in the long-term. An offset strategy is proposed for the Project to compensate for the loss of vegetation and TECs and will focus on re-establishing local and regional habitat links to provide an effective biodiversity corridor for the long term.

Chapter 8 presents a summary of recommended mitigation measures to minimise adverse impacts on threatened species and populations predicted for the Project. Offsetting strategies are described in detail in the EIS biodiversity offset strategy report.

7.2.1 Flora

The Project's impacts on species and populations of threatened flora known, presumed and with potential to occur in the Study Area are discussed below.

i. *Acacia pendula* (Weeping Myall)

Two small stands of regenerating *Acacia pendula* (Weeping Myall) have been recorded in grassland within the Study Area, and belong to the for *Acacia pendula* population within the Hunter catchment that is listed under the TSC Act. The Project is expected to result in the direct removal of one of the stands of *Acacia pendula* (Weeping Myall).

Acacia pendula (Weeping Myall) persists only as very small remnants stands of less than 1 ha or as isolated trees (Threatened Species Scientific Committee, 2008). A disjunct population of *Acacia pendula*, estimated to be comprised of fewer than 1000 individuals, occurs at the eastern limit of its distributional range in the Hunter Valley. The core of the species' distribution occurs inland. Threats such as broad-scale habitat removal will increase the susceptibility of any remaining individuals to consequences of edge effects such as competition by invasive pasture weed species, modification or removal of ground layer components and grazing by feral animals (Threatened Species Scientific Committee, 2008), particularly as the species flowers sporadically and doesn't reliably produce seed.

Anglo American has proposed a substantial Offsets Package to compensate for the loss of habitat for *Acacia pendula* (Weeping Myall). With the implementation of the proposed mitigation and compensatory measures, the Project is not considered likely to result in a significant impact to the species.

ii. *Eucalyptus camaldulensis* (River Red Gum)

One mature River Red Gum was recorded on the floodplain of Saddlers Creek, in the south west portion of the Study Area, and regenerating individuals are considered likely to occur.

The Hunter Catchment is the only coastal catchment in which the species has been recorded. The population that occurs in the catchment is disjunct and at the limit of range of the species. Regeneration of this community is also low as a result of clearing, changes to hydrology, tree dieback, grazing and weed infestation (NSW Scientific Committee, 2005a).

The Project has been designed such that the Project Disturbance Footprint does not include Saddlers Creek and its floodplain. The River Red Gum and other riparian vegetation will not be removed. It will instead be subject to extensive restoration and rehabilitation works that will lead to the conservation of the species and population in the Study Area.

No significant impact is predicted to occur to the River Red Gum as a result of the Project.

iii. *Diuris tricolor* (Pine Donkey Orchid)

Approximately 30 individuals of the Pine Donkey Orchid were recorded within the Study Area in habitat that will be removed by the Project.

The Muswellbrook population of this species is known from a number of occurrences ranging from scattered individuals to large colonies consisting of a few thousand individuals, and typically occurs in open grassy woodland often associated with Box-Gum Woodland (DEC (NSW), 2005k). This population is of high conservation value as it is disjunct from other populations and highly restricted in its geographic distribution, found within an area measuring less than 50 km². This population also exists at the eastern limit of the species' range.

The removal of habitat would be likely to constitute a significant impact to the species. This species has been nominated within the SEARs to be a Matter Requiring Further Consideration. Additional information is presented in **Section 9.2** as required by Section 9.2.5.2 of the FBA (OEH, 2014b).

Anglo American has proposed a substantial Offsets Package to compensate for the loss of habitat for the Pine Donkey Orchid. With such mitigation and compensatory measures in place, the Project is not considered likely to result in a significant impact to the species.

iv. *Cymbidium canaliculatum* (Tiger Orchid)

A single Tiger Orchid was recorded within the Project Disturbance Footprint.

The Hunter catchment population forms the south eastern limit of the geographic range for this species and is of significant conservation value as it is one of the few epiphytic orchids occurring at temperate latitudes (Peake, 2006).

In the absence of appropriate mitigation measures, the removal of habitat for the Project could constitute a significant impact to the species. However, Anglo American is committed to implementing mitigation and offsetting measures to address the loss of one Tiger Orchid and habitat for the Tiger Orchid. With such mitigation and compensatory measures in place, the Project is not considered likely to result in a significant impact to the species.

7.2.2 Fauna

A total of 21 threatened fauna species have been recorded within the Study Area since surveys conducted in 2000, despite the relatively small area and degraded nature of vegetation. The Project will remove known habitat for threatened fauna occurring in the Study Area, and if mitigation measures were not implemented, the Project would be likely to have significant impacts on many locally occurring populations (see **Appendix G**).

Anglo American has committed to various onsite compensatory measures aimed at restoring, rehabilitating and increasing the amount of habitat available for threatened species in the Study Area. A substantial Offsets Package has been prepared to compensate for the loss of habitat and potential impacts to threatened fauna species.

With the implementation of the proposed avoidance, mitigation and compensation measures, the project is considered unlikely to result in a significant impact to fauna species. Impacts of the Project on these species are discussed below.

i. Nectarivorous birds

Impact: Moderate

The removal of forest and woodland communities by the Project will result in a loss of foraging, shelter and breeding habitat for locally occurring blossom-dependant birds.

A number of tree species in the Study Area provide suitable forage habitat for threatened nectarivorous bird species, including the Black-chinned Honeyeater. Nectarivorous species rely on an abundance of blossoms year round. This makes structural complexity and canopy tree diversity important as variations in flowering periods allow birds to forage within the region throughout the year.

The removal of important flowering tree species will have short to medium term effects on flowering resources and thus the fauna species that depend on them. This will occur while the rehabilitated and planted canopy species reach reproductive maturity and before they begin to flower and produce nectar regularly. Although some of these birds are mobile, nomadic species that follow blossoming trees, others are fairly sedentary and because of habitat fragmentation will be unable to disperse to remnant woodland elsewhere in the locality. These species are also likely to have difficulty successfully relocating due to competition from existing residents of new areas.

The loss of a large proportion of the forest and woodland in the Project Boundary is likely to represent a significant loss of locally important foraging and roosting habitat for the various blossom-dependant birds. However, Anglo American is preparing a substantial Offsets Package that includes restoration of riparian communities along Saddlers Creek and onsite Box-Gum Woodland rehabilitation. These objectives aim to replace the loss of vegetation with woodland and forest trees to maintain/increase current levels of foraging resources in the area. With the implementation of these mitigation measures, the Project is considered unlikely to result in a significant impact to nectarivorous birds.

ii. Woodland Birds

Impact: Moderate to High

The removal of forest and woodland communities by the Project will result in a loss of foraging, shelter and breeding habitat for threatened woodland birds. Fragmentation and diminishing sizes of woodland patches are perceived to be the processes most responsible for the declines of woodland bird populations in NSW.

Passerine species are most at risk, particularly as many are ground-feeding, insectivorous, and sedentary (Reid, 1999). These characteristics render such woodland birds more susceptible to direct habitat loss and landscape fragmentation because they are less able to disperse across open ground and successfully relocate to patches of remnant woodland

elsewhere in the locality. For example, the Brown Treecreeper has limited capacity for dispersal, with a maximum gap-crossing threshold of less than 100 m (Cooper and Walters, 2002; Doerr *et al.*, 2011); while Grey-crowned Babblers appear unable to travel over distances greater than 900 m (Blackmore *et al.*, 2011). The removal of habitat complexity and ground resources will impact on the availability of nesting and forage habitat, while the removal of vegetation cover is likely to increase the risk of predation of woodland birds from loss of shelter habitat.

Where populations are able to disperse to nearby patches, increasing intraspecific and interspecific competition for space and resources (Maron *et al.*, 2011) and increased exposure to predation (Ford, 2011) can become drivers of continuing decline. Equally important to direct loss is the degradation of remaining patches of habitat that facilitates further decline from KTP.

Many woodland bird species are dependent on small tree hollows for nesting. On average, such cavities do not form in trees that are less than 150 years old (Mackowski, 1984). Mature box trees within the Study Area are likely to represent a significant nesting resource for local woodland birds and scattered paddock trees are known to be a keystone resource in disturbed and fragmented landscapes (Gibbons and Boak, 2002; Gibbons and Lindenmayer, 2002; Gibbons *et al.*, 2008). The abundance of scattered paddock trees in adjacent farmlands is likely to facilitate some dispersal to nearby sites like Wollemi National Park, and this is an important factor in reducing inbreeding depression (Sunnucks, 2011).

For these reasons, the forest, woodland and adjacent grassland communities within the Study Area are likely to constitute important habitat for many threatened woodland birds.

Without staged clearance of the vegetation to minimise the loss of habitat at any one time, and without actions to replace that loss in the short term as the clearance takes place, the Project will result in a significant loss of foraging, shelter and breeding habitat for resident woodland birds. However, the Project will undertake progressive clearing in which the likely maximum distance of the strip width to be cleared at any one time will be approximately 200 m. Maintenance or re-establishment of scattered trees in large clearings around the Study Area is a critical component of restoration and rehabilitation works to provide dispersal avenues for woodland birds into surrounding remnant vegetation. Longer term objectives to replace the loss of vegetation with mature woodland and forest trees will be realised as part of the Project's Offsets Package to maintain and/or increase current levels of foraging resources in the area. With the implementation of these mitigation measures, the Project is considered unlikely to result in a significant impact to woodland birds.

iii. Raptors

Impact: Low to Moderate

The removal of forest, woodland and adjacent grassland communities by the Project will result in the loss of potential nesting and foraging resources for threatened raptors. Habitat removal will affect the availability of prey upon which raptors depend by also removing habitat for arboreal and terrestrial species.

Many raptor species depend on extensive territories for foraging and nesting. Many species occupy a large home range that include both remnant forest or woodland and grassland habitats (Debus, 1984) and are generally tolerant of agricultural landscapes providing there is some woodland habitat available for nesting (Marchant and Higgins, 1993). The loss of vegetated habitat is likely to cause local effects on prey resources within the Study Area and surrounds. If prey species decline or disperse to other areas there could be a loss of a varied diet for raptors. For example, in undisturbed habitat Little Eagles prey on native marsupials and birds. In disturbed habitat, as habitat alters native prey communities, the species primarily hunt abundant introduced prey such as rabbits (Olsen *et al.*, 2010).

One of the main threats to raptors, particularly owl species, is that they require large hollows for nesting, which are typically a very limiting resource in modified and fragmented agricultural landscapes. Considering the relatively low proportion of large hollows in the Study Area, the loss of remaining hollows and future hollows may be important for the raptor species recorded. It is possible that these species, particularly the Barking Owl, Spotted Harrier and Little Eagle, could lose actual or potential nest sites within the Study Area, although no nest sites have been identified in this area to date.

The Project is unlikely to put these species at risk in the long-term. However, replanting of future hollow-bearing trees to replace existing hollow-bearing trees will be undertaken as part of rehabilitation measures in the Study Area to ensure raptors do not lose substantial foraging resources or future nesting. In the short term, the installation of nest boxes will be undertaken to replace hollows being removed. If the landscape is rehabilitated and replanted to forest and woodland species, such bird species are likely to maintain their presence in the locality in the long term. With the implementation of these mitigation measures, the Project is considered unlikely to result in a significant impact to raptors.

iv. *Migratory Birds*

Impact: Low to Moderate

The removal of forest and woodland by the Project will result in the loss of known and potential foraging habitat for migratory birds (Rappole and McDonald, 1994), particularly for the Swift Parrot, Rainbow Bee-eater and Regent Honeyeater.

Eucalypt tree species of various ages within the Study Area provide flowering resources such as nectar and psyllid lerps. As such, the Study Area and surrounding conservation areas are likely to be locally significant for winter-foraging migratory birds. Vegetation in these areas represents relative islands of foraging habitat in a largely cleared agricultural and mining district, which increases their importance. Nectarivorous species rely on mass flowering events to fuel their migration to the next resource patch. Drought periods and poor flowering seasons can increase the significance of remaining patches of intact woodland and forest.

Swift Parrots and Regent Honeyeaters are migratory and are likely to occur in the locality generally anytime during the austral winter as they preferentially use fertile lowland woodlands such as those found in the Study Area on their migratory routes. Swift Parrots have been recorded foraging in the Study Area, and Regent Honeyeaters have been

detected in the Mt Arthur Coal Mine lease. Both species are reliant on box/ironbark woodlands for foraging and birds are strongly associated with flowering and lerp bearing *Eucalyptus* spp. (Saunders and Heinsohn, 2008) which form a significant proportion of the diet during poor flowering seasons (Oliver D. L., 2000; Kennedy and Overs, 2001; NSW Scientific Committee, 2004; Kennedy and Tzaros, 2005).

The loss of a large proportion of the forest and woodland in the Study Area is likely to represent a loss of locally important foraging and roosting habitat for the migratory nectarivorous species. If clearance is not staged, and if no actions are taken to replace lost habitat, the Project may result in short to mid-term impacts for these species. Rehabilitation measures to replace the loss of vegetation with mature woodland and forest trees will be realised as part of the Project to maintain and/or increase current levels of foraging resources in the area. With the implementation of these mitigation measures, the Project is considered unlikely to result in a significant impact to migratory birds.

v. *Microbats*

Impact: Moderate to High

The removal of forest, woodland and adjacent grassland communities from the Study Area will result in the loss of known foraging and/or roosting habitat for a number of threatened microbats, as well as potential movement corridors through patches of vegetation.

The Study Area is considered important for local populations of hollow-dependent bats and the Project is likely to have a significant impact on the local occurrence of the Yellow-bellied Sheath-tail-bat, Greater Long-eared Bat, Eastern Freetail-bat and Greater Broad-nosed Bat. These hollow-dependent microbat species are highly mobile but have consistently been recorded within the locality and Study Area. It is likely that the Study Area supports core habitat, including possible roosting sites, within the home ranges of the above species. Habitat removal will affect the availability of suitable foraging and roosting habitat for tree-roosting species that shelter in tree hollows. This may affect the capacity of some individuals to disperse and relocate to surrounding habitat elsewhere in the locality.

The loss of vegetation from the Study Area is not considered likely to significantly affect the breeding or roosting habitat of cave-roosting microbats, which shelter in sandstone crevices and rock overhangs, most likely in the north of the Mt Arthur Coal Mine lease and Mt Ogilvie. However, bat call analysis has indicated that a number of these species travel large distances from their roosting sites and are likely to regularly visit the Study Area to forage. The loss of vegetation may reduce the availability of foraging habitat for some cave-roosting species.

The Southern Myotis (*Myotis macropus*) may potentially lose some foraging habitat due to the removal of the industrial dam in the minor additional mining areas at Drayton Mine. However, as this is a highly mobile species that travels large distances to forage and roost, and as other water bodies will still remain within the locality, the industrial dam is not considered to be important habitat for the species. The removal of the industrial dam is therefore unlikely to have a significant impact on the species.

Rehabilitation measures to replace the loss of vegetation with woodland and forest trees will be realised as part of the Project to maintain and/or increase current levels of foraging and

roosting resources in the area. Other mitigation measures will be implemented including appropriate timing of the removal of habitat, so that it is not undertaken during torpor to allow local populations to relocate naturally where possible and reduce direct harm to individuals or populations. With the implementation of these mitigation measures, the Project is considered unlikely to result in a significant impact to microbats.

vi. *Mammals*

Impact: Low

The removal of forest, woodland and adjacent grassland communities will result in the loss of potential habitat and movement corridors for threatened mammals that may occur within the Study Area.

No threatened mammals excepting microbat species were recorded in the Study Area. From a combination of low records within the locality, the results of trapping sessions, habitat requirements and a likelihood of occurrence assessment, it has been determined that threatened mammals are unlikely to utilise the Study Area on a regular basis. Therefore while the loss of vegetation may remove potential shelter and forage habitat for species such as the Squirrel Glider and Spotted-tailed Quoll, it is unlikely to significantly impact these fauna species as they are reasonably mobile and able to utilise woodland habitat of better quality in the wider locality.

Rehabilitation measures to replace the loss of vegetation and ground debris will be realised as part of the Project's rehabilitation and Offsets Package to maintain and/or increase the presence and diversity of mammals in the locality in the long term. With the implementation of these mitigation measures, the Project is considered unlikely to result in a significant impact to mammals.

vii. *NSW State Environmental Planning Policy (SEPP) 44 – Koala Habitat Protection*

The Koala (*Phascolarctos cinereus*) is listed as Vulnerable under both the EPBC Act and the TSC Act. The species has not been recorded within the Study Area and no evidence of a permanent resident population was found during surveys. There are no historical or anecdotal records of koalas occurring in the Study Area, although there are eight records of the species within the locality.

The species is considered unlikely to occur within the Study Area. However, it requires additional planning considerations than other threatened species as it is covered by a State Environmental Planning Policy (SEPP) and has an approved recovery plan prepared by DECC (Department of Planning, 1995).

Within NSW legislation, SEPP 44 – Koala Habitat Protection has been prepared to assist in the conservation of the koala. The aim of SEPP 44 is to encourage the appropriate conservation and management of areas of natural vegetation that provide habitat for koalas. According to Schedule 1, the Muswellbrook LGA is identified as a locality to which this planning instrument applies.

Assessment under SEPP 44 is based on an initial determination of whether the land constitutes potential koala habitat. This is determined by assessing whether the feed tree species listed in Schedule 2 constitute 15 per cent or more of the total number of trees in the upper or lower strata. If potential koala habitat is present, the area must be further assessed to determine if the land is core koala habitat.

Of the feed tree species in Schedule 2, *Eucalyptus albens* (White Box), *Eucalyptus albens* x *Eucalyptus moluccana* (White Box x Grey Box intergrade), *Eucalyptus camaldulensis* (River Red Gum), and *Eucalyptus tereticornis* (Forest Red Gum) occur within the Study Area in low abundance. Both *Eucalyptus albens* (White Box) and *Eucalyptus moluccana* (Grey Box) are known koala secondary food trees and thus it is probable that koalas would browse on intergrades of these two tree species. This indicates that the Study Area contains potential koala habitat.

Given that potential koala habitat occurs in the Study Area, the policy requires that it must be determined whether the area forms core koala habitat under the definition of SEPP 44. Core koala habitat is defined under this legislation as:

"An area of land with a resident population of koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population".

Searches for scats and other traces failed to identify the koala, or evidence of the species and there is no historical record of the species within the Study Area. The Study Area is not considered to be core koala habitat as defined under SEPP 44; hence the preparation of a Koala Plan of Management is not required. SEPP 44 therefore does not place any constraints on the Project.

viii. Biodiversity

The Study Area supports a high diversity of bird species, but a low diversity of other fauna, with few reptiles, amphibians and arboreal mammals recorded. In contrast, the minor additional mining areas at Drayton Mine (including the industrial dam) are unlikely to support a diversity of any group of fauna species,

The species recorded in the Study Area are common and widespread in the locality and have either adapted to, or are tolerate of, habitat clearing where remnant fragments exist amidst a predominantly agricultural landscape. The result is a modified, less complex and less diverse vegetation structure typical of the Hunter region. This has influenced the fauna assemblage of the Study Area and resulted in the proliferation of species that can tolerate degraded and fragmented habitat and survive with low availability, abundance and diversity of habitat features.

However, given the extent of woodland habitat to be removed, it is likely that some common fauna species that occur in the Study Area will experience adverse impacts. The Project will result in the removal of foraging, breeding and shelter habitat, which is likely to have an impact on viable local populations as further fragmentation will reduce the ability of animals to cross open landscapes and increase the likelihood of isolation. Individuals and local

populations able to disperse into new habitat are likely to have difficulty successfully relocating due to intra- and interspecific competition for territory and the limiting nature of nesting and forage resources in the locality.

7.3 Summary of Direct Impacts on MNES

The area of direct removal of native vegetation and habitat has been summarised for the relevant MNES in **Table 7.2** below. The impacts on MNES are discussed in further detail in **Appendix A**, which contains a detailed summary of the assessment of MNES as required under the EPBC Act. The reduction in the Project Disturbance Footprint by 25% has led to a reduction in impacts to Box-Gum Woodland from 181 ha to 22 ha (reduction by 53%). There has been a reduction on forest and woodland habitat for threatened fauna species from 389 ha to 291 ha (reduction by 10%).

Table 7.2 Direct Project Impacts on MNES

Common Name	Preferred Habitat	Used For	Present or Likely to be Present	Approximate Area of Direct Impact (ha)
Communities				
Box-Gum Woodland	-	-	Y	22
Weeping Myall Woodland	-	-	N	0
Plants				
Leek-orchid	F, W, G	-	Y (low)	1,438
Illawarra Greenhood	F, W, G	-	N	0
Austral Toadflax	F, W, G	-	Y (low)	1,438
Birds				
Regent Honeyeater	F, W	Infrequent Foraging; low numbers	Y (low)	291
Swift Parrot	F, W	Infrequent Foraging; low numbers	Y (low)	291
Mammals				
Spotted-tailed Quoll	F, W	Foraging; low density	Y (low)	291
Koala	F, W	Foraging or movement	N	291
Grey-headed Flying-fox	F, W	Infrequent Foraging; low numbers	N	291

Table 7.2 Direct Project Impacts on MNES

Common Name	Preferred Habitat	Used For	Present or Likely to be Present	Approximate Area of Direct Impact (ha)
Greater Long-eared Bat	F, W	Foraging and roosting	Y	291
Large-eared Pied Bat	F,W	Foraging only	Y	291
Amphibians				
Green and Golden Bell Frog	Wetland	Foraging and breeding	N	0

7.4 Indirect Impacts on Terrestrial Habitats

The Project is likely to have indirect impacts (Dale *et al.*, 2001) on the ecological values of the Study Area and surrounds. Many of these impacts are forms of environmental emissions (Spellerberg, 1998; Rabin *et al.*, 2003; Driussi and Jansz, 2006) or are related to habitat degradation caused by invasive species.

The disturbance of the minor additional mining areas at Drayton Mine is unlikely to exacerbate any existing indirect impacts above the current background impacts resulting from the operation of the existing mine. This is because these impacts are currently being managed under existing regulations relating to the current mine approval and will presumably be continued or improved for the Project.

The following sections provide discussion on the relevant types of indirect impacts, which are made with particular reference to the Study Area.

7.4.1 Competition for Resources

Removal of habitat and forced emigration from the Study Area will impact on the successful relocation of a range of fauna. Dispersal into new areas of habitat can significantly increase con-specific competition and alter population dynamics with existing occupants (Dickman, 1991; Rappole and McDonald, 1994; Amarasekare, 2002; Maron *et al.*, 2011). Overcrowding has the potential to create conflict over territoriality, viable home ranges and overlap of structural niches (Lawlor, 1980); restrict accessibility to limiting forage, roosting and breeding resources; alter predator-prey interactions; potentially increase the incidence and spread of diseases; and affect the availability of mates (Nelson *et al.*, 1960). Competition for such resources may lead to injury and death for various fauna, or push those unable to settle out of suitable habitat.

7.4.2 Noise

Fauna species are sensitive to elevated levels of noise in their environment, which is generally as a result of anthropogenic sources (Fletcher and Busnel, 1978). Persistent noise can affect an animal's physiology by impacting on its hearing and energy budget, interrupting foraging and reducing reproductive success and long-term survival. Behavioural impacts include habitat loss through avoidance and a retreat away from favourable habitats (AMEC, 2005). While some species will habituate and become accustomed to periodic noise disturbance (Fletcher and Busnel, 1978), other species may be forced to relocate, which again will be restricted by habitat degradation.

Anthropogenic noise can adversely impact an individual or species' reproductive success and mortality (AMEC, 2005) by affecting signal production, deployment, perception and response. Interference can distort or mask social, warning, mating or territorial calls and how they are heard and interpreted by other animals (Chan *et al.*, 2010). It can indirectly change population dynamics by disrupting navigation, impacting on predator-prey interactions, changing habitat use and affecting courtship and parental care (Owings and Morton, 1998; Rabin *et al.*, 2003; Chan *et al.*, 2010).

Traffic, particularly from large mining trucks and excavation machinery; blasting during the mining phase; and noise from generators and machinery will elevate noise levels in the environment. This can have temporary impacts on various fauna species and affect the value of the habitats that remain (AMEC, 2005) although it is evident from the proximity of existing mining operations (such as the southern Mt Arthur pits) that the Study Area is already currently subject to this type of noise.

Noise will diminish within areas that are progressively rehabilitated and, in the long term, noise levels will return to normal following rehabilitation of the total mined area and cessation of mining.

7.4.3 Light

The Project has the potential to increase the level of artificial light in the natural environment. Increased light levels may adversely impact wildlife by direct glare, chronic or periodic increased illumination and temporary unexpected fluctuations in light levels (Longcore and Rich, 2004; Saleh, 2007; Longcore and Rich, 2010).

While the construction and operation phases of the Project will have some effect on the surrounding forest and woodland environment, the impacts from lighting are likely to remain close to the immediate disturbance boundary of the operational mining area, with only limited glare into the surrounding natural vegetation. It is likely that most fauna species would habituate to the periodic disturbance and light pollution from the mine is unlikely to have a significant or long-term impact on any fauna species.

Artificial light will diminish within areas that are progressively rehabilitated and, in the long term, light levels will return to normal following rehabilitation of the total mined area and cessation of mining.

7.4.4 Dust

The Project will generate dust during the removal of vegetation, construction and mining phases. As with the impacts caused by anthropogenic noise, dust pollution can lead to a decrease in habitat quality by affecting the health of trees and leading to altered community structure, thereby reducing the overall amount of available habitat.

Plants are typically most affected by dust, as it can settle and accumulate on leaf surfaces and impair essential physiological processes including photosynthesis, respiration, and transpiration by shading or clogging stomata and reducing light penetration through leaves (Spencer and Tinnin, 1997; Ministry for the Environment (NZ), 2001). Dust can also abrade the leaf surface and cuticle, increasing the plant's susceptibility to pathogens, fungal disease, and toxic gaseous pollutants (Farmer, 1993). These impacts increase mortality and decrease productivity which can result in changes in vegetation and community structure (Farmer, 1993).

The effect of dust deposition will affect animals that rely on plants, either as a source of food or habitat. Physiological impacts may result in a reduction in the size and abundance of fruits and sugar levels, while dust on the foliage and fruit may affect palatability to animals (Ministry for the Environment (NZ), 2001).

Dust is not expected to pose a significant problem for the native flora and fauna within the Study Area as the occurrence of regular meteorological events such as rainfall and wind will prevent a significant change in dust accumulation levels.

7.4.5 Erosion

The Study Area is already subject to erosion in places, mostly due to historic land clearance for grazing, and subsequent erosion due to the lack of vegetation holding the surface soil together. Grazing exacerbated this impact by introducing large numbers of hard hoofed cattle, which wear tracks in the soil and degrade stream banks while drinking.

The Project has the potential to increase the amount of erosion occurring within the Study Area through the construction of roads and tracks, and mine associated infrastructure. This has the potential to impact on the ecology of the area by removing surface vegetation and creating bare areas that are more susceptible to invasion by weeds. Erosion also has the potential to adversely affect the water quality in waterways by increasing sedimentation, nutrients and pollutants. The Project will result in the creation of new haul roads and access tracks; however sediment control structures, as per the Erosion and Sediment Guidelines, will be constructed to minimise the amount of erosion and consequent impacts of the Project.

Management measures proposed for the control of erosion are described in detail in the EIS soil and land capability impact assessment.

7.4.6 Vehicle Strike

Vegetation clearance and increased traffic associated with the Project may impact fauna through increased vehicle strike, injury and mortality. The Project will result in the construction of additional roads and tracks which means an increased length of road for animals to cross and negotiate, as well as an increase in the number of vehicles operating in the Study Area. Vehicle strike can pose a significant risk to some wildlife, particularly but not exclusively ground dwelling species (Taylor and Goldingay, 2010). While some mobile species, such as birds, have the potential to move away from the path of clearing, other species that are less mobile, and those that are nocturnal and restricted to tree hollows, may have difficulty moving over relatively large distances. Pre-clearance surveys however, are likely to reduce the risk of mortality during clearing.

Vehicle strike is likely to be most significant during the construction phase, when vegetation and habitats are being cleared. This may also occur during the operation of the mine as a result of collision with vehicles entering and leaving the mining area as well as during the normal daily movements of workers and vehicles throughout the site.

Although some mortality of animals as a result of vehicle strike is likely, it is not expected to be significant. The majority of the roads within the Study Area would not be able to be traversed at high speed due to the terrain and site traffic control, and animals are expected to be able to avoid vehicles. Appropriate signage and careful driving policies will increase the awareness of drivers and decrease the risk further. The risk of vehicle strike will diminish as areas that are progressively rehabilitated will return to current levels following rehabilitation.

7.4.7 Weeds, Feral Animals and Overabundant Native Species

Alterations to habitat conditions often favour introduced and/or hardy native plant and animal species that can proliferate in disturbed conditions. Habitat fragmentation and associated edge effects reduce the availability and quality of refugia for native fauna and increase feral animal access to resources. This can in turn increase the risk of predation and competition for resources of local native fauna (Dickman, 1996; Doak, 2002; Fitzgerald and Wilkinson, 2009). It can also increase native flora susceptibility to infection from pathogens (Dale *et al.*, 2001; Garkaklis *et al.*, 2004) such as the fungus *Phytophthora cinnamoni* which causes dieback (NSW Scientific Committee, 2004h).

Invasive weed and feral animal infestation are already evident within the Study Area and are threats whose impacts are well established in the Hunter region (Bryson and Carter, 2004). Invasive species compete with natives for resources and can aggressively invade areas, displacing native plants and animals. Feral animals such as rabbits, hares, pigs, goats, wild dogs, cats, foxes, aggressive birds such as mynas, and feral honey bees (Oldroyd *et al.*, 1997) pose a major threat to many native and threatened species (West and Saunders, 2007; Fitzgerald and Wilkinson, 2009). They compete for food and nest or roost sites; breed in more open areas following clearance of forest and woodland; prey on adults, juveniles and eggs; and damage and degrade natural habitats and breeding sites.

As previously mentioned, the likely presence of predators (such as the European Red Fox) may be a key factor in the low numbers and diversity of ground-dwelling fauna in the Study Area and surrounds. Foxes have long been recognised to be a major contributor to the decline of ground-nesting birds, small to medium mammals and reptiles (DECC (NSW), 2007a; SEWPaC, 2010b). Some native fauna such as the Eastern Grey Kangaroo can become prolific on mine areas. Overabundant native animals can cause overgrazing and other related problems.

Generally, the proportion of exotic plants found within the Study Area is highest around the lower slopes and valley floors where the land has been used for more intensive agriculture and livestock can facilitate weed dispersal. The upland areas tend to have a more intact grassy and herbaceous ground stratum that has fewer serious weeds. The control of weeds can help recover threatened species (West and Saunders, 2007; Fitzgerald and Wilkinson, 2009; Hunter-Central Rivers Catchment Management Authority, 2010).

Weed species are well established in the Study Area and region, and the Project is not considered likely to exacerbate them. A weed and feral animals control program will be prepared as part of the Biodiversity Action Plan (BAP). With the implementation of this plan, the Project is not likely to increase the presence of effects of feral species. **Section 8.2.6** provides details regarding the BAP.

7.5 Impacts on Groundwater Dependent Ecosystems

7.5.1 *Impacts to Groundwater*

The impacts to potentially biologically available groundwater resources as a result of the project have been analysed in detail in the EIS groundwater impact assessment.

The EIS groundwater impact assessment predicts a lowering of the groundwater in the alluvium along a four (4) km section of Saddlers Creek, negligible impacts upon river flows and minimal change to the salinity of groundwater except possibly a reduction in salinity. These are further outlined below:

- Extent of groundwater drawdown – during mining
 - Drawdown is predicted to not extend into the Hunter River alluvium.
 - The zone of drawdown influence is predicted to extend into the Saddlers Creek alluvium. The groundwater level within the Saddlers Creek alluvium is predicted to be cumulatively lowered by 1 m to 2 m along a 4 km creek section, located between the Project and the adjacent Mt Arthur mining areas.
- Reduction of baseflow to rivers/creeks
 - Baseflow within Saddlers Creek is predicted to reduce by up to 130 ML/year about 50 years post mining. The baseflow within Saddlers Creek is predicted

to progressively recover to a rate about 5 ML/year lower than pre-mining conditions.

- Baseflow to the Hunter River is predicted to be progressively reduced by up to 10 ML/year about 300 years post mining. The baseflow within the Hunter River is predicted to progressively recover to a rate about 3 ML/year lower than pre-mining conditions. This will have negligible impact on the daily river flow.

➤ Groundwater quality

- The existing beneficial use of the Saddlers Creek alluvial groundwater will not be impacted during mining. The Saddlers Creek alluvium will most likely remain too saline for primary industries in the long-term. Post mining migration of lower TDS spoil water from the Blakefield mining area into the Saddlers Creek alluvium may reduce the salinity of water in the alluvium over the long-term.

7.5.2 Impacts to Groundwater Dependent Ecosystems

As shown in **Table 7.1**, the project will entail clearing some of the communities listed as probable GDEs, including approximately 11 of the 39 ha of Hunter Floodplain Red Gum Woodland; and all of the 2.2 ha of Hunter River Oak Forest.

There is also some albeit limited potential for indirect impacts on the remaining patches of potential GDEs.

The EIS groundwater impact assessment predicts a lowering of the groundwater in the alluvium along a 4 km section of Saddlers Creek and this has, in theory potential to impact upon the vegetation along the creek. However, the majority of vegetation probably obtains a significant proportion of water from surface flows in the creek and overland, and within moisture stored in soil. While there is a possibility of some subtle reduction in tree growth in this area, the availability of water from creek flow, overland flow and within soil (rather than alluvium) is likely to be sufficient to sustain the vegetation within these two communities.

The EIS groundwater impact assessment also predicted negligible impacts upon flows in Saddlers Creek and the Hunter River. For this reason, there is also likely to be negligible if any impact upon the ecology of these two water bodies.

The EIS groundwater impact assessment predicted minimal change to the salinity of groundwater, except possibly a reduction in salinity. Such a minor reduction in salinity, if it occurs, is not considered likely to negatively impact vegetation that is partially dependent upon groundwater. Rather, it may be neutral or beneficial to deep rooted species within such vegetation because the dominant tree species are not well adapted to saline conditions.

7.6 Aquatic Impacts

7.6.1 Water Quality and Habitat

The Project will be a nil discharge site and is unlikely to result in significant or long-term adverse impacts to Saddlers Creek, the Hunter River or wider catchment. The Project will have limited interaction with these watercourses and is unlikely to adversely affect downstream water quality, result in the disturbance or loss of in-stream macrophytes and fringing riparian vegetation, or disrupt fauna communities. According to the threatened species Schedules of the FM Act the Hunter River drainage basin is outside the known distribution of any listed species or ecological communities. The restoration and land management measures proposed for Saddlers Creek will increase aquatic and riparian habitat quality, which will have flow on effects into the Hunter River.

7.6.2 Water Extraction

As part of the Project, water pipelines and associated pumping infrastructure will be installed from Drayton South down to the Hunter River, for the purpose of water extraction if it is needed. Some limited clearing of vegetation may be required for the construction, operation and maintenance of the pipelines. These impacts are expected to be minimal and will not have a significant impact upon threatened flora and fauna or disturb fish habitats. The pipeline locations were inspected during field surveys, and any riparian vegetation was found to predominantly be comprised of invasive vines, grasses and herbaceous species. It is not considered to be significant from a local or regional perspective due to the very small area to be impacted and the lack of good quality native vegetation that will be removed. Erosion will need to be addressed as the banks are quite steep and soil is loosely held together by weedy ground cover. Channel stability is likely to be improved with the construction of the pipelines as the steep river banks and loose soil will need to be addressed for accessibility.

i. Water Extraction

The results of the water balance modelling indicate that there is a reasonable probability that offsite water supplies will not be required to meet the operational demands of the Project.

However, should dry conditions prevail at any time over the Project life, there is at least a 90% chance each year that the existing Water Access Licences held by Anglo American will be sufficient for the Project (see EIS surface water impact assessment). The water balance has also confirmed that the Project will not need to discharge any water into the Hunter River over the life of the Project. This is consistent with the existing operations at Drayton Mine, which has not needed to source water from offsite supplies or discharge water over the life of the Project (see EIS surface water impact assessment).

Further details with regard to the Projects water extraction requirements are detailed in the EIS surface water impact assessment.

Considering the above, it is not expected that there will be an immediate need to extract water from the Hunter River such that it will result in an adverse impact on the ecology of the Hunter River or on water quality.

7.7 Cumulative Impacts

The Hunter Valley has experienced extensive vegetation clearance and continues to be subject to significant landscape modification as a result of past and present land practices. Broad-scale clearance has occurred in the region to make way for urban development, various agricultural practices including grazing and cropping, thoroughbred horse breeding, forestry and coal mining. The Project will add to ecological impacts that continue to be experienced on a regional scale by removing 1,438 ha of vegetation, of which 291 ha is remnant forest, open woodland and shrubland.

The Hunter is the State's primary coal producing region. Multiple coal mining projects are already established, or proposed and seeking development approval, in close proximity to the Project (NSW Department of Planning, 2005). Each mine has a significant disturbance footprint and requires land for associated infrastructure. Numerous transport routes and related facilities connect to and service these sites. When considered together, these projects have and will clear substantial areas of vegetation and habitat and exacerbate erosion and some forms of environmental pollution. If no mitigation or compensatory measures are provided, cumulative impacts on flora and fauna will result as habitats are further reduced and fragmented, potentially resulting in very limited occurrences of remnant vegetation and irretrievably modifying the biodiversity values of the region.

When considered together with the Project, a high proportion of the surrounding locality will be subject to extensive mining within the next two to three decades. Based upon available proposals of mining tenements within the vicinity of the Project, the combined impacts of mining could remove 4,625 ha of forest and woodland and derived grassland. Approximately 913 ha of this vegetation is Box-Gum Woodland. Approximately 805 ha of other TECs listed under the TSC Act will be removed (**Table 7.3**).

Although severely cleared in the past, many contemporary mining projects are capable of positively addressing current and future threatened species and ecological community impacts via offsetting, particularly when considered collectively. In light of these impacts, current assessments and offsetting projects now place a high focus on replacing and supplementing ecological communities by rehabilitating mined areas and returning them to forest and woodland. The mined landscaped will be progressively restored to flora and fauna habitat in the medium to long term. Additionally, all of the mines have provisions for offsetting ecological impacts. This involves the onsite rehabilitation and/or purchase of additional land that contains suitable like-for-like forest, woodland and grassland at a pre-determined ratio. These will collectively and significantly increase the total areas of native vegetation that exist in the locality in the future.

Some vegetation communities to be impacted, particularly Box-Gum Woodland, are currently not well represented within secure tenures. However, this situation is likely to change within the locality in the near future as a number of mining projects are proposing to establish permanent biodiversity offsets containing Box-Gum Woodland and other closely related vegetation.

The Project is developing a package of offsets to compensate for the loss of Box-Gum Woodland and other native vegetation, which will be detailed in the EIS biodiversity offset strategy report. The offsets provided by the Project will protect existing forest and woodland communities and restore vegetation on farmland. The offsetting arrangements, in combination with the offsets provided by surrounding mining developments, will result in an increase in total woodland vegetation in the locality and an increase in such vegetation under conservation tenures.

Table 7.3 Cumulative Impacts on Vegetation in the Muswellbrook LGA

Vegetation Community	Area of Vegetation Impact (ha)																		Total (ha)	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Upper Hunter White Box-Ironbark Grassy Woodland Hunter Floodplain Red Gum Woodland Total Box-Gum Woodland Communities	4	-	-	-	-	116.45	-	38	-	-	-	-				1.3				160
	11	-	-	-	-	-	0.3	10	0.66	-	<1	-				0.2				22
	15	0	0	0	0	116	0	48	1	0	0	0	0	0	0	2	0	0	0	182
Central Hunter Box-Ironbark Woodland	151	-	-	-	-	2	-	-	24	-	473	22	9.62				1.02	0.8		683
Narrabeen Footslopes Slaty Gum Woodland	97	-	-	-	-	24.21	-	-	-	-	-	-						0.1		121
Other Native Forest & Woodland	28	5.75	7.50	38	-	97.9	52.5	49	24	-	86	2	4.81	6.6	10.3	25	0.57	0.4	140	578
Total Other Native Forest & Woodland	276	6	8	38	0	124	53	49	48	0	559	24	14	7	10	25	2	1	140	1384
Upper Hunter White Box-Ironbark Grassy Woodland Derived Native Grassland	3	-	-	-	-	699.54	-	-	-	-	-	-				24				727
Hunter Floodplain Red Gum Woodland Derived Native Grassland	4	-	-	-	-	-	-	-	-	-	-	-				0.6				5

Table 7.3 Cumulative Impacts on Vegetation in the Muswellbrook LGA

Vegetation Community	Area of Vegetation Impact (ha)																		Total (ha)	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Non-TEC Derived Native Grassland	1140	-	-	-	22	49.8	280	-	678	1.2	-	46	103.6			6.4				2327
Total Derived Grasslands	1539	0	0	0	22	749	280	0	678	1	0	46	104	0	0	31	0	0	0	3058
Total Native Forest, Woodland and Derived Grasslands	1438	6	8	38	22	990	333	97	727	1	559	70	118	7	10	58	2	1	140	4625
TOTAL BOX-GUM WOODLAND (incl. Grassland) (CEEC)	22	0	0	0	0	816	0	48	1	0	0	0	0	0	0	26	0	0	0	913

Key:

- 1 Drayton South (current study)
- 2 Drayton Antiene Rail Facility (2000)
- 3 Drayton Mine Modification (2009)
- 4 Drayton Mine Extension (2007)
- 5 Bengalla Modification 4 (2010)
- 6 Mt Arthur Coal Consolidation Project (2009)
- 7 Mt Arthur Coal South Pit Extension (2006)
- 8 Mt Arthur Coal North Coal Project (2000)
- 9 Mt Arthur Coal Proposed Underground Project (2007)

10	<i>Mt Arthur Coal Ventilation Shaft (2006)</i>
11	<i>Ravensworth Operations (2010)</i>
12	<i>Ravensworth Narama Extended Project (2009)</i>
13	<i>Bayswater B Powerstation (2009)</i>
14	<i>Mangoola Mine Modification 4 (2010)</i>
15	<i>Bayswater to Mt Piper transmission line relocation - modification to Mangoola Coal Mine Plans and Relocation of 500kV electricity transmission line (2010)</i>
16	<i>Mount Pleasant Modification (2010)</i>
17	<i>Liddell Power Station North-South Gas Pipeline (2009)</i>
18	<i>Liddell Power Station East-West Gas Pipeline (2008)</i>
19	<i>Hunter Valley Operations South Coal Project (2008)</i>

7.8 Duration and Timing of Impacts

The duration and timing of impacts of the Project will influence the overall magnitude of impacts on the ecology of the Study Area.

The duration and timing of impacts of the Project will influence the overall magnitude of impacts on the ecology of the Study Area.

Mining operations at Drayton South will commence in the Whynot and Blakefield, mining areas generally progressing north to south. Approximately 1,438 ha of forest, woodland and grassland are to be progressively removed. However, the total impacts of the Project will not occur concurrently; vegetation clearance and mining will be a staged process and areas outside of the Drayton South disturbance footprint will not be impacted. Rehabilitation and restoration of forest and woodland cover will also occur progressively and follow each phase of clearing and mining such that the *net loss* of vegetation at a given stage of the 15 year life of the Project will be minimised. Thus, the majority of the Study Area will remain vegetated, although it will predominantly be composed of young, rehabilitated vegetation. These young rehabilitated areas will still represent habitat for some fauna species, including woodland birds. They will play an important role in maintaining habitat areas as the Project progresses, and ultimately provide varying degrees of regeneration and community structure across the Study Area.

At the cessation of mining, areas to be used for buildings and other mine infrastructure will be rehabilitated in the longer term. Moreover, all of the mined areas other than the final void will be revegetated to reflect the original forest and woodland communities.

7.9 Permanence and Reversibility of Impacts

Due to the nature of mining activities, the Project will result in extensive ecological impacts on a local scale. Apart from the final void area, the remainder of the Study Area is likely to experience reversible impacts, and the implementation of appropriate management and mitigation measures can considerably reduce the magnitude and extent of these impacts.

If appropriate effort is put into the subsequent rehabilitation and restoration, it is possible to recreate the communities that previously existed over much of the Study Area and encourage the recovery and relocation of flora and fauna. The Project is implementing best practise final landform modelling design to optimise biodiversity outcomes throughout the mine closure process. Rehabilitation and regeneration of forest and woodland is possible on degraded areas and has the potential to reduce the impacts of habitat removal on threatened species. The planting of threatened flora species which are known to occur in the disturbance footprint will also reduce impacts on these species and enable recovery of populations in the Study Area.

Chapter 8

Measures to Avoid and Mitigate Impacts

The purpose of this chapter is to outline the impact mitigation measures proposed to ameliorate the ecological impacts of the Project. As demonstrated in previous chapters, the Study Area is bio-diverse and provides habitat for a wide range of flora and fauna, including species listed under State and Commonwealth threatened species legislation. Accordingly, the Project has been designed with substantial mitigation measures and of the provision of biodiversity offsets to minimise the impact of the Project on biodiversity. Biodiversity offsets are discussed in detail in EIS biodiversity offset strategy report.

The following hierarchy of measures have been developed to reduce the ecological impacts of the Project:

- **Avoid** – to the extent possible, the Project has been designed to avoid or minimise ecological impacts;
- **Mitigate** – where certain impacts are unavoidable through design changes, mitigation measures have been introduced to ameliorate the ecological impacts of the Project; and
- **Compensate** – the residual impacts of the Project, following the implementation of mitigation measures, will be compensated to offset what would otherwise be a net loss of habitat. This is outlined in detail in the EIS biodiversity offset strategy report.

The following sections of this chapter outline the impact avoidance and mitigation measures proposed for the Project. **Section 8.4** provides details of a Biodiversity Action Plan (BAP) that will be developed to coordinate the implementation of all the proposed impact avoidance, mitigation and compensation measures proposed for the Project.

8.1 Measures to Avoid Impacts

Open-cut coal mine projects are reliant on the location of commercial quantities of mineral resources and thus cannot readily avoid impacts to flora and fauna habitats that may occur above such deposits. That notwithstanding, impact avoidance has been achieved to varying degrees through modification of the Project design. Where feasible, the location of mine associated infrastructure has been located away from natural habitats.

Avoiding environmental impacts has been considered where possible throughout the Project planning and design phases. Detailed pre-feasibility studies into the Project were undertaken and preliminary assessments of ecological values and other potential environmental impacts were used to inform mine plans and operational alternatives. The primary objective of the pre-feasibility studies was to develop alternative Project layout concepts to best avoid and minimise environmental and social impacts related to the Project whilst maximising resource recovery and operational efficiency in order to justify the continuation of the life of Drayton Mine.

The Project conceptual mine plan has undergone a number of major revisions since its inception. The current mine layout is the minimum practical disturbance area and has been designed to be in close proximity to Drayton Mine to allow for the utilisation of existing infrastructure. Although limiting the utilisation of the coal resource, the current mine layout has been significantly reduced from the previous application to increase the buffer distance between the Project and the horse stud properties located to the south. The conceptual mine plan also addresses the reasons provided by the PAC for the refusal of the previous Drayton South application, with all proposed open cut mining areas located entirely within the extent of mining recommended by the Drayton South PAC (Kibble *et al.*, December 2013).

The reduction in the Project Disturbance Footprint correspondingly reduces the impacts on biodiversity, including impacts on TECs and threatened species. The revisions to the Project Disturbance Footprint has enabled the Project to avoid approximately 490 ha of vegetation and habitat for threatened species (comprising approximately 159 ha Box-Gum Woodland, 31 ha other TECs and 300 ha of non-listed vegetation). Construction of Project infrastructure and mining areas will be conducted progressively in conjunction with rehabilitation, to spread the disturbance over time and thus to minimise the loss of vegetation at any particular point in time.

The above approach balances the impacts on the surrounding environment with the continued provision of social and economic benefits currently generated by Drayton Mine to the wider community, and delivers a Project that is in the public interest.

8.2 Measures to Mitigate Impacts

8.2.1 General Measures

Where the design of the Project is determined, measures can be considered to mitigate some of the direct and indirect impacts. The Project will implement a number of general environmental control measures which will help to protect the ecology of the site. General mitigation measures proposed to be implemented by the Project are summarised below:

- Management and monitoring of water bodies – regular assessments of the Hunter River and Saddlers Creek upstream, downstream and at water discharge sites to determine water quality and system health;

- Management of surface water, and erosion and sedimentation controls – to protect the integrity of the landscape;
- Dust minimisation – control of dust reduces the indirect impacts on vegetation condition and the habitat quality for all native species;
- Noise minimisation –reducing the potential for disturbance of animals in habitat patches around the mine in the study area; and
- Lighting management – benefit fauna by reducing the potential for disturbance of nocturnal native animals via night light emissions around the mine

Additional mitigation measures specific to ecology that will be implemented include minimising vegetation and habitat loss; vegetation restoration and rehabilitation and soil works; and ongoing monitoring. These are discussed in subsequent subheadings below.

8.2.2 Minimising Impacts during Development Works

In order to minimise clearing impacts and unnecessary disturbance to native vegetation, the following procedures will be implemented:

- The limits of clearing will be delineated during the construction process and marked clearly on plans and on the ground utilising a permit to disturb process;
- Native vegetation beyond the identified clearing areas will not be disturbed; and
- Ancillary facilities such as stockpile sites, site compounds and construction zones will not be located beyond the limits of clearing.

Where clearing of vegetation and fauna habitats will take place, pre-clearing and clearing protocols will be followed, including:

- Preparation of an inventory of trees and hollows to be removed, prior to clearing;
- Pre-clearance checks of hollow-bearing trees for the presence of bird nests and arboreal mammals, such as possums, gliders and bats, prior to felling;
- Safe removal of animals found to be occupying trees prior to the clearing of trees and their appropriate relocation into nearby woodlands;
- Where practicable, propagation of flora species of high conservation value to other suitable sites in the Study Area, e.g. threatened orchids and *Acacia pendula*;
- Where practicable, relocation of flora species of high conservation value to other suitable sites in the Study Area, e.g. threatened orchids and *Acacia pendula*. *Cymbidium canaliculatum* is an epiphyte that lives on live or dead trees and as such can be relocated (by translocating sections of its tree) to suitable habitat outside the Project Disturbance Footprint;

- Provision of nest boxes or location of salvaged tree hollows in nearby woodland to compensate for the hollows to be removed due to vegetation clearance, and the numbers to be proportional to the number of hollows removed;
- Placement of boulders and large logs in nearby areas of retained vegetation to allow their continued use as fauna habitat; and
- Implementation of a dam drainage protocol for any dams to be decommissioned that includes safe removal of animals to suitable alternate locations, timing of clearance works to non-breeding seasons for appropriate target species and chytrid protocols for ecologists and machinery entering the water to limit the transmission of disease.

Where possible, the retention and protection of large old canopy trees should be achieved (in areas where they remain); as these provide valuable habitat resources including hollows, woody debris and reliable blossom production as the resources within the Project Disturbance Footprint is lost over the life of the Project. It also involves protection of any remaining medium sized trees, which will replenish the population of large old trees in future as current individuals continue to senesce.

8.2.3 *Vegetation Restoration and Rehabilitation*

In order to maximise the conservation of biodiversity and mitigate the impacts of the Project, some areas of existing vegetation will be retained in the Study Area, and other areas will be restored to build onto existing and future areas of native vegetation, conservation lands and natural corridors. Restoration efforts will generally aim to achieve other accepted revegetation criteria where relevant, such as the following descriptors for woodland (McIntyre *et al.* 2002):

- Tree density of about 30 to 40 mature trees per hectare, which is accepted as being ecological optimal for woodland units;
- Minimum woodland patch sizes of at least 5 ha, which maintains patch viability; and
- Continuous groundcover of tussock grasses, forbs and woody debris, which are important in woodland and riparian corridors for soil stabilisation and attenuation of surface water flows.

Restoration and rehabilitation works will be staged in concurrence with clearing for the mine to minimise as much as possible the loss of habitat at any one time.

For restoration and management of the habitat values of the Study Area, the following measures will be implemented:

- Use of local provenance native shrubs, trees and groundcover plants to maintain genetic health of planting stock and optimise success of revegetation;

- Use of native shrubs, trees and groundcover plants that are characteristic of the vegetation proposed to be cleared to mitigate the loss of these species from the Study Area;
- The use of characteristic species also pertains to those species characteristic of Hunter Lowland Redgum Forest, which will be planted as part of the woodland rehabilitation effort at Drayton Mine to address the loss of 0.4 ha of regrowth Hunter Lowland Redgum Forest;
- Translocation of topsoil from the Project Disturbance Footprint to areas being rehabilitated/revegetated to conserve the native seed bank of local ecological communities;
- Inclusion of logs, dead trees and stumps in strategic locations to enhance fauna habitat;
- Incorporation of existing natural vegetation where possible;
- Provision of vegetative links to existing bushland remnants in the Study Area; and
- Management of weeds and feral animals.

8.2.4 Measures to Protect Threatened Species Onsite

i. Cymbidium canaliculatum (Tiger Orchid)

Translocation of *Cymbidium canaliculatum* in the Project Disturbance Footprint will be undertaken to address the Project impacts on the species, as recommended by OEH. Epiphytic orchids typically have a high chance of successful translocation (Vallee *et al.*, 2004; Tremblay, 2008). Mangoola Coal, working with experts in the field, is in the process of developing best practice procedures for the salvage and translocation of a large number of *Cymbidium canaliculatum* from their approved disturbance area to suitable host trees in nominated Biodiversity Offset Areas. Monitoring of already translocated individuals indicates they are in good health (Umwelt, 2013).

Although translocation of *Cymbidium canaliculatum* has been successful to date, Mangoola Coal also experimented with propagation techniques for *Cymbidium canaliculatum* to ensure that the population is maintained in the event that the translocated individuals fail. In 2013, tubers from one *Cymbidium canaliculatum* were subdivided into 12 individual plants using a variety of growth mediums including woody debris, potting mix and wood chips. Ten out of the 12 plants have survived and healthy plants were relocated into the Mangoola Coal offset area in 2014 during the cooler months (SLR, March 2014). Subdivision using tubers may present a potential propagation process that can be utilised for individual plants that may not be salvageable.

Considering the above, Anglo American is committed to the translocation of the *Cymbidium canaliculatum* individual from the Project Disturbance Footprint to a suitable conservation area. Translocation would be to suitable remnant woody vegetation in a recipient site as close as possible to the location where the plant naturally occurs. Options include the

proximate Drayton Wildlife Refuge or primary ridgeline, subject to the availability of a suitable mature host tree.

Anglo American will consult with Mangoola Coal and appropriate experts regarding best practice for the translocation and possible propagation of *Cymbidium canaliculatum*. Translocation will be conducted according to the ANPC best practice guidelines, 'Guidelines for the Translocation of Threatened Plants in Australia' (Vallee *et al.*, 2004) to ensure successful translocation of the species. Translocation of this species will ensure the individual and local occurrence of the species still remains within the Hunter catchment, and will be subject to protection mechanisms to be applied to the Project's offset lands.

ii. *Acacia pendula* (Weeping Myall)

Anglo American has considered options to translocate individuals of *Acacia pendula* (Weeping Myall) within the Project Disturbance Footprint. However, translocation is not considered to be a viable option for this species as it is known to be very difficult and is unlikely to succeed.

It is proposed that propagation trials be undertaken for *Acacia pendula* (Weeping Myall) found within the Project Disturbance Footprint. For many *Acacia* species, propagation from seed is a reliable method (ANPS, 2006; ANPS, 2010; Simmons, 2012) and such trials would increase our knowledge of the biology of the species and retain the local genetic diversity of this disjunct population. However, it is acknowledged that the endemic form of *Acacia pendula* (Weeping Myall) is commonly known to be poor seeders (Bell *et al.*, 2007) and the likelihood of success under the current available information appears to be uncertain.

It is therefore proposed that propagation trials include use of rootstock material and top soil. Since *Acacia pendula* (Weeping Myall) is known to principally reproduce colonially via suckering from rootstock, there is an opportunity to introduce the species to offset areas using root material. Propagation from root stock and top soil of other *Acacia* species, such as *Acacia ausfeldii*, has been successfully undertaken at Ulan Coal Mine. Both the removal and translocation of 100-150mm of top soil and the stripping of 150-300m of sub-soil root zone has stimulated the establishment of 28 new *Acacia ausfeldii* plants (Ulan Coal Mines Limited, March 2013). The general disturbance from translocation is also thought to have promoted propagation (Eco Logical, 2014). The viability of this propagation process at recipient sites would be subject to monitoring and adaptive management.

Further to the above, one extant patch of *Acacia pendula* (Weeping Myall) will be retained onsite near Saddlers Creek and will not be cleared by the Project. This patch will be permanently protected as part of the offsetting commitments for the Project (see the EIS biodiversity offset strategy report).

iii. *Swift Parrot* (*Lathamus discolor*)

The Study Area is a forage location for the Swift Parrot (*Lathamus discolor*) as individuals were recorded foraging during 2011 surveys. The Swift Parrot is a generalist nectarivore that can forage on the blossoms of many different tree species. The species is likely to forage in the locality of the Study Area from time to time depending on their migration

pathway and the availability of blossom resources at that time. Although the species is not likely to be present in the locality every season, flowering resources within the Study Area and wider locality may be locally significant for Swift Parrot (*Lathamus discolor*) as the vegetation represents islands of foraging habitat within a predominantly cleared agricultural landscape.

Considering the above, activities to enhance the quantity and quality of foraging habitat for Swift Parrot (*Lathamus discolor*) onsite will be undertaken as part of the offsetting commitments for the Project (see the EIS biodiversity offset strategy report). Due to the staged nature of the Project and to the fact that rehabilitation and restoration works will be carried out concurrently, these activities will be capable of maintaining foraging habitat for the species over the life of the Project. Furthermore, provision has been made for regular monitoring to assess the improvement of potential foraging habitat as rehabilitation and restoration works progress.

8.2.5 Biodiversity Monitoring

In order to ensure that the biodiversity objectives for the Project are achieved, an ecological monitoring program including the use of reference sites will be developed to record the ongoing status and health of flora and fauna that is to be retained on the Study Area and in the offsite offset areas. This will provide feedback data to determine the level of success of the mitigation and compensation measures implemented for the Project. Such monitoring is typically undertaken using appropriate reference sites that are located away from mining activities to use as a baseline against which to compare the status of habitats in close proximity to mining.

This section discusses these strategies and their applicability to the Project.

Reference Sites

The establishment of reference sites is recommended by the *ICMM Good Practice for Mining and Biodiversity guidelines* to enable impacts resulting from mining to be better understood and quantified (ICMM, 2006). Reference areas serve as a benchmark against which changes in biodiversity over time can be compared (for example, through the use of the BACI before-after/control-impact, approach). This approach collects and compares data from sites before and after the impact has occurred, and also from control (non-impacted) and impacted sites. Reference sites help to determine which changes are directly attributable to the mining operations and which are the results of unrelated outside factors. They are useful in rehabilitation, as they allow a desired endpoint to be set for rehabilitation efforts, and progress towards this endpoint through time can be quantified.

Reference sites for this Project will be selected before construction activities and mining commence. Ideally, locations suitable as reference sites should contain the same ecological community that is being impacted; be in a similar position in the landscape; have similar topography and disturbance history; and not be subject to impacts from the mine (ICMM, 2006). Appropriate locations for reference sites will be determined in consultation with relevant government agencies as part of the finalisation of the BAP.

i. Statistical Analysis of Monitoring Data

At each reference site, a range of data will be collected in order to allow comparisons to be made between impacted and non-impacted sites. This would provide an indication of the potential impacts occurring as a result of the Project. The full range of data to be collected at each reference site will be developed to enable statistical analysis of data.

Statistical analysis of data will be an important tool to compare the progress of rehabilitation and restoration works against reference sites. Data will be added to a database annually so that it will form a data matrix that is amenable to appropriate analysis, for example, using classification and ordination techniques, parametric statistics, or Analysis of Similarity.

Monitoring Sites

Monitoring activities will include the monitoring of reference sites as well as monitoring of vegetation communities, populations of threatened flora and fauna on the Study Area and offsets. The monitoring program will track the progress of regeneration of native vegetation in the Study Area and offsets, and will identify problems that require active management, such as infestations of weeds and feral animals, or failure of some areas of plant species to regenerate.

This section considers the broad principles to be considered for ecological monitoring programs; more detailed specifications for ecological monitoring will be contained in the BAP.

ii. Vegetation Monitoring

A vegetation monitoring strategy will be established to determine the magnitude of the ecological impacts from mining activities on the various flora and fauna species known or likely to occur in the Study Area, and their habitats. The monitoring program would provide information to quantify the change in biodiversity over time within the Study Area. It is proposed that monitoring sites be established in areas of vegetation both inside and outside of the disturbance area and in designated reference sites. Regenerated areas are also proposed to be monitored in the long term to allow changes in species composition and structure over time to be quantified. Information should be used in adaptive management, in order to continually improve the outcomes of the rehabilitation and land management strategy. Appropriate data management procedures will be implemented to ensure that all data is collected using appropriate techniques and suitably analysed to allow meaningful spatial and temporal comparisons to be made. More specific details of the vegetation monitoring strategy will be contained in the BAP.

iii. Threatened Species Monitoring

Monitoring will be undertaken on selected threatened species of flora and fauna, in order to determine whether populations are being adversely affected by the Project.

Threatened species monitoring will:

- Enable the identification of the impacts of the Project on threatened species;

- Identify changes in population numbers over time;
- Determine the success of impact mitigation and conservation measures; and
- Highlight areas for improvement if these measures are found to be inadequate.

Threatened species monitoring will involve conducting targeted threatened species surveys in areas of known habitat in order to record the abundance of selected species. This should include both flora and fauna species. The level of monitoring effort would be determined according to risk level and biology of the particular species in question (e.g. coordinating with breeding or movement times).

8.2.6 Biodiversity Action Plan

A BAP will be developed for the Project that will enable Anglo American to enact the 'avoid and mitigate' principles during the construction and operation of the mine. The BAP is the key document that will ensure that the Project's conservation objectives are met for mitigation works to be completed onsite and that impacts to biodiversity are adequately managed for the life of the Project.

The BAP is intended to be a working document that guides all facets of onsite biodiversity management and mitigation for the Project, and will include clear objectives and actions. The BAP will incorporate all of the impact mitigation measures as described in the previous sections and will provide detailed specifications for their implementation. The BAP will specify what measures will be undertaken, how they will be undertaken, and will provide a timeline to ensure that all activities are conducted according to the plan. The BAP will also make provisions to address specific such as the occurrence of threatened species.

The BAP will provide for a monitoring program and key performance indicators against which to measure progress. The BAP will specify appropriate review periods where progress is reviewed and the document updated as required.

The BAP will include, where appropriate:

- Fencing measures;
- Delineation of clearing limits for disturbance activities during the construction and operational phase;
- Soil conservation;
- Pre-clearing and clearing protocols;
- Fauna rescue or translocation where practical;
- Rehabilitation and restitution of adjoining habitat where possible, including staged restoration and rehabilitation works in concurrence with clearing activities to minimise loss of potential habitat;

- Control and ongoing management of environmental and noxious weeds;
- Management and monitoring of surface water flows and water bodies;
- Measures to to minimise other environmental effects such as dust, noise and night time lighting emissions;
- Control and ongoing management of feral animals; and
- Ecological monitoring.

The BAP will include clear objectives, key performance objectives and management actions of biodiversity values to be protected and of the proposed mitigation measures including, where appropriate:

- Minimising human disturbance to native flora and fauna;
- Limiting clearance or disturbance of native vegetation;
- Minimising impacts to, and where possible protecting, threatened species and communities;
- Minimising impacts to aquatic habitats and species; and
- Ongoing monitoring of impacts on flora and fauna and implementation of adaptive management plans.

The BAP will also prescribe further information on the staged rehabilitation of all mine disturbed areas and will specify how the Study Area will be closed to mining and returned to other land uses. This will include post-mining land use, conceptual final landform design, and rehabilitation methodology.

The implementation of the BAP will be funded by Anglo American for the life of the Project.

8.3 Residual Impacts that cannot be Avoided or Mitigated

The residual impacts of the Project are shown in **Figure 14** and include direct impacts to TECs and woodland/forest habitat for threatened species, *Diuris tricolor* (Pine Donkey Orchid), *Cymbidium canaliculatum* (Tiger Orchid) and *Acacia pendula* (Weeping Myall).

Chapter 9 applies the FBA to the Project to quantify the impacts in terms of biodiversity credits. The Project will need to implement offsetting measures that can address this credit liability in order to compensate for the residual impacts of the Project.

Chapter 9

Assessment of Residual Impacts

9.1 Credit Summary

This section summarises the biodiversity credit profile for the Project. The Biodiversity Credit Profile report is provided with this biodiversity assessment report (**Appendix H**).

Biometric plot and transect data, field data sheets, and spatial layers used in the Credit Calculator can be provided upon request.

9.1.1 Species Credits

The FBA results indicate that 390 species credits will be required for the loss of approximately 30 individuals of *Diuris tricolor* (Pine Donkey Orchid).

Ten species credits will be required to address the loss of one individual *Cymbidium canaliculatum* (Tiger Orchid).

Approximately 1,155 species credits will be required to address the loss of one patch of *Acacia pendula* (Weeping Myall).

The total required for the Project is 1,555 species credits (**Table 9.1**).

Table 9.1 Project Impacts – Species Credits

Common Name	Scientific Name	Species Credits Required
Pine Donkey Orchid	<i>Diuris tricolor</i>	390
Tiger Orchid population in the Hunter Catchment	<i>Cymbidium canaliculatum</i> population in the Hunter Catchment	10
Weeping Myall	<i>Acacia pendula</i> population in the Hunter Catchment	1,155
Total Credits Required		1,555

9.1.2 Ecosystem Credits

The FBA results indicate that 15,333 ecosystem credits are required to address the impacts of the Project on native vegetation and species habitat (**Table 9.2**).

MU 5: Central Hunter Box-Ironbark Woodland and MU 6: Narrabeen Foothills Slaty Box Woodland generates the highest number of ecosystem credits (7,961 and 5,323 respectively). This is because these vegetation units comprise the largest proportion of the woodland to be cleared from the Project Disturbance Footprint.

MU 9 and MU 10 (Cooba Scrub and Planted Vegetation) are not located within the Project Disturbance Footprint. MU 11 and MU 12, which comprise non-listed grasslands derived from MU 5: Central Hunter Box-Ironbark Woodland, produce site value scores of less than 17 points. Therefore, offsets are not required to address impacts to these vegetation zones.

Table 9.2 Project Impacts - Ecosystem Credits

Map Unit (MU)	Vegetation Map Unit name, as referred to in this Biodiversity Assessment Report	Plant Community Type (PCT)	Biometric Vegetation Type (BVT)	% Cleared*	Vegetation Type, as used in the Vegetation Information System (VIS) Classification Database	Condition	Area of Impact (ha)	Current Site Value	Future Site Value	Ecosystem Credits Required
MU 1	Upper Hunter White Box-Ironbark Grassy Woodland (CEECE/EEC)	1606	HU820	29%	White Box - Narrow-leaved Ironbark - Blakely's Red Gum shrubby open forest of the central and upper Hunter	WL - Mod/Good	3.8	83.85	0.00	254
MU 2	Upper Hunter White Box-Ironbark Grassy Woodland Derived Native Grassland (CEECE/EEC)	1606	HU820	29%	White Box - Narrow-leaved Ironbark - Blakely's Red Gum shrubby open forest of the central and upper Hunter	GL - Mod/Good - Poor	2.7	29.51	0.00	69
MU 3	Hunter Floodplain Red Gum Woodland (CEECE/EEC)	42	HU599	95%	River Red Gum / River Oak riparian woodland wetland in the Hunter Valley	WL - Mod/Good	10.9	68.67	0.00	602
MU 4	Hunter Floodplain Red Gum Woodland Derived Native Grassland (CEECE/EEC)	42	HU599	95%	River Red Gum / River Oak riparian woodland wetland in the Hunter Valley	GL - Mod/Good - Poor	4.3	27.33	0.00	103
MU 5	Central Hunter Box-Ironbark Woodland (EEC)	1691	HU905	79%	Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	WL - Mod/Good	150.9	65.62	0.00	7,961
MU 6	Narrabeen Footslopes Slaty Box Woodland (EEC)	1176	HU618	40%	Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion	WL - Mod/Good	97.0	68.44	0.00	5,323
MU 7	Central Hunter Bullock Forest Regeneration	1692	HU906	53%	Bull Oak grassy woodland of the central Hunter Valley	WL - Mod/Good	25.9	44.27	0.00	950
MU 8	Hunter Valley River Oak Forest	485	HU712	50%	River Oak riparian grassy tall woodland of the western Hunter Valley (Brigalow Belt South Bioregion and Sydney Basin Bioregion)	WL - Mod/Good	2.2	65.33	0.00	71
MU 9	Coobera Scrub	1691	HU905	79%	Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	WL - Mod/Good - Other - Shrubby	0.0	n/a	n/a	n/a
MU 10	Planted Vegetation	n/a	n/a	n/a	n/a	n/a	0.0	n/a	n/a	n/a
MU 11	Other Grassland	1691	HU905	79%	Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	GL - Mod/Good - Poor	981.0	16.15	0.00	0
MU 12	Other Grassland	1691	HU905	79%	Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	GL - Low	159.4	10.42	0.00	0
TOTALS							1,438			15,333

*This is the percent cleared value of the PCT in the major catchment area

9.2 Matters that Require Further Consideration

9.2.1 *Box-Gum Woodland*

(a) the area and condition of the CEEC or EEC to be impacted directly and indirectly by the proposed development.

The approximate area of Box-Gum Woodland CEEC/EEC to be directly impacted by the Project is 22 ha, comprising:

- Approximately 4 ha of MU 1: Upper Hunter White Box-Ironbark Grassy Woodland and 3 ha of native grassland derived from this community (MU 2), which represent a respective 4% and 2% of the total extent of these communities in the Study Area; and
- Approximately 11 ha of MU 3: Hunter Floodplain Red Gum Woodland and 4 ha of native grassland derived from this community (MU 4); which represent a respective 28% and 42% of the total extent of these communities in the Study Area.

(b) the extent and overall condition of the CEEC or EEC within an area of 1000 ha and then 10,000 ha surrounding the proposed development footprint.

Within 1000 ha:

The proposed development covers an area greater than 1000 ha. For this reason, all vegetation would be cleared within a 1000 ha circle, centred on the mid point of the project. The total area (that includes woodland and derived native grassland) is shown in **Table 7.1**.

Within 1000 ha:

Within an area of 10,000 ha, a suite of plant communities are part of the CEEC and, for the purposes of this estimation, they include the following plant community types listed in the Greater Hunter Native Vegetation Mapping (OEH, 2012a):

- Grey Box/Grey Gum/Rough-barked Apple/Blakely's Red Gum grassy open forest of the central Hunter;
- Silvertop Stringybark/White Box grassy open forest of the slopes of the upper Hunter and Liverpool Ranges;
- Silvertop Stringybark/Yellow Box grassy open forest of the eastern Liverpool Ranges;
- White Box grassy woodland on basalt soils of the upper Hunter and Liverpool Ranges;
- Yellow Box/Rough-barked Apple grassy woodland of the upper Hunter and Liverpool Plains.

The CEEC has a grassland form, as derived native grassland, no mapping exists to clearly differentiate the areas of this as opposed to other types of grassland within the subregion. Hence it has not been considered within this section.

Within a 10,000 ha circle, there is estimated to be approximately 314 ha of Box Gum Woodland, of which approximately 14.7 ha or 4.68% would be cleared by the proposed development.

No formal estimate is available for the percentage of derived native grassland, but for the purposes of this report, it is assumed to be in the same order/percentage as for woodland.

(c) an estimate of the extant area and overall condition of the CEEC or EEC remaining in the IBRA subregion after the impact of the proposed development has been taken into consideration.

To calculate the proportion remaining in the IBRA subregion, all of the aforementioned plant communities were considered, together with those of relevance in the lower Hunter (DECCW (NSW), 2011). In the lower Hunter portion of the IBRA region, only one community, is regarded here as being consistent with the CEEC, that being Hunter Lowland Redgum Forest.

Within the IBRA subregion, there is estimated to be approximately 8,704 ha of Box Gum Woodland, of which approximately 14.7 ha or 0.17% would be cleared by the proposed development.

No formal estimate is available for the percentage of derived native grassland, but for the purposes of this report, it is assumed to be in the same order/percentage as for woodland.

(d) the development proposal's impact on:

(i) abiotic factors critical to the long-term survival of the CEEC or EEC. For example, will the impact lead to a reduction of groundwater levels or substantial alteration of surface water patterns?

Upper Hunter White Box-Ironbark Grassy Woodland (MU 1) and its derived grassland (MU 2) occur on hills and rises, predominantly to the east of the Project Disturbance Footprint. The Project is unlikely to have a significant impact on abiotic factors that are critical to the long-term survival of this community within the Study Area.

The Project, due to its proximity to Saddlers Creek, could have adverse effects on riparian vegetation (including MU 3: Hunter Floodplain Red Gum Woodland) if operation of the mine impacts on surface flow patterns or degrades the stream bank environment. Without measures to protect the creek habitat, the Project could have significant impact on abiotic factors that may adversely affect the long-term survival of this community within the Study Area.

Anglo American will implement general measures to manage water bodies, traffic, surface water flows, erosion and sedimentation within operational areas. This will mitigate the

potential impacts of the Project on the habitat for Box-Gum Woodland around Saddlers Creek.

(ii) characteristic and functionally important species through impacts such as, but not limited to, inappropriate fire/flooding regimes, removal of understorey species or harvesting of plants.

The Project will completely remove approximately 22 ha of Box-Gum Woodland from the Study Area. Seed and tissue material may be harvested from remaining occurrences within the Study Area in order to facilitate restoration and revegetation efforts but will not be carried out in such a manner that will adversely impact on characteristic and functionally important species.

(iii) the quality and integrity of an occurrence of the CEEC or EEC through threats and indirect impacts including, but not limited to, assisting invasive flora and fauna species to become established or causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants which may harm or inhibit growth of species in the CEEC or EEC.

The Project could have adverse indirect effects on remaining occurrences of Box-Gum Woodland within the Study Area by exacerbating KTPs or allowing movement of nutrients, sedimentation and other pollutants from the operational areas.

Anglo American will implement general measures to manage water bodies, traffic, surface water flows, erosion and sedimentation within operational areas. This will mitigate the risk of exacerbating KTPs that may adversely affect Box-Gum Woodland.

(e) direct or indirect fragmentation and isolation of an important area of the CEEC or EEC.

The main occurrences of Box-Gum Woodland in the Study Area are on hills and rises, predominantly to the east of the Project Disturbance Footprint. The occurrences within the Study Area are currently quite fragmented. The Project is unlikely to further fragment or isolate an important area of Box-Gum Woodland within the Study Area.

(f) the measures proposed to contribute to the recovery of the CEEC or EEC in the IBRA subregion.

Anglo American is proposing to undertake substantial restoration work along Saddlers Creek as part of offsetting measures (see the EIS biodiversity offset strategy report), which will restore, increase and protect occurrences of Box-Gum Woodland in the Study Area and contribute to the recovery of Box-Gum Woodland in the Hunter subregion.

9.2.2 *Diuris tricolor* (Pine Donkey Orchid)

The patch of this species that occurs on site is part (a subpopulation) of an endangered population listed for the species in the Muswellbrook area (OEH 2007). The endangered population is described in the OEH species profile as:

"Diuris tricolor is an endemic Australian terrestrial orchid (i.e. it grows rooted in the ground rather than from rocks or trees). Plants have between one and three leaves which are up to 30 cm long and 0.4 cm wide. The flower stalk is between 20-40 cm high and has 2-6 flowers, which are bright yellow to orange, speckled with red to purple and white markings. The sepals (the down-pointing slender green segments) are very long and often crossed. The Muswellbrook Local Government Area (LGA) population of Diuris tricolor has particularly large flowers relative to other populations of the species.

The population of Diuris tricolor in the Muswellbrook LGA, in the upper Hunter Valley, comprises a number of occurrences, ranging from a few scattered individuals to a few thousand plants. The area of occupancy of the population is less than 50 km². Therefore, the geographic distribution of the population is estimated to be highly restricted. The population of Diuris tricolor in the Muswellbrook LGA is at the eastern limit of the geographic range of the species and all other populations of the species are located west of the Great Dividing Range. The distance of the Muswellbrook LGA population to the nearest population of the species to the west is about 100 km. Therefore the population in the Muswellbrook LGA is disjunct and at the limit of its geographic range.

Habitats are described as:

- Found in sclerophyll woodland and derived grassland on flats or small rises, on a range of substrates including sandy or loamy soils.*
- The habitat of Diuris tricolor in the Muswellbrook LGA has been fragmented by past land clearing."*

(a) the size of the local population directly and indirectly impacted by the development.

The local (i.e. onsite) population of *Diuris tricolor* (Pine Donkey Orchid) comprises approximately 30 individuals. These individuals will be directly impacted by the Project.

(b) the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to:

- (i) an estimate of the change in habitat available to the local population as a result of the proposed development;*

The Muswellbrook population of this species is known from a number of occurrences ranging from scattered individuals to large colonies, and typically occurs in open grassy woodland often associated with Box-Gum Woodland (DEC (NSW), 2005k). Within the Study Area, the species was recorded in Box-Gum Woodland.

The Project will reduce the area of available habitat by approximately 22 ha. This comprises 7% of the available habitat within the Study Area.

(ii) the proposed loss, modification, destruction or isolation of the available habitat used by the local population; and

The Project will result in the loss of habitat being used by the species. Other areas of habitat occur around Saddlers Creek and in the hills to the east of the Project Disturbance Footprint.

Anglo American will implement general measures to manage water bodies, traffic, surface water flows, erosion and sedimentation within operational areas. This will mitigate the potential impacts of the Project on the habitat for the species, particularly around Saddlers Creek. Thus, this action is not likely to modify, isolate or destroy the remaining habitat in the Study Area.

(iii) modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.

Atlas records or other documented, quantifiable means must be used by the assessor to estimate what percentage of the species' population and habitat is likely to be lost in the long term within the IBRA subregion due to the direct and indirect impacts of the development.

Analysis of the other occurrences of the species using the OEH Wildlife Atlas records indicates that the occurrence on site is one of 11 records from the Muswellbrook portion of the IBRA subregion. However, larger occurrences of the orchid occur at Mount Arthur which has over 200 plants and it is likely that the orchids that occur on the project site are a small occurrence. However, if all such records represented the same sized patches this would mean that the removal of the patch would be removing approximately 9% of the plants in the Muswellbrook area.

Not all habitat for the species has been surveyed and the orchid occurs in some patches of derived native grassland and several woodland types, but not all patches. This is because habitat modification by grazing and weed invasion has removed the orchid from some areas.

Based upon current data, and because much of the potential habitat has not been surveyed for it, it is assumed that less considerably than 9% of the woodland and grassland habitat for the Muswellbrook population would be cleared for the development.

(c) the likely impact on the ecology of the local population. At a minimum, address the following:

(i) for fauna:

- breeding;
- foraging;
- roosting; and
- dispersal or movement pathways.

Not applicable.

(ii) for flora, address how the proposal is likely to affect the ecology and biology of any residual plant population that will remain post development including where information is available:

- pollination cycle
- seedbanks
- recruitment, and
- interactions with other species (e.g. pollinators, host species, mycorrhizal associations)

Based upon all existing data, the local patch or subpopulation of this species would be entirely removed by the proposed development. As described above, other small patches or subpopulations exist at (subpopulations) occur at Mount Arthur and Drayton (eg in within the Drayton Wildlife Reserve). These are already isolated occurrences, having been isolated by historic clearing for agriculture. For the reasons stated below, it seems unlikely that the other patches would interact with those within the Project Disturbance Footprint.

Little is known about the reproductive ecology, particularly dispersive abilities, of *Diuris tricolor*. *Diuris tricolor* experiences short flowering events (2-4 weeks) any time between early September to late October and so is likely to be pollinated (possibly by insects) in this period. The flower of *D. tricolor* is superficially similar to the orchid *Diuris basaltica* is thought to be pollinated by native halictid bees through food deception (Walker, 1997). Similarly *Diuris fragrantissima* is pollinated by native bees by mimicing a native lily (Tonkinson, 1985).

As most terrestrial orchids have small, wind dispersed seed (Weston *et al.*, 2005) it is possible that seed may be present in the surface soil across some other areas of the Study Area (though the species has only been found to occur in one restricted area of the site despite repeated surveys over several years). The relative success of recruitment from seed is not well known, but it is noted that aside from microclimatic conditions (such as space, light, soil temperature etc.), weather conditions (particularly rainfall in the months preceding the flowering season) influences emergence and flowering times and may therefore also influence germination.

Fire may also indirectly promote seed germination by altering the levels of soil nutrient and reducing competition as found in *Diuris fragrantissima*. In *Diuris fragrantissima*, hot summer fires have also promoted flowering in the following springs (Murphy *et al.*, 2008a).

A factor that is also likely to influence recruitment from seed is presence of mycorrhizal fungal symbionts in the soil. All terrestrial orchids that have been studied so far rely on fungal symbionts either for germination of dormant seed and/or for root growth of juveniles following germination, depending on the species (Weston *et al.*, 2005). Species of *Diuris* have been propagated using this symbiotic method and tuber division (Murphy *et al.*, 2008). Soil microclimatic conditions can also determine both the presence of fungal symbionts in specific locations, and the ability of particular species of orchids to become inoculated with their symbionts (Phillips *et al.*, 2011).

(d) a description of the extent to which the local population will become fragmented or isolated as a result of the proposed development.

The local patch or subpopulation of this species would be entirely removed by the proposed development. There will be no remaining patches of the local occurrence after mining. However, other similar occurrences (subpopulations) occur at Mount Arthur and Drayton (eg in within the Drayton Wildlife Reserve). These are already isolated occurrences, having been isolated by historic clearing for agriculture. The proposed development will not significantly further fragment these populations.

(e) the relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range

As stated above, other similar occurrences (subpopulations) of this orchid occur at Mount Arthur and Drayton (eg in within the Drayton Wildlife Reserve). At the former area, there are over 200 orchids known from a conservation area established on the Mt Arthur site. Based upon OEH records, there are also at least 16 plants, probably many more at the Drayton Wildlife Reserve.

These are already isolated occurrences, having been isolated by historic clearing for agriculture. The remaining occurrences of the species in the locality are quite widely dispersed (considering the small size of these plants) and may not currently interact to exchange gene flow through cross pollination.

(f) the extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population.

Not applicable. The local patch or subpopulation of this species would be entirely removed by the proposed development.

(g) the measure/s proposed to contribute to the recovery of the species in the IBRA subregion.

A known population of *Diuris tricolor* (Pine Donkey Orchid) occurs in the Drayton Wildlife Refuge. Since a Wildlife Refuge may be revoked at any time, Anglo American is willing to secure the area of the Drayton Wildlife Refuge supporting the *Diuris tricolor* (Pine Donkey Orchid) population under an additional conservation mechanism, such as a Conservation Agreement under Part 4, Division 12 of the *National Parks and Wildlife Act 1974* (NP&W Act) or a BioBanking Agreement under Part 7A, Division 2 of the TSC Act. It is recognised that in doing so, the local occurrence of the species will be protected in perpetuity. Anglo American plans to consult with OEH and other relevant agencies to progress the matter.

The possibility of translocating *Diuris tricolor* (Pine Donkey Orchid) from the Project Disturbance Footprint to conservation areas will be considered by Anglo American; however, it is noted that translocation of ground orchids is difficult (Vallee *et al.*, 2004; Sommerville *et al.*, 2013).

Seed and tissue propagation trials will be conducted of the *Diuris tricolor* (Pine Donkey Orchid) population within the Project Disturbance Footprint. Whilst the success of such trials is uncertain, it is noted that another threatened species, *Diuris fragrantissima* (Sunshine Orchid), has been recorded as living for up to 20 years in cultivation (Murphy *et al.*, 2008b). Any propagation trials will utilise genetic material that will be collected prior to clearing, to ensure local genetic diversity is not lost.

To protect remaining occurrences of *Diuris tricolor* habitat in the Study Area, Anglo American is proposing to undertake substantial restoration work along Saddlers Creek as part of offsetting measures (see the EIS biodiversity offset strategy report). These measures will restore, increase and protect remaining *Diuris tricolor* habitat in the Study Area and contribute to the recovery of the species in the Hunter subregion.

Chapter 10

Compensatory Measures

Anglo American is committed to providing a substantial Biodiversity Offset Package (BOP) to address the residual impacts of the Project and to ensure that the Project does not result in a net loss of biodiversity values.

The BOP will be focussed on the protection, restoration and maintenance of onsite and offsite conservation lands. The BOP has been prepared in accordance with Anglo American's internal Biodiversity Performance Standard (2011), which is consistent with the "maintain or improve" approach as it requires that:

- The target of no net biodiversity loss or net positive contribution to biodiversity is to be considered at the operational level based on the biodiversity risk and/or opportunity posed to the business;
- Operational biodiversity action plans should be aligned with National Biodiversity Frameworks and take cognisance of regional and/or local conservation planning frameworks where these exist; and
- Where there is the potential for significant adverse or positive impacts on biodiversity the implications of this risk and/or opportunity facing the operation needs to be assessed and the extent of the risk or opportunity translated into a business case for biodiversity management.

The BOP is described and discussed in the EIS biodiversity offset strategy report, which has been prepared to support the EIS.

Chapter 11

Conclusion

Despite the impacts of past agriculture, the Project would have a substantial impact on the ecology of the local area. If no mitigation and compensation measures were proposed, it would result in the net loss of approximately 291 ha of native forest and woodland and 1,147 ha of grassland vegetation from the Study Area, which includes 22 ha of Box-Gum Woodland and 248 ha of other state-listed ecological communities.

Most of the vegetation to be cleared from the Study Area comprises TECs that have been over-cleared in the Central Hunter region and are therefore locally significant. When it is considered that these communities have undergone a large decline across their range due to cumulative clearing and that less than a third of their original distribution remains today, the Project is considered to have a significant impact on TECs if no ameliorative or compensatory actions are undertaken. The vegetation that is proposed to be cleared from the Study Area also provides habitat for a range of threatened species. At least 21 threatened or migratory fauna species and four threatened flora species listed under the TSC Act and / or the EPBC Act were recorded or are likely to occur within the Study Area.

In recognition of the potential ecological impacts of the Project, Anglo American will implement a series of mitigation measures to ameliorate the impacts of the Project. Anglo American is committed to delivering a substantial offsetting strategy that addresses the residual impacts of the Project. The Project adopts a “maintain or improve” approach to offsetting; this means that the offsetting strategy will aim to achieve no net loss of biodiversity values, including the area and condition of habitat for fauna, over the life of the Project.

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Figures

Figure 1	Regional Locality
Figure 2	Conceptual Project Layout
Figure 3	Minor Additional Mining Areas at Drayton Mine
Figure 4	Landscape Features
Figure 5	Plot and Transect Locations
Figure 6	Fauna Survey Locations
Figure 7	Aquatic Survey Locations
Figure 8	Vegetation Units within the Study Area
Figure 9	Vegetation in the Additional Mining Areas at Drayton Mine
Figure 10	Threatened Species Recorded in the Study Area
Figure 11	Project Footprint
Figure 12	Vegetation within the Project Disturbance Footprint
Figure 13	Drayton Mine – Existing Offsets
Figure 14	Impact Summary

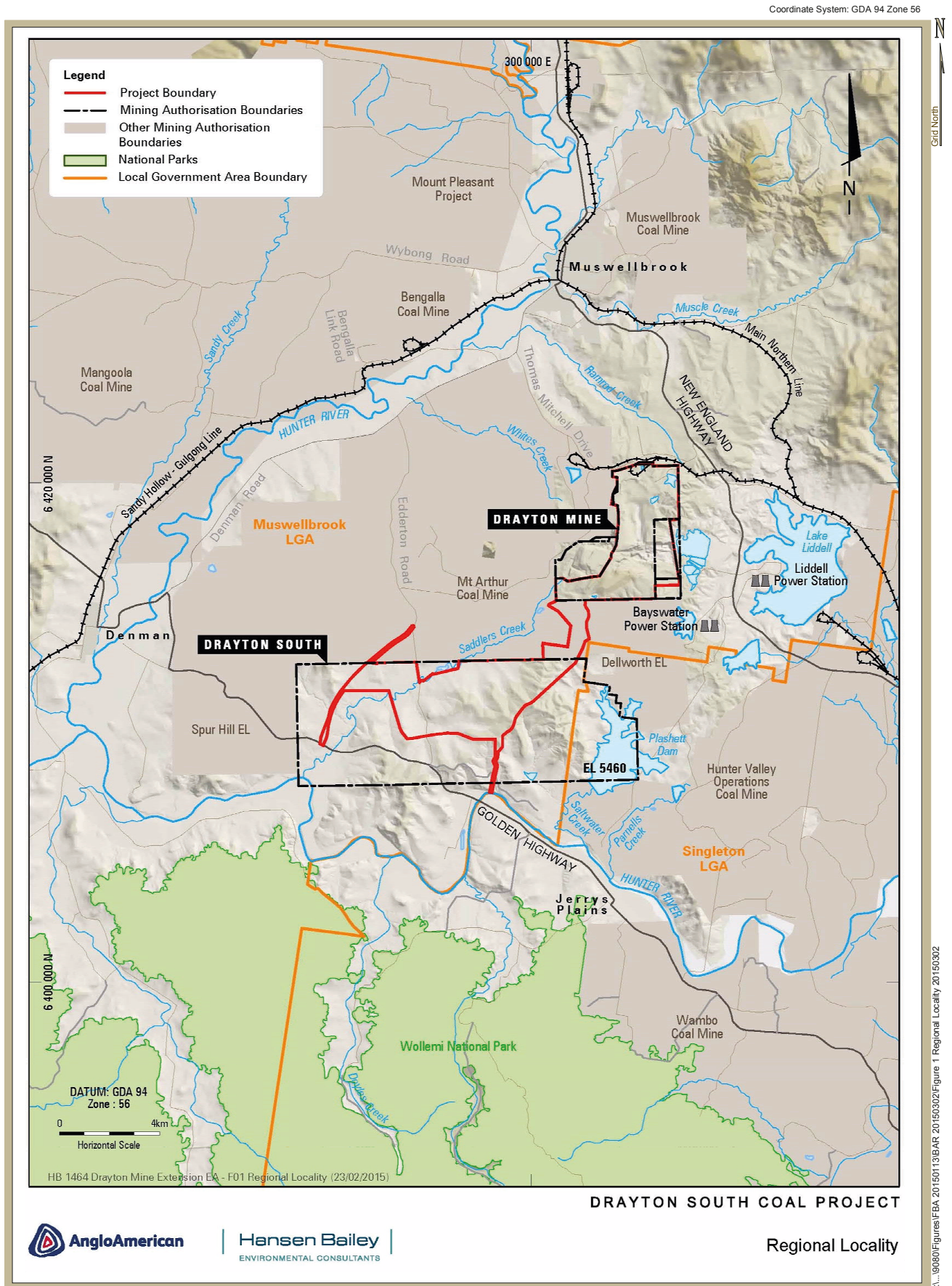


Figure 1 Regional Locality

Coordinate System: GDA 94 Zone 56

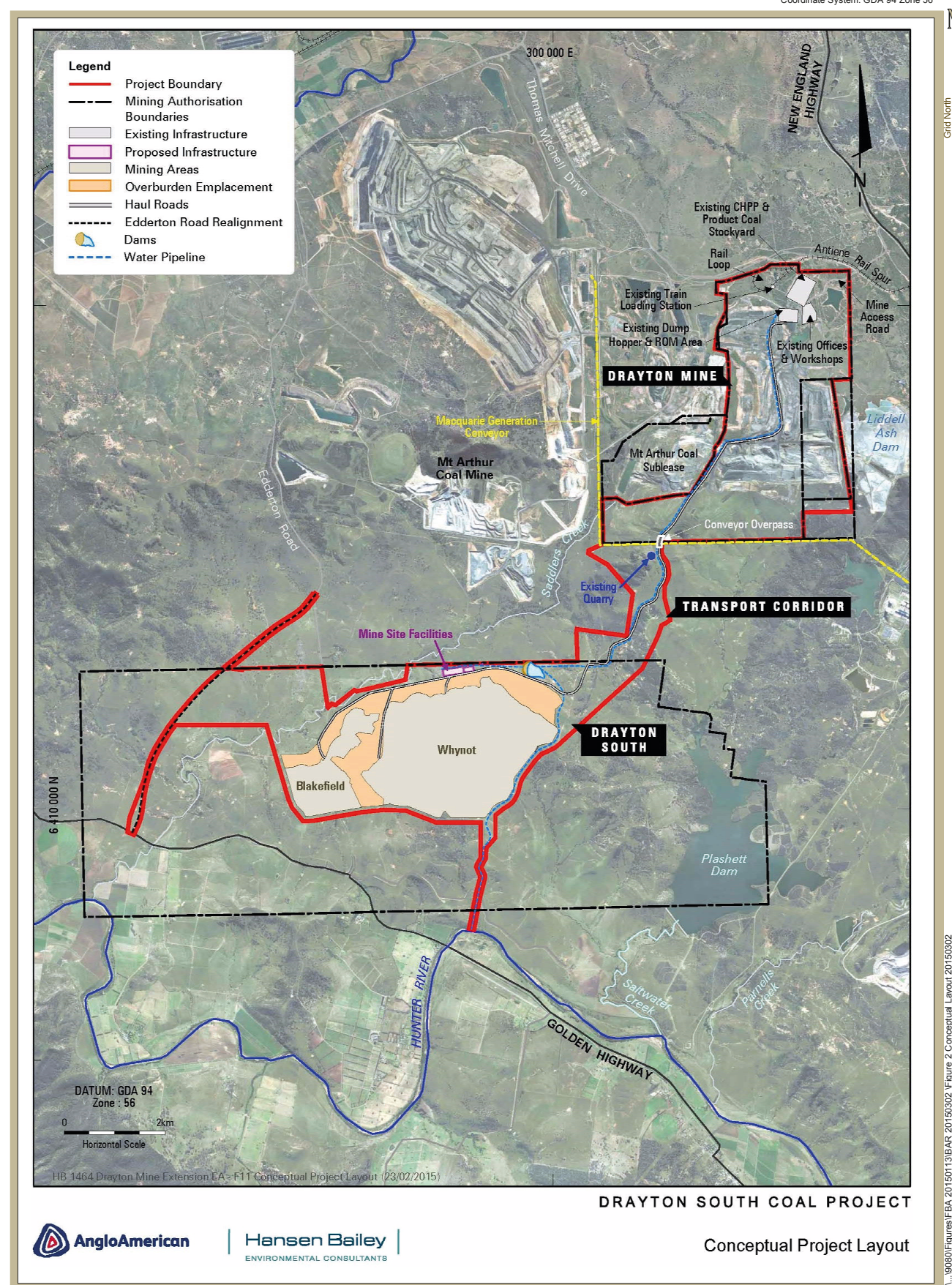


Figure 2 Conceptual Project Layout