

Ecology Impact Assessment

J

DRAYTON SOUTH COAL PROJECT

Ecology Impact Assessment

For:

Hansen Bailey

October 2012

Final

CUMBERLAND ECOLOGY

PO Box 2474, Carlingford Court 2118
www.cumberlandecology.com.au

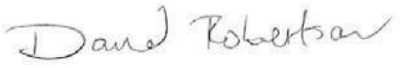
Report No. 9080RP3

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.

Revision	Date Issued	Reviewed by	Revision Type
1	29/08/2011	TP/CP/DR	First draft
2	19/12/2011	TP/CP	Second draft
3	12/03/2012	CP/DR	Third draft
4	10/06/2012	HB/Anglo	Final Draft
5	25/06/2012	HB/Anglo	Final Report
6	23/07/2012	HB/Anglo	Final Report
7	08/08/2012	HB/Anglo	Final Report
8	10/08/2012	DP&I/OEH/SEWPaC	Final Report

Approved by: Dr. David Robertson

Position: Director



Signed:

Date: *26 October, 2012*

Table Of Contents

EXECUTIVE SUMMARY

1 INTRODUCTION

1.1 Project Background *1.2*

1.2 The Study Area *1.3*

1.3 Report Structure *1.7*

1.4 Related Studies *1.7*

2 EXISTING ENVIRONMENT

2.1 Regional Context *2.1*

2.1.1 Sydney Basin Bioregion *2.1*

2.1.2 Conservation Reserves *2.1*

2.2 Climate *2.2*

2.3 Topography *2.2*

2.4 Geology *2.3*

2.5 Soils and Land Capability *2.3*

2.6 Hydrology *2.4*

2.6.1 Saddlers Creek *2.4*

2.6.2 Hunter River *2.4*

2.7 Land Use *2.5*

3 LEGISLATIVE FRAMEWORK

3.1 Commonwealth Legislation *3.1*

3.1.1 Environment Protection and Biodiversity Conservation Act 1999 *3.1*

3.2 State Legislation *3.2*

3.2.1 Environmental Planning and Assessment Act 1979 *3.2*

3.2.2 Threatened Species Conservation Act 1995 *3.3*

Table Of Contents *(Cont'd)*

3.2.3 State Environmental Planning Policy 44 – Koala Habitat Protection *3.3*

3.2.4 Other Relevant Legislation *3.5*

3.2.5 Biodiversity Offsetting Policy Documents *3.5*

4 METHODOLOGY

4.1 Desktop Review *4.1*

4.1.1 Literature Review *4.1*

4.1.2 Database Analysis *4.2*

4.1.3 Review of Regional Vegetation Mapping *4.2*

4.2 Field Survey *4.3*

4.3 Flora Surveys *4.6*

4.3.1 Vegetation Mapping *4.6*

4.3.2 Floristic Census *4.9*

4.3.3 Quadrat Sampling *4.9*

4.3.4 Threatened Species Targeted Surveys *4.10*

4.3.5 Identification of Ground Water Dependent Ecosystems (GDEs) *4.11*

4.4 Fauna Habitat Assessment *4.13*

4.4.1 Hollow Assessment *4.13*

4.5 Terrestrial Fauna Surveys *4.13*

4.5.1 Trapping Surveys *4.14*

4.5.2 Bat Surveys *4.18*

4.5.3 Bird Surveys *4.18*

4.5.4 Diurnal Surveys *4.19*

4.5.5 Nocturnal Surveys – Spotlight Searches *4.19*

4.5.6 Incidental Observations *4.21*

4.6 Aquatic Surveys *4.21*

Table Of Contents *(Cont'd)*

4.6.1 Habitat Assessment *4.22*

4.6.2 Macro-invertebrate Sampling *4.23*

4.6.3 AUSRIVAS and SIGNAL Analysis *4.24*

4.7 Potential Offset Site Surveys *4.27*

4.7.1 Onsite Surveys *4.27*

4.7.2 Preliminary Offsite Field Studies *4.27*

4.7.3 Detailed Offsite Offset Surveys *4.28*

4.7.4 Biodiversity Offset Package *4.31*

4.8 Survey Limitations *4.33*

5 FLORA RESULTS

5.1 General Condition of the Environment *5.1*

5.2 Vegetation Communities *5.2*

5.2.1 Native Grasslands *5.5*

5.2.2 Exotic Grasslands *5.8*

5.2.3 Woodland Communities *5.8*

5.3 Summary of Vegetation Community MNES *5.22*

5.4 Flora of the Study Area *5.25*

5.4.1 Threatened Flora Species *5.25*

5.4.2 Invasive Species *5.29*

5.5 Potentially Occurring Threatened TECs and Flora *5.31*

5.5.1 Vegetation Communities *5.31*

5.5.2 Flora *5.32*

5.6 Summary of Flora MNES *5.33*

6 FAUNA RESULTS

6.1 Fauna Habitat *6.1*

6.1.1 Extant Habitat *6.2*

Table Of Contents *(Cont'd)*

6.1.2 Remnant Forest and Woodland *6.3*

6.1.3 Regenerating Shrubland and Forest *6.10*

6.1.4 Grassland *6.10*

6.1.5 Riparian Vegetation *6.13*

6.1.6 Aquatic Habitat *6.13*

6.2 Fauna of the Study Area *6.16*

6.2.1 General Fauna Assemblage *6.16*

6.2.2 Threatened Fauna Species *6.17*

6.2.3 Invasive Fauna *6.38*

6.3 Potentially Occurring Threatened Fauna *6.41*

6.3.1 Avifauna *6.41*

6.3.2 Migratory Species *6.49*

6.4 Summary of Fauna MNES *6.51*

6.5 Aquatic Study *6.52*

6.5.1 Habitat Assessment *6.52*

6.5.2 Site Condition and Ecological Integrity *6.60*

6.5.3 Vertebrate Species *6.67*

6.5.4 Threatened Species *6.69*

7 IMPACT ASSESSMENT

7.1 Direct Loss of Vegetation and Habitat *7.1*

7.1.1 Threatened Ecological Communities *7.5*

7.1.2 Groundwater Dependent Ecosystems (GDEs) *7.8*

7.1.3 Loss of Important Habitat Features *7.8*

7.1.4 Habitat Fragmentation and Patch Size *7.11*

7.1.5 Reduction or Loss of Habitat Connectivity *7.12*

7.1.6 Edge Effects *7.13*

Table Of Contents *(Cont'd)*

7.2 Impacts to Threatened Species *7.14*

7.2.1 Flora *7.15*

7.2.2 Fauna *7.17*

7.3 Summary of Direct Impacts on MNES *7.23*

7.4 Indirect Impacts *7.24*

7.4.1 Competition for Resources *7.25*

7.4.2 Noise *7.25*

7.4.3 Light *7.26*

7.4.4 Dust *7.26*

7.4.5 Erosion *7.27*

7.4.6 Vehicle Strike *7.27*

7.4.7 Weeds, Feral Animals and Overabundant Native Species *7.28*

7.5 Impacts to the Hunter River Catchment *7.29*

7.5.1 Water Quality and Habitat *7.29*

7.5.2 Water Extraction and Discharge *7.29*

7.6 Cumulative Impacts *7.30*

7.7 Duration and Timing of Impacts *7.35*

7.8 Permanence and Reversibility of Impacts *7.35*

7.9 Summary of Impacts *7.36*

8 IMPACT MITIGATION

8.1 Measures to Avoid Impacts *8.1*

8.2 Measures to Mitigate Impacts *8.2*

8.2.1 Minimising Vegetation and Habitat Loss *8.3*

8.2.2 Vegetation Restoration and Rehabilitation *8.4*

8.3 Monitoring and Reference Sites *8.5*

8.3.1 Reference Sites *8.6*

Table Of Contents *(Cont'd)*

8.3.2 Monitoring *8.6*

8.4 Biodiversity Action Plan *8.7*

9 BIODIVERSITY OFFSET PACKAGE

9.1 Introduction *9.1*

9.1.1 BOP Components *9.2*

9.1.2 Minimum Offset Requirements *9.4*

9.2 Onsite Offsets *9.7*

9.2.1 Restoration of Saddlers Creek *9.7*

9.2.2 Onsite Conservation of Vegetation *9.11*

9.2.3 Rehabilitation and Revegetation of the Project Disturbance Footprint *9.12*

9.2.4 Likely Success of Rehabilitation *9.12*

9.3 Offsite Offsets *9.13*

9.4 Biodiversity Offset Management Plan *9.13*

9.5 Security of the Offset Properties *9.15*

9.6 Cumulative Offsets *9.16*

9.7 Summary of the Biodiversity Offset Package *9.16*

10 THE OFFSITE OFFSET PROPERTY

10.1 General Description of the Offsite Offset Property *10.1*

10.2 Vegetation Communities of the Offsite Offset Property *10.2*

10.2.1 Silvertop Stringybark - gum open forest on basalts of the Liverpool Range, Brigalow Belt South and Nandewar *10.6*

10.2.2 Silvertop Stringybark grassy open forests, eastern Nandewar and New England Tablelands *10.7*

10.2.3 Box - gum grassy woodlands, Brigalow Belt South and Nandewar *10.9*

10.2.4 White Box - stringybark shrubby woodlands, Brigalow Belt South and Nandewar *10.10*

Table Of Contents *(Cont'd)*

10.2.5 White Box grassy woodland, Brigalow Belt South and Nandewar *10.11*

10.2.6 River Oak riparian woodland, eastern NSW *10.12*

10.2.7 Rough-barked Apple - Blakely's Red Gum riparian grassy woodlands, Brigalow Belt South and Nandewar *10.14*

10.2.8 Derived grasslands, Brigalow Belt South and Nandewar *10.15*

10.2.9 Low Diversity Derived Native Grassland *10.17*

10.3 Fauna Habitat Values of the Offsite Offset Property *10.19*

10.3.1 Hollow Resources *10.19*

10.3.2 Flowering Resource *10.24*

10.3.3 Ground Debris and Understorey Complexity *10.27*

10.3.4 Rock Outcrops *10.29*

10.3.5 Riparian Corridors and Dams *10.30*

10.4 Regenerative Potential of the Vegetation on the Offsite Offset Property *10.31*

10.5 Threatened Species on the Offsite Offset Property *10.33*

10.6 Adequacy of the BOP in Addressing Project Impacts *10.48*

10.7 MNES Addressed through Provision of the BOP *10.51*

10.8 Compliancy of the BOP with NSW and Commonwealth Offsetting Policies *10.51*

11 CONCLUSION

BIBLIOGRAPHY

Table Of Appendices

A. MINISTER'S REQUIREMENTS FOR ASSESSMENT UNDER THE EPBC ACT

B. IDENTIFICATION GUIDELINE (FLOWCHART) AND ADVICE (THREATENED SPECIES SCIENTIFIC COMMITTEE) FOR BOX-GUM WOODLAND

C. TSC ACT FINAL DETERMINATION: BOX-GUM WOODLAND

D. FLORA SPECIES RECORDED IN THE STUDY AREA

E. FLORA QUADRAT DATASET

F. FAUNA SPECIES RECORDED IN THE STUDY AREA

G. LIKELIHOOD OF OCCURRENCE - THREATENED FLORA SPECIES

H. LIKELIHOOD OF OCCURRENCE - THREATENED FAUNA SPECIES

I. ASSESSMENTS OF SIGNIFICANCE (THE SEVEN-PART TEST)

I.1	Introduction	*I.1*
I.2	Box-Gum Woodland Seven-part Test	*I.1*
I.3	Central Hunter Box-Ironbark Seven-part Test	*I.1*
I.4	Narrabeen Footslopes Slaty Box Woodland Seven-part Test	*I.1*
I.5	Hunter Lowland Redgum Forest Seven-part Test	*I.1*
I.6	Weeping Myall Population Seven-part Test	*I.1*
I.7	Pine Donkey Orchid Species/Population Seven-part Test	*I.1*
I.8	Tiger Orchid Population Seven-part Test	*I.1*
I.9	Black-chinned Honeyeater Seven-part Test	*I.1*
I.10	Little Lorikeet Seven-part Test	*I.1*
I.11	Regent Honeyeater Seven-part Test	*I.1*
I.12	Swift Parrot Seven-part Test	*I.1*
I.13	Brown Treecreeper Seven-part Test	*I.1*
I.14	Diamond Firetail Seven-part Test	*I.1*
I.15	Flame Robin Seven-part Test	*I.1*
I.16	Gang-gang Cockatoo Seven-part Test	*I.1*
I.17	Glossy Black-Cockatoo Seven-part Test	*I.1*

Table Of Appendices

	I.18	Grey-crowned Babbler Seven-part Test	*I.1*
	I.19	Hooded Robin Seven-part Test	*I.1*
	I.20	Satin Flycatcher Seven-part Test	*I.1*
	I.21	Scarlet Robin Seven-part Test	*I.1*
	I.22	Speckled Warbler Seven-part Test	*I.1*
	I.23	Turquoise Parrot Seven-part Test	*I.1*
	I.24	Varied Sittella Seven-part Test	*I.1*
	I.25	Barking Owl Seven-part Test	*I.1*
	I.26	Little Eagle Seven-part Test	*I.1*
	I.27	Masked Owl Seven-part Test	*I.1*
	I.28	Powerful Owl Seven-part Test	*I.1*
	I.29	Spotted Harrier Seven-part Test	*I.1*
	I.30	Cave-roosting Microbats Seven-part Test	*I.1*
	I.31	Hollow-roosting Microbats Seven-part Test	*I.1*
	I.32	Spotted-tailed Quoll Seven-part Test	*I.1*
	I.33	Squirrel Glider Seven-part Test	*I.1*
J.	**AUSTRALIAN COMMONWEALTH AND NSW PRINCIPLES FOR BIODIVERSITY OFFSETTING**		
K.	**SADDLERS CREEK RESTORATION: CMA AGREEMENT**		
L.	**SURVEY DATA FROM THE OFFSITE OFFSET PROPERTY**		
M.	**SUMMARY OF ASSESSMENT OF MNES**		
	M.1	Introduction	*M.1*
	M.2	Methods	*M.1*
	M.3	Species Profiles and Likely Occurrence in the Study Area	*M.1*
		M.3.1 Box-Gum Woodland	*M.1*
		M.3.2 Weeping Myall Woodland	*M.1*
		M.3.3 Regent Honeyeater and Swift Parrot	*M.1*

Table Of Appendices

	M.3.4	Spotted-tail Quoll	*M.1*
	M.3.5	Koala	*M.1*
	M.3.6	Greater Long-eared Bat	*M.1*
	M.3.7	Green and Golden Bell Frog	*M.1*
	M.3.8	Lobed Blue Grass	*M.1*
	M.3.9	Finger Panic Grass	*M.1*
	M.3.10	Leek-orchid	*M.1*
	M.3.11	Illawarra Greenhood	*M.1*
	M.3.12	Austral Toadflax	*M.1*
M.4	Impact Assessment		*M.1*
M.5	Avoidance, Mitigation and Offset Measures		*M.1*
M.6	Conclusion		*M.1*

List of Photographs

5.1	Derived Native Grassland (Box-Gum Woodland) Dominated by Native Perennial Grasses in the Study Area	5.6
5.2	Upper Hunter White Box-Ironbark Grassy Woodland on Slopes in the Study Area	5.10
5.3	Upper Hunter White Box-Ironbark Grassy Woodland on a Hilltop in the Study Area	5.10
5.4	Hunter Floodplain Red Gum Woodland with a Canopy Dominated by Young Yellow Box Trees	5.12
5.5	Hunter Floodplain Red Gum Woodland with Mature Yellow Box Trees	5.12
5.6	Central Hunter Box-Ironbark Woodland 1	5.14
5.7	Central Hunter Box-Ironbark Woodland 2	5.14
5.8	Narrabeen Footslopes Slaty Box Woodland 1	5.16
5.9	Narrabeen Footslopes Slaty Box Woodland 2	5.16
5.10	Central Hunter Bulloak Forest Regeneration	5.17

List of Photographs

5.11	Hunter Valley River Oak Forest in the Riparian Zone	5.18
5.12	Regrowth Hunter Lowland Red Gum Forest adjacent to an Industrial Dam at Drayton Mine	5.19
5.13	Planted Vegetation along Edderton Road	5.21
5.14	Planted Acacias along a Haul Road at Drayton Mine	5.21
5.15	Threatened Orchid *Diuris tricolor* Recorded within the Study Area	5.28
5.16	*Diuris tricolor* in Open Grassy Understorey	5.28
5.17	Open grassy Box-Gum Woodland Habitat where *Diuris tricolor* was Recorded	5.29
6.1	A Large Tree Hollow in the Study Area	6.5
6.2	Australian Kestral in a Tree Hollow (Photo: D. Stojanovic, 2011)	6.5
6.3	Stag Providing Valuable Large Hollows	6.6
6.4	A Typical Hollow-bearing Tree in the Study Area	6.7
6.5	Woodland Margins and Scattered Trees	6.9
6.6	Grassland Habitat in the Study Area Containing Scattered Paddock Trees	6.12
6.7	Grassland Habitat in the Minor Additional Mining Areas at Drayton Mine	6.12
6.8	Aquatic Habitat along and within Saddlers Creek	6.14
6.9	Industrial Dam at Drayton Mine	6.15
6.10	Brown Treecreeper (Photo: D. Stojanovic, 2011)	6.21
6.11	Diamond Firetail (Photo: D. Stojanovic, 2011)	6.23
6.12	Adult Grey-crowned Babbler (Photo: D. Stojanovic, 2011)	6.25
6.13	Male Scarlet Robin (Photo: D. Stojanovic, 2011)	6.26
6.14	Swift Parrot (Photo: D. Stojanovic, 2011)	6.30
6.15	Low-value Habitat at Site S1 along Saddlers Creek	6.54
6.16	Low-value Habitat at Site S2 along Saddlers Creek	6.55
6.17	Habitat at site H3 (Proposed Water Outflow Pipeline) along the Hunter River	6.57
6.18	Habitat Upstream of the Confluence of the Hunter River and Saddlers Creek	6.58
10.1	Silvertop Stringybark - Gum Open Forest (Quadrat T9)	10.6
10.2	Silvertop Stringybark - Gum Open Forest (Quadrat T14)	10.7
10.3	Silvertop Stringybark Grassy Open Forests, Eastern Nandewar and New England Tablelands (Quadrat T4)	10.8
10.4	Silvertop Stringybark Grassy Open Forests, Eastern Nandewar and New England Tablelands (Quadrat T13)	10.8
10.5	Box - Gum Grassy Woodlands, Brigalow Belt South and Nandewar	

List of Photographs

	(Quadrat T7)	10.9
10.6	White Box - Stringybark Shrubby Woodlands, Brigalow Belt South and Nandewar (Quadrat T20)	10.10
10.7	White Box Grassy Woodland, Brigalow Belt South and Nandewar (Quadrat T5)	10.11
10.8	White Box Grassy Woodland, Brigalow Belt South and Nandewar (Quadrat T8)	10.12
10.9	River Oak Riparian Woodland, Eastern NSW (Quadrat T1)	10.13
10.10	River Oak Riparian Woodland, Eastern NSW (Quadrat T1)	10.13
10.11	Rough-barked Apple - Blakely's Red Gum Riparian Grassy Woodlands, Brigalow Belt South and Nandewar (Quadrat T15)	10.14
10.12	Rough-barked Apple - Blakely's Red Gum Rparian Grassy Woodlands, Brigalow Belt South and Nandewar (Quadrat T15)	10.15
10.13	Derived Grasslands on the Offsite Offset Property	10.16
10.14	Derived Grasslands on the Offsite Offset Property	10.16
10.15	Low Diversity Derived Grassland on the Offsite Offset Property	10.17
10.16	Low Diversity Derived Grassland on the Offsite Offset Property	10.18
10.17	Regeneration of Canopy Eucalypts in Low Diversity Derived Grassland	10.18
10.18	Multi-branched Stag with Numerous Hollows	10.22
10.19	An Example of a Basal Hollow on the Offsite Offset Property	10.23
10.20	Hollowed Stags on the Offsite Offset Property	10.24
10.21	Flowering and Budding Trees	10.25
10.22	Flowering Understorey Shrubs	10.25
10.23	Woody Ground Debris	10.28
10.24	Woody Ground Debris	10.28
10.25	Example of Rocky Outcrop at Ridgetop, in the Eastern Section of the Offsite Offset Property	10.29
10.26	Chilcotts Creek	10.30
10.27	Farm Dam on the Offsite Offset Property	10.31
10.28	Recent Ringbarking of Canopy Trees on the Offsite Offset Property	10.32

List of Figures

1.1	Regional Locality	1.4
1.2	Project Layout	1.5
1.3	Minor Additional Mining Areas at Drayton Mine	1.6
4.1	Flora Survey Locations	4.12
4.2	Fauna Survey Locations	4.20
4.3	Aquatic Survey Locations	4.26
4.4	Survey Locations on the Offsite Offset Property	4.32
5.1	Vegetation Communities within the Study Area	5.23
5.2	Vegetation in the Minor Additional Mining Areas at Drayton Mine	5.24
5.3	Threatened Flora Recorded within the Study Area	5.30
6.1	Threatened Fauna Recorded within the Study Area	6.40
6.2	Biplot of the Condition of Each Aquatic Survey Site According to SIGNAL Scores	6.66
7.1	Project Impacts on Vegetation Communities	7.4
9.1	Drayton Mine Existing Offsets	9.3
9.2	Conceptual Drayton South Final Landform	9.6
10.1	Location of the Offsite Offset Property	10.4
10.2	Vegetation Communities of the Offsite Offset Property	10.5
10.3	Threatened Flora and Fauna Species Recorded on the Offsite Offset Property	10.34
M.1	Location and Extent of Box-Gum Woodland within the Study Area	M.4
M.2	Box-Gum Woodland Condition Classes in the Study Area	M.5
M.3	MNES in Muswellbrook LGA (Relevant Fauna)	M.15
M.4	MNES in Muswellbrook LGA (Relevant Flora)	M.16
M.5	Project Impacts on Box-Gum Woodland	10.34

List of Tables

S.1	Vegetation Communities within the Study Area	6
S.2	Vegetation Communities in the Minor Additional Mining Areas at Drayton Mine	8
S.3	Threatened Fauna Species Recorded in the Study Area	8
3.1	Director-General's EARs and Locations Discussed in this Report	3.3
3.2	Koala Feed Trees (Schedule 2, SEPP 44)	3.4
4.1	Summary of Dates for Field Surveys Completed	4.3
4.2	Field Survey Weather Conditions (Jerrys Plains Forecasts)	4.5
4.3	Braun-Blanquet Scoring System	4.10
4.4	Cumulative Survey Effort completed for the Study Area	4.15
4.5	Cumberland Ecology Fauna Trapping Effort	4.17
4.6	Weather Observations for Offsite Offset Surveys	4.28
4.7	Survey Effort – Offsite Offset Property	4.29
5.1	Vegetation Communities within the Study Area	5.3
5.2	Vegetation Communities in the Minor Additional Mining Areas at Drayton Mine	5.5
5.3	Summary of Likely Occurrence of Relevant Community MNES in Study Area	5.22
5.4	Summary of Likely Occurrence of Relevant Flora MNES in Study Area	5.34
6.1	Qualitative Assessment – Remnant Forest and Woodland Habitat	6.4
6.2	Flowering Periods for Dominant Tree Species	6.8
6.3	Qualitative Assessment – Woodland Margins	6.9
6.4	Qualitative Assessment – Grassland Habitat	6.11
6.5	Qualitative Assessment – Riparian Habitat	6.13
6.6	Threatened Fauna Species Recorded in the Study Area	6.18
6.7	Foraging Guilds of Microbat Species Recorded in the Study Area	6.33
6.8	Summary of Likely Occurrence of Relevant Fauna MNES in Study Area	6.51
6.9	Summary of Aquatic Habitat Assessment	6.59
6.10	Health of Aquatic Sites According to AUSRIVAS Bands	6.60
6.11	AUSRIVAS Band Keys	6.61
6.12	Aquatic Physical and Chemical Data	6.64
6.13	SIGNAL Macroinvertebate Scores	6.65
6.14	Vertebrate Fauna Recorded in the Hunter River	6.68
7.1	Areas of Vegetation to be Removed by the Project	7.3

List of Tables

7.2	Direct Loss of Native Vegetation and Habitat for MNES in the Study Area	7.23
7.3	Cumulative Impacts on Vegetation in the Surrounding Locality (Muswellbrook LGA)	7.32
9.1	Total Offset Areas Required for the Project	9.4
9.2	Offsetting Areas Proposed within the BOP	9.5
10.1	Vegetation Communities of the Offsite Offset Property	10.2
10.2	Hollow Count Data – Offsite Offset Property	10.20
10.3	Flowering Schedule for Canopy Species that are Present on the Offsite Offset Property	10.26
10.4	Threatened and Migratory Species Recorded on the Offsite Offset Property	10.33
10.5	Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area	10.35
10.6	Habitat Available to Threatened Species on the Offsite Offset Property	10.45
10.7	Summary of Areas in the BOP Compared with the Offset Requirements of the Project	10.49
10.8	Habitat Provided by the Biodiversity Offset Package for MNES	10.52
10.9	Evaluation of BOP against the OEH Offsetting Principles	10.54
10.10	Evaluation of the BOP against the Commonwealth Offsets Policy	10.65
D.1	Flora Species Recorded in the Study Area	D.1
E.1	Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area	E.1
F.1	Fauna Species Recorded in the Study Area	F.1
G.1	Likelihood of Occurrence of Potential Threatened Flora Species	G.1
H.1	Likelihood of Occurrence of Potential Threatened Fauna Species	H.1
I.1	Ecological Communities and Species Subject to a Seven-part Test	I.3
L.1	Hollow Dataset from the Offsite Offset Property	L.1
L.2	Quadrat Dataset from the Offsite Offset Property	L.5
L.3	Flora Species List from the Offsite Offset Property	L.20
L.4	Fauna Species Recorded on the Offsite Offset Property Compared with the Study Area	L.23
I.1	Ecological Communities and Species Subject to a Seven-part Test	I.3
I.1	Ecological Communities and Species Subject to a Seven-part Test	I.3
M.1	MNES Relevant to the Study Area	M.1
M.2	Summary of Likely Occurrence of Relevant MNES in Study Area	M.13

List of Tables

M.3	Direct Loss of Native Vegetation and Habitat for MNES in the Study Area	M.17
M.4	Significant Impact Criteria for Critically Endangered and Endangered Ecological Communities	M.20
M.5	Significant Impact Criteria for Critically Endangered and Endangered Species	M.21
M.6	Significant Impact Criteria for Vulnerable Species	M.22
M.7	Habitat Provided by the Biodiversity Offset Package for MNES	M.25

Glossary of Terms

Anglo American	Anglo American Metallurgical Coal Pty Ltd, the Proponent
AUSRIVAS	Australian Rivers Assessment System
BAP	Biodiversity Action Plan; a plan of management for the onsite offsets and the Project Disturbance Footprint
BOP	Biodiversity Offset Package
BOMP	Biodiversity Offset Management Plan; a site-specific plan of management for the offsite offset properties
Box-Gum Woodland	EPBC-listed CEEC and TSC-listed EEC *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.* Note that this refers collectively to both the woodland and grassland forms of the community.
CEEC	Critically Endangered Ecological Community
CMA	Hunter-Central Rivers Catchment Management Authority
DP&I	NSW Department of Planning and Infrastructure (formerly the Department of Planning)
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
EA	Environmental Assessment
EARs	Director-General's Environmental Assessment Requirements
EEC	Endangered Ecological Community

EP&A Act	NSW *Environmental Planning and Assessment Act 1979* (under which the Project Approval for the Project is sought)
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FM Act	*Fisheries Management Act 1994*
GDEs	Groundwater Dependent Ecosystems
LGA	Local Government Area
Locality	Land within 20 km radius of the Project Boundary
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
NP&W Act	*National Parks and Wildlife Act 1974*
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)
PEA	Preliminary Environmental Assessment
PFS	Pre-Feasibility Study (conducted by Cumberland Ecology)
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
ROM	Run of Mine. The raw coal extracted by methods of dragline and blasting
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (formerly Department of Environment, Water, Heritage and the Arts)
Study Area	The Study Area comprises an overall area of approximately 4,597 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 Ecology Impact Assessment. 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 27 year open cut coal and highwall 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 pipelines 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 *Threatened Species Conservation Act 1995*

Executive Summary

S1 Introduction

Cumberland Ecology was commissioned by Hansen Bailey Environmental Consultants on behalf of Anglo American Metallurgical Coal Pty Ltd (Anglo American, the Proponent) to prepare an ecology impact assessment report for the Drayton South Coal Project (the Project). The purpose of the assessment is to form part of an Environmental Assessment (EA) being prepared by Hansen Bailey to support an application for Project Approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to facilitate the continuation of the existing Drayton Mine by the development of an open cut and highwall coal mining operation and associated infrastructure within the Drayton South area, and also minor additional mining areas within the East, North and South Pits at Drayton Mine.

This ecology impact assessment examines the terrestrial and aquatic flora and fauna assemblages and their habitats, with particular focus on the Drayton South area and transport corridor (collectively, the Study Area). It assesses the impacts of the construction and operation of the Project on biodiversity values, with due consideration of the potential impact on threatened fauna and flora species, populations and ecological communities protected under both State and Commonwealth legislation.

The specific objectives of this assessment are as follows:

- Present and analyse the results of literature and database reviews;
- Present survey results and describe the flora and fauna present or likely to occur based on collected information;
- Identify and consider the impacts of the Project upon threatened species and ecological communities listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), New South Wales (NSW) *Threatened Species Conservation Act 1995* (TSC Act) and *Fisheries Management Act 1994* (FM Act) recorded or likely to be present; and
- Prescribe a Biodiversity Offset Package (BOP) that will protect threatened flora and fauna, compensate for the potential residual impacts of the Project that cannot be otherwise avoided or mitigated, and provide for a net gain of conserved woodland and forest habitats in the long term.

This assessment addresses the Project's Environmental Assessment Requirements (EARs) of the Director-General of the NSW Department of Planning and Infrastructure (DP&I). The Project requires approval from a Planning Assessment Commission under Part 3A of the EP&A Act.

The Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) has determined that the Project is a controlled action under the EPBC Act and has accredited DP&I's assessment processes. The Project requires the approval of the Commonwealth Minister for the Environment.

S2 Project Background

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, at which time the operation will have to close.

The Drayton South Coal Project (the Project) will allow for the continuation of mining at Drayton Mine by the development of open cut and highwall mining operations within the Drayton South area (Drayton South) while continuing to utilise the existing infrastructure and equipment from Drayton Mine. It also includes minor additional mining areas within the East, North and South Pits. Collectively the Project encompasses Drayton Mine, Drayton South and the transport corridor which will link the two operational areas.

The Project is located approximately 10 km north west of the village of Jerrys Plains and approximately 13 km south of the township of Muswellbrook in the Upper Hunter Valley of NSW. The Project is predominately situated within the Muswellbrook Shire Local Government Area (LGA), with the south west portion falling within the Singleton LGA.

The Project will extend the life of Drayton Mine by a further 27 years ensuring the continuity of employment for its workforce, the ongoing utilisation of its infrastructure and the orderly rehabilitation of Drayton Mine's completed mine areas.

S3 Methodology

S3.1 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 that was completed on behalf of the Hunter-Central Rivers Catchment Management Authority (Peake 2006) 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 (OEH 2011) and SEWPaC EPBC Protected Matters Search Tool (SEWPaC 2011b). The number and age of records of threatened species recorded within a 10 km radius of the Study Area was used to assess the likelihood of threatened species occurring. The 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.

S3.2 Field Surveys

Extensive systematic surveys have been conducted of the Study Area and Drayton Mine in the past (Saunders 2006; Cumberland Ecology 2007; Cumberland Ecology 2009; Ecotone 2000; The Ecology Lab Pty Ltd 2000). Additional surveys were completed in 2009 and 2011 by Cumberland Ecology as part of the current ecology impact 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 (DEC (NSW), 2004) and included quadrat sampling, habitat assessments, targeted species searches, trapline surveys, nocturnal surveys and bat surveys (harp and anabat). 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 (AUSRIVAS).

S3.3 Offset Field Surveys

The nature, magnitude and location of most open cut coal mining projects mean that in the majority of cases broad areas of forest, woodland, open grassland and threatened species habitat will be cleared. In this regard it was apparent during the early design and assessment phases that the Project would be required to develop an ecological offsets strategy to compensate for the residual ecological impacts of the Project, particularly those to threatened vegetation communities. As a consequence of this, onsite and offsite offsets were investigated as part of the ecology impact assessment.

Surveys of potential onsite offset areas were completed during field studies of the Study Area and included vegetation mapping, general habitat assessments and targeted surveys as part of the survey programme for the Study Area. Potential areas that were investigated included onsite sections of Saddlers Creek and vegetation along the primary ridgeline in the Study Area.

A high level desktop analysis of suitable areas in which to prioritise searches for candidate offsite offset properties was completed for the Project. A desktop review of the known threatened species occurrences in the general vicinity of suitable offset areas was also completed. This was followed by preliminary inspections and assessment of a number of properties throughout the Hunter Valley. These were conducted with due consideration to the above desktop analysis, to ascertain the offset potential of the land for the Project. Notes were made regarding the following: threatened species and their habitat; key habitat features (rock outcrops, streams, etc); major weed infestations; current and historical land use; dominant vegetation types and broad patterns of occurrence; and other relevant attributes or management issues. Detailed surveys of a potential offsite offset property have been completed for the Project.

S4 Results

S4.1 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 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. 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.

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.

S4.2 Vegetation Communities

The major vegetation communities that occur within the Study Area and their onsite extents are listed 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 Central Hunter Box-Ironbark Woodland.

Many 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. Some of these vegetation communities conform to the EPBC Act and TSC Act listed Box-Gum Woodland.

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.

S4.3 Flora

Over 250 plant species were recorded in the Study Area, of which a high proportion of these are native. Five threatened plant species listed under the TSC Act and / or 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);
- *Bothriochloa biloba* (Lobed Blue Grass) (Vulnerable, EPBC 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.

S4.4 Fauna

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 bird and 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.

Table S.1 Vegetation Communities within the Study Area

Vegetation Community*	Status		Conservation Listing	Area of Vegetation (ha)	
	TSC Act	EPBC Act		Within Study Area	Within Disturbance Footprint
Central Hunter Bulloak Forest Regeneration	-	-	Not listed	26	25
Hunter Valley River Oak Forest	-	-	Not listed	2	2
Central Hunter Box-Ironbark Woodland	EEC	-	Conforms to Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions.	479	181
Hunter Floodplain Red Gum Woodland	EEC	CEEC	Conforms to the EPBC listing of White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Box-Gum Woodland). Conforms to TSC listing of Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions.	40	11
Narrabeen Footslopes Slaty Box Woodland	VEC	-	Conforms to Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion.	100	98
Upper Hunter White Box-Ironbark Grassy Woodland	EEC	CEEC	Conforms to White Box Yellow Box Blakely's Red Gum Woodland. This community is dominated by White Box - Grey Box intergrades.	94	63
Cooba Scrub	-	-	Not listed	65	9

Table S.1 Vegetation Communities within the Study Area

Vegetation Community*	Status		Conservation Listing	Area of Vegetation (ha)	
	TSC Act	EPBC Act		Within Study Area	Within Disturbance Footprint
Planted Vegetation	-	-	Not listed	9	0
Derived Native Grassland - Hunter Floodplain Red Gum Woodland	EEC	CEEC	Conforms to Box-Gum Woodland	10	4
Derived Native Grassland - Upper Hunter White Box-Ironbark Grassy Woodland	EEC	CEEC	Conforms to Box-Gum Woodland	159	103
Other Grassland	-	-	Not listed	3613	1432
TOTAL				**4597**	**1928**

** Nomenclature based on Peake (2006)*

Table S.2 Vegetation Communities 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			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**

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

Family	Scientific Name	Common Name	Legal Status	
			TSC Act	EPBC Act
AVES				
Apodidae	*Hirundapus caudacutus*	White-throated Needletail		Mi
Accipitridae	*Circus assimilis*	Spotted Harrier	V	
Accipitridae	*Hieraaetus morphinoides*	Little Eagle	V	
Psittacidae	*Lathamus discolour*	Swift Parrot	E	E; Ma
Strigidae	*Ninox connivens*	Barking Owl	V	
Meropidae	*Merops ornatus*	Rainbow Bee-eater		Mi
Climacteridae	*Climacteris picumnus*	Brown Treecreeper	V	
Acanthizidae	*Pyrrholaemus saggitatus*	Speckled Warbler	V	
Meliphagidae	*Melithreptus gularis gularis*	Black-chinned Honeyeater (eastern subspecies)	V	
Pomatostomidae	*Pomatostomus temporalis temporalis*	Grey-crowned Babbler (eastern subspecies)	V	
Petroicidae	*Petroica boodang*	Scarlet Robin	V	
Petroicidae	*Melanodryas cucullata*	Hooded Robin	V	
Estrildidae	*Stagonopleura guttata*	Diamond Firetail	V	

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

Family	Scientific Name	Common Name	Legal Status	
			TSC Act	EPBC Act
MAMMALIA- BATS				
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	V	
Molossidae	*Mormopterus norfolkensis*	Eastern Freetail-bat	V	
Vespertilionidae	*Chalinolobus dwyeri*	Large-eared Pied Bat	V	V
Vespertilionidae	*Miniopterus orianae oceanensis*	Eastern Bentwing-bat	V	
Vespertilionidae	*Myotis macropus*	Southern Myotis	V	
Vespertilionidae	*Nyctophilus corbeni*	Greater Long-eared Bat	V	V
Vespertilionidae	*Scoteanax rueppellii*	Greater Broad-nosed Bat	V	
Vespertilionidae	*Vespadelus troughtoni*	Eastern Cave Bat #	V	

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

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.

S5 Impacts

The largest direct impact of the Project is the removal of native vegetation from the Study Area. Approximately 1928 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:

- 181 ha of state- and commonwealth-listed Box-Gum Woodland; comprising 74 ha of woodland and 107 ha of derived native grassland;
- 279 ha of other state-listed TECs;
- 36 ha of other native vegetation not listed under legislation; and
- 1432 ha of grassland not listed under legislation.

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.

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 EPBC Act and/or TSC Act. Without any amelioration, the Project will also have a significant impact on a number of threatened woodland birds, hollow-dependent microchiropteran bats within the locality and migratory species such as the Swift Parrot (*Lathamus discolor*). Due to the potential impacts to the EPBC Act listed 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 it has been highly disturbed in the past and currently retains little value as habitat for flora and fauna, including threatened species.

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.

S5.1 Cumulative Impacts

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.

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 would represent a minimum loss of 5113 ha of native forest and woodland and derived native grassland. Approximately 1073 ha of this vegetation is Box-Gum Woodland. Another 835 ha of TSC-listed communities 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 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.

S6 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 described within the Part 3A Guidelines for Threatened Species Assessment for the use of environmental offsets under the EPBC Act:

- **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.

S6.1 Avoidance

Avoiding environmental impacts has been considered where possible throughout the Project planning and design phases. Significant modification to the design of the Project has led to the current proposal. It is considered the most efficient alternative as it provides for improved biodiversity outcomes while being socially and economically viable and relying on existing infrastructure associated with Drayton Mine.

S6.2 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 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 (BAP) 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 biodiversity management and biodiversity mitigation for the Project, and will include clear objectives and actions. 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 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.

S6.3 Biodiversity Offset Package (BOP)

A Biodiversity Offset Package (BOP) has been developed to offset the residual impacts of the Project on flora and fauna, once the avoidance and mitigation measures have been implemented. The BOP addresses the residual impacts of the Project in a strategic and meaningful way that will deliver a real biodiversity outcome, and will ensure that the Project does not result in a net loss of biodiversity values. The Project adopts a "maintain or improve" approach to offsetting; this means that the BOP aims to achieve no net loss of biodiversity values, including the area and condition of habitat for fauna, over the life of the Project.

The main components of the BOP are:

1. **Onsite Offsets**, comprising the following:
    a. Restoration of Saddlers Creek;
    b. Conservation of areas proposed for retention along the primary ridgeline of the Study Area; and
    c. Rehabilitation of the Project Disturbance Footprint; and
2. **Offsite Offset Land**.

Anglo American is committed to meeting a significant portion of their offset requirements onsite through the restoration of Saddlers Creek, rehabilitation of the Drayton South disturbance footprint and retention and protection of vegetation along the primary ridgeline of the Study Area. An offsite offset containing suitable remnant open forest and woodland habitats will be acquired to address residual impacts that cannot be addressed through onsite offsetting. This property will be secured permanently for conservation and managed under a site-specific management plan to improve and maintain the conservation values of the offsite offset.

The BOP will address the predicted loss of 1928 ha of remnant forest, woodland and derived native grassland by provision of 3653 ha of offset land, or a ratio of 1.9:1 for total vegetation to be cleared. Of this, the BOP will afford an immediate 1290 ha of existing forest and woodland to offset the progressive loss of 389 ha of forest and woodland. This will provide an immediate offset to impact ratio of 3.3:1 for forest and woodland generally.

The BOP will address the predicted loss of 74 ha of remnant Box-Gum Woodland by the provision of 794 ha of existing Box-Gum Woodland (10.7:1). Similarly for the estimated clearance of 107 ha of listed Derived Native Grassland, the BOP will supply an overall 898 ha of EEC Derived Native Grassland (a ratio of 8.4:1), of which a subset comprises 343 ha of CEEC Derived Native Grassland (a ratio of 3.2:1). The total area of remnant and

grassland Box-Gum Woodland that will be supplied by the BOP in the long term will offset the predicted impacts on remnant and grassland Box-Gum Woodland in the Study Area by approximately 9.7:1.

Impacts to 279 ha of other state-listed TECs will be offset at a ratio of 5.2:1.

All of the mines in the area propose to rehabilitate mined areas and return them to forest and woodland. The mined landscaped will be progressively returned as flora and fauna habitat in the medium to long term. Additionally, all of the mines have provisions for offsetting ecological impacts. All of the mines will or have purchased additional surrounding lands that contain forest, woodland and Derived Native Grasslands. These will collectively and significantly increase the total areas of native vegetation that exist in the locality in the future and will significantly increase the total area of native vegetation within conservation corridors and reserves in the locality.

S7 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 389 ha of native forest and woodland and 107 ha of derived native grasslands from the Study Area, which includes 181 ha of Box-Gum Woodland and 279 ha of other state-listed TECs.

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 five threatened flora species listed under the TSC Act and / or the EPBC Act were recorded or are likely to occur within the Study Area. Others, like the Regent Honeyeater, are considered to have potential to occur.

In recognition of the potential ecological impacts of the Project, a BOP has been developed to compensate for the residual impacts on threatened species and ecological communities that cannot be addressed through avoidance and mitigation measures. The BOP provides a significant conservation outcome for the Project by providing a suite of measures, that include both onsite and offsite offsets, to mitigate and compensate for the ecological impacts of the Project. The focus of the BOP is on the onsite restoration and rehabilitation of Saddlers Creek under supervision of the Catchment Management Authority, which will be supplemented by the permanent conservation and ongoing management of an offsite offset property.

When the mitigation and BOP are considered, the Project will have a major ecological benefit in the long term. It will contribute to maintaining the total forest and woodland area of the locality through rehabilitation and it will substantially increase the area of forest and

woodland under conservation tenure within the Hunter region. Hundreds of hectares of Box-Gum Woodland, prime habitat for threatened woodland species, will be added to conservation tenure. The ratio of native vegetation to be conserved to that cleared will represent a minimum of 6:1 for Box-Gum Woodland and 3:1 for other native vegetation.

Chapter **1**

Introduction

Cumberland Ecology was commissioned by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Anglo American Metallurgical Coal Pty Ltd. (Anglo American, the Proponent) to prepare an ecology impact assessment for the Drayton South Coal Project (the Project). The purpose of the assessment is to form part of an Environmental Assessment (EA) being prepared by Hansen Bailey to support an application for a contemporary Project Approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to facilitate the continuation of the existing Drayton Mine by the development of an open cut and highwall coal mining operation and associated infrastructure in the Drayton South area.

The scope of work completed by Cumberland Ecology for this assessment included:

- Addressing the Director-General's Environmental Assessment Requirements relating to ecology, issued on 3 August 2011;
- Describing and mapping vegetation communities;
- Identifying threatened vegetation communities protected under legislation;
- Identifying and mapping the location of threatened fauna 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;
- Providing advice regarding the referral of the Project to the Commonwealth;
- Where relevant, recommending measures for mitigation in order to manage impacts on threatened species and areas of high conservation value; and
- Presenting an offsets package that will compensate for the potential residual impacts of the Project that cannot be otherwise avoided or mitigated.

The objectives of this assessment were to document the findings of the ecological investigation of the Project and to assess the impacts of the Project on current biodiversity values. This includes threatened fauna and flora 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).

1.1 Project Background

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, at which time the operation will have to close.

The Project will allow for the continuation of mining at Drayton Mine by the development of open cut and highwall mining operations within the Drayton South mining area while continuing to utilise the existing infrastructure and equipment from Drayton Mine.

The Project is located approximately 10 km north west of the village of Jerrys Plains and approximately 13 km south of the township of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW). The Project is predominately situated within the Muswellbrook Shire Local Government Area (LGA), with the south west portion falling within the Singleton LGA. **Figure 1.1** illustrates the location of the Project. The Project is located adjacent to two thoroughbred horse studs, two power stations and several existing coal mines.

The Project will extend the life of Drayton Mine by a further 27 years ensuring the continuity of employment for its workforce, the ongoing utilisation of its infrastructure and the orderly rehabilitation of Drayton Mine's completed mining areas.

Anglo American is seeking Project Approval under Part 3A of the *Environmental Planning & Assessment Act 1979* (EP&A Act) to facilitate the extraction of coal by both open cut and highwall mining methods within Exploration Licence (EL) 5460 for a period of 27 years. The Project Application Boundary (Project Boundary) is shown on **Figure 1.1**.

The Project generally comprises:

- The continuation of the operations of the Drayton Mine as presently approved with minor additional mining areas within the East, North and South Pits;
- The development of an open cut and highwall mining operation extracting up to 7 Mtpa of ROM coal over a period of 27 years;
- The utilisation of the existing Drayton Mine workforce and equipment fleet (with an addition of a highwall miner and coal haulage fleet);
    - The Drayton Mine fleet consists of at least a dragline, excavators, fleet of haul trucks, dozers, graders, water carts and associated supporting equipment;
- The use of Drayton Mine's existing voids for rejects and tailings disposal and water storage to allow for the optimisation of the Drayton Mine final landform;

- The utilisation of the existing Drayton Mine infrastructure including the Coal Handling and Preparation Plant (CHPP), rail loop and associated loadout infrastructure, workshops, bath houses and administration offices;
- The construction of a transport corridor between Drayton South and Drayton Mine;
- The utilisation of the Antiene Rail Spur off the Main Northern Railway to transport product coal to the Port of Newcastle for export;
- The realignment of a section of Edderton Road; and
- The installation of water management and power reticulation infrastructure at Drayton South.

All access to the Project will continue to be via the Drayton Mine Access Road off Thomas Mitchell Drive and will use the transport corridor to travel between Drayton Mine and Drayton South. An emergency entry / exit will be required to be developed and maintained off Edderton Road for health and safety purposes only.

The conceptual layout of the Project is shown in **Figure 1.2**.

1.2 The Study Area

The Study Area comprises an overall area of approximately 4,597 ha (**Figure 1.2**) and includes the proposed Drayton South disturbance footprint, the transport corridor, the Edderton Road realignment and water pipelines to the Hunter River. The Study Area is the key focus of this ecology impact assessment and 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 EA.

As part of the current ecology impact assessment, minor additional mining areas comprising an overall area of approximately 37 ha at Drayton Mine were also assessed (**Figure 1.3**). 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.

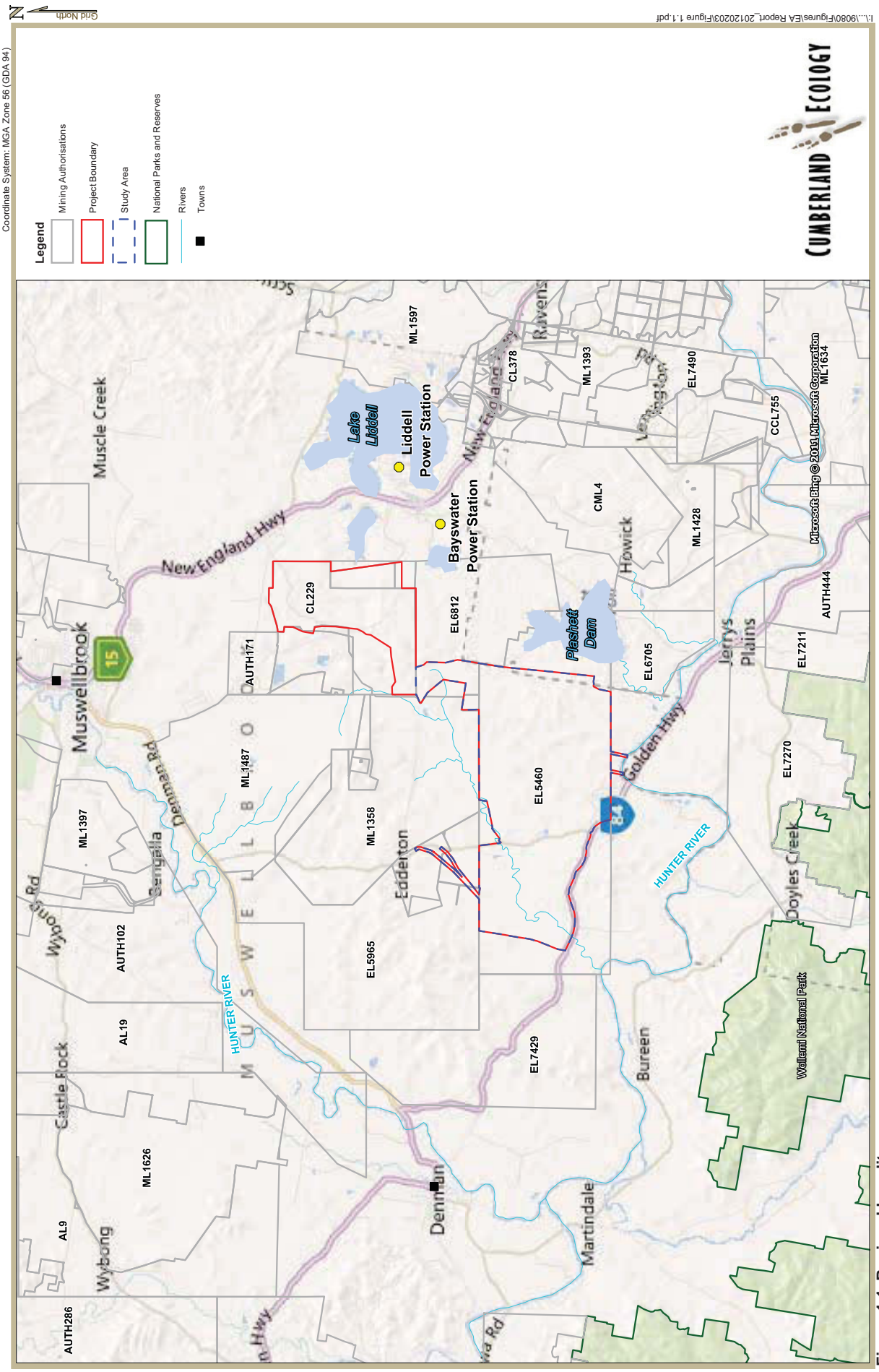


Figure 1.1. Regional Locality

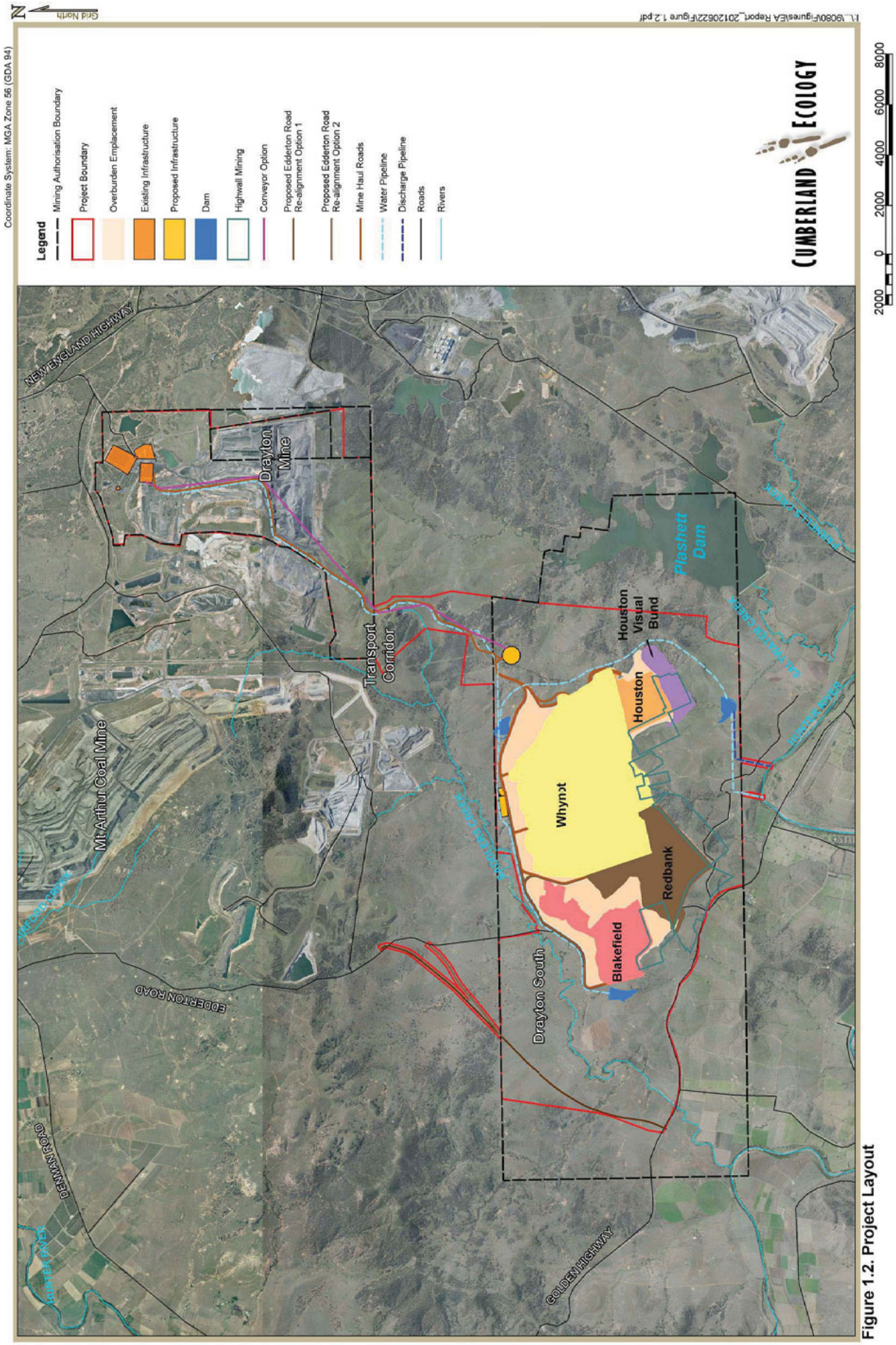


Figure 1.2. Project Layout

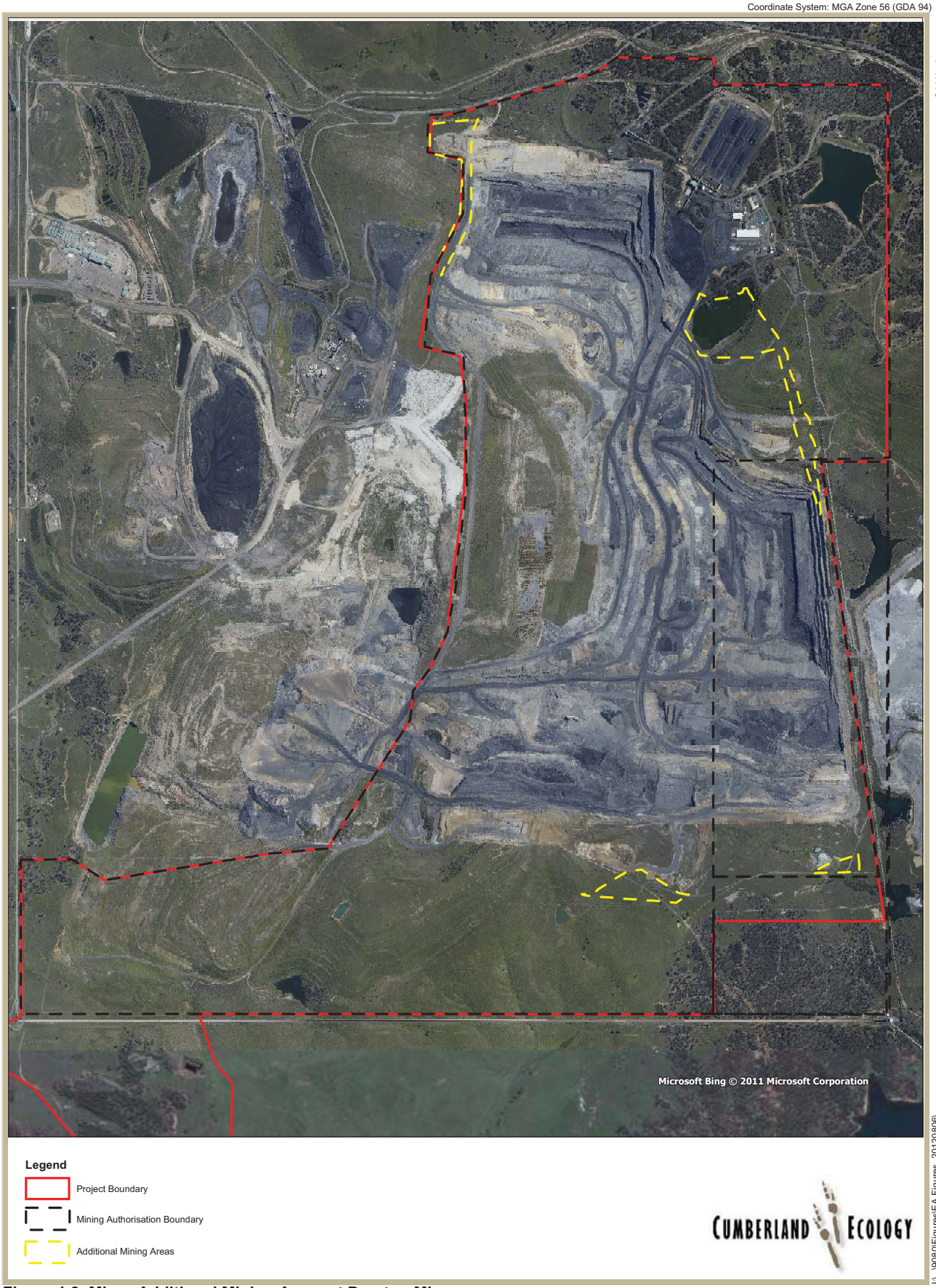


Figure 1.3. Minor Additional Mining Areas at Drayton Mine

1.3 Report Structure

The structure of this report is as follows:

- **Chapter 1** Introduction;
- **Chapter 2** Existing Environment;
- **Chapter 3** Legislative Framework;
- **Chapter 4** Methodology;
- **Chapter 5** Flora Results;
- **Chapter 6** Fauna Results;
- **Chapter 7** Impact Assessment;
- **Chapter 8** Impact Mitigation;
- **Chapter 9** Biodiversity Offset Package (BOP);
- **Chapter 10** The Offsite Offset Property; and
- **Chapter 11** Conclusions.

MNES are addressed throughout this ecology impact assessment; the assessment of MNES is also consolidated into Appendix M of this report. The assessment of MNES is also addressed throughout the EA (main volume).

1.4 Related Studies

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

- The EA stygofauna impact assessment;
- The EA agricultural impact statement;
- The EA surface water impact assessment;
- The EA groundwater impact assessment; and
- The EA soil and land capability impact assessment.

Chapter 2

Existing Environment

2.1 Regional Context

2.1.1 Sydney Basin 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 (NSW) 2011). 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 and is 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 (NSW) 2011). 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).

2.1.2 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 the east 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 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 (NSW) 2011). 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; Grey-crowned Babbler; Diamond Firetail; Speckled Warbler; Brown Treecreeper; Regent Honeyeater; Hooded Robin;
    - Barking Owl;
    - Squirrel Glider; and
    - Greater Long-eared Bat.

2.2 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 (BOM) 2012a).

2.3 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 (NSW) 2011) 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%.

2.4 Geology

The Hunter Valley is characterised by a complex of Permian shales, sandstones, conglomerates, volcanics and coal seams (OEH (NSW) 2011). 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.

2.5 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 (Drayton South EA, **Appendix P**). 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 wetted (Drayton South EA, **Appendix Q**). These natural properties generally produce highly erodible soils (Harpstead, Sauer 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 seed banks degraded, resulting in lower diversity vegetation.

In accordance with the NSW rural land capability assessment system, S*ystems 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 soil and land capability impact assessment in **Appendix Q** of the Drayton South EA.

2.6 Hydrology

The Study Area lies within the Saddlers Creek catchment, which is part of the larger Hunter River catchment area (13,400 km^2). 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 (see **Figure 1.1**).

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).

2.6.1 Saddlers Creek

Saddlers Creek is a degraded, ephemeral creek approximately 11 km in length. The creek is subject to prolonged dry spells, and when it does flow, has poor water quality due to groundwater discharge. It is characterised by deeply eroded channels, small tributaries, a generally dry creek bed and some small discontinuous ponds that are able to retain water for extended periods of time. The headwaters are located within the existing Drayton Mine and pass through a small portion of the Mt Arthur Coal Mine lease before entering the Study Area (see **Figure 1.2**). Saddlers Creek traverses the Study Area in a north east to south west direction and eventually joins the Hunter River downstream on the adjacent Woodlands Horse Stud (Darley).

2.6.2 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, Miller et al. 2005; Fryirs, Spink et al. 2009) and disrupted flow regimes.

2.7 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. Refer to **Chapter 5** for detailed description of the landscape.

Chapter 3

Legislative Framework

The Project is seeking Project Approval under Part 3A of the EP&A Act to enable the operations as proposed.

The approval process will be considered against both Commonwealth and State environmental legislation to assess all impacts on threatened species, endangered communities and Matters of National Environmental Significance (MNES).

3.1 Commonwealth Legislation

The Commonwealth legislation relevant to this ecology impact assessment is listed below.

3.1.1 Environment 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 Sustainability, Environment, Water, Population and Communities (SEWPaC). 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 based on the Project constituting a controlled action under the EPBC Act due to likely impacts on the following MNES:

- Nationally threatened species and ecological communities; and
- Listed migratory species.

Following submission of the referral the Minister for SEWPaC declared the Project to be a controlled action under section 75 of the EPBC Act and confirmed that the Project will be assessed by accredited assessment under Part 3A of the EP&A Act.

As part of this process SEWPaC issued its requirements for the assessment of a controlled action (**Appendix A**) that are required to be integrated into this ecology impact assessment for the Project. This ecology impact assessment has therefore been prepared to fulfil the

SEWPaC requirements and a summary of the assessment of MNES is provided in **Appendix M** of this report.

3.2 State Legislation

The State legislation relevant to this ecology impact assessment are listed below.

3.2.1 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.

Part 3A of the EP&A Act has previously provided an approvals regime for all 'major projects'. Major projects are defined under Schedule 1 of *State Environmental Planning Policy (Major Development) 2005* (Major Development SEPP) and are identified by way of declaration as a listed project in the Major Development SEPP or by notice in the NSW Government Gazette.

In October 2011, Part 3A of the EP&A Act was repealed. However the Project has been granted the benefit of transitional provisions and as a result, is a development to which Part 3A applies.

Part 3A developments are expected to deliver the following environmental outcomes (Department of Infrastructure; Planning and Natural Resources 2005):

- Maintain or improve biodiversity values (i.e. there is no net impact on threatened species or native vegetation);
- Conserve biological diversity and promote ecologically sustainable development;
- Protect areas of high conservation value (including areas of critical habitat);
- Prevent the extinction of threatened species;
- Protect the long-term viability of local populations of a species, population or ecological community; and
- Protect aspects of the environment that are matters of national environmental significance.

i. Director-General's Environmental Assessment Requirements

All applications for Project Approval under Part 3A of the EP&A Act must be accompanied by an EA. The EA is to be prepared in accordance with the Director-General's Environmental Assessment Requirements (EARs). The EARs for the Project were issued on 3 August

2011. This ecology impact assessment, which forms a component of the EA, has been prepared in accordance with the EARs concerning biodiversity. **Table 3.1** below lists the EARs that are relevant to this assessment and the sections in this report where those EARs are addressed.

Table 3.1 Director-General's EARs and Locations Discussed in this Report

Key Issue	Requirements	Report Section
Biodiversity	An accurate estimate of any vegetation clearing associated with the Project	Table 7.1
	A detailed assessment of the potential impacts of the Project on any terrestrial and aquatic threatened species or populations and their habitats, endangered ecological communities or groundwater dependent ecosystems	Chapter 7
	A detailed description of the measures that would be implemented to avoid or mitigate impacts to biodiversity	Chapter 8
	An offset strategy to ensure that the Project maintains or improves the biodiversity values of the region in the medium to long term (in accordance with NSW and Commonwealth policies), paying particular attention to the existing Saddlers Creek Conservation Area and Mt Arthur Coal's biodiversity offset areas	Chapter 9 and Chapter 10

3.2.2 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 Act through threat abatement and species recovery programs. The TSC Act requires consideration of whether a development (Part 4) or an activity (Part 5) 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. However, there is no statutory requirement for an assessment of significance for this Project as the Project will be assessed under Part 3A of the EP&A Act.

3.2.3 State Environmental Planning Policy 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 this SEPP, 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 3.2**) 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 3.2 Koala Feed Trees (Schedule 2, SEPP 44)

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

i. NSW Recovery Plan for the Koala

In addition to the SEPP, a State-wide Koala Recovery Plan (DECC (NSW) 2008) 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, Callaghan 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.

3.2.4 Other Relevant Legislation

Further NSW legislation and planning policies that are relevant to the protection of biodiversity are listed below:

- *National Parks and Wildlife Act 1974*;
- *Water Management Act 2000*; and
- *Fisheries Management Act 1994*.

3.2.5 Biodiversity Offsetting Policy Documents

For the development of offsetting strategies for the Project, the following documents were considered:

- *Principles for the Use of Biodiversity Offsets in NSW* (OEH 2011a); and
- *Draft Policy Statement: Use of Environmental Offsets under the Environment Protection and Biodiversity Conservation Act 1999* (DEWR 2007).

Since the initial preparation of this ecology impact assessment, a new offsetting policy document was released by SEWPaC on the 1 October 2012 (SEWPaC 2012). This policy document supersedes the draft policy statement issued in 2007 by the former Department of the Environment and Water Resources (DEWR 2007).

Chapter 4

Methodology

The environment within the Study Area was systematically surveyed in 2000 (Ecotone, 2000; The Ecology Lab Pty Ltd, 2000); and then in 2009 and 2011 (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 ecology impact assessment.

4.1 Desktop Review

4.1.1 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 Local Government Area. 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. 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 (Dames and Moore 2000; Umwelt (Australia) Pty Limited 2006a, 2006b, 2007; Cumberland Ecology 2009). There has also been regional mapping of the vegetation of the central Hunter Valley by Peake (2006). These studies have been reviewed and relevant information from them used in the preparation of this ecological assessment.

ii. Study Area

Field surveys of various parts of the Study Area were completed in 2000, 2009 and 2011. The results are provided in this ecology impact assessment (**Chapter 5** and **Chapter 6**). 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, 2009a.

4.1.2 Database Analysis

Other existing information on the biodiversity values of the Study Area and its surrounds were obtained through the interrogation of the OEH Atlas of NSW Wildlife database (OEH 2011) and SEWPaC EPBC Act Protected Matters Search Tool (PMST) (SEWPaC 2011b). The number and age of records of threatened species recorded within the Muswellbrook LGA was used to assess the likelihood of threatened species. The 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.

4.1.3 Review of Regional Vegetation Mapping

Regional-scale vegetation mapping of the central Hunter Valley was completed between 1996 and 2006 on behalf of the Hunter-Central Rivers Catchment Management Authority (CMA) (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 CMA 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 quadrat data. As a result, mapping included in this ecology impact assessment differs from CMA mapping; it provides a more fine-scale breakdown of vegetation communities and also shows the extent of regeneration that has occurred since the CMA report was published. Further details are provided in **Section 4.3.1**.

4.2 Field Survey

Cumberland Ecology has conducted several field surveys of the Study Area that collectively complied with standards provided in the former NSW Department of Environment and Conservation (DEC) 'Threatened Biodiversity Survey and Assessment Guidelines for Development and Activities' (DEC (NSW) 2004c) and the former Department of Environment and Climate Change (DECC) 'Threatened Species Assessment Guidelines' (DEC (NSW) 2005d). 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. The field sessions were completed in two main stages; early surveys completed in 2009-10 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 4.6** for further details). The survey focused on habitat assessments; in-situ water quality measurements and macro-invertebrate 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 4.1**:

Table 4.1 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 4.1 Summary of Dates for Field Surveys Completed

Dates of Survey	Tasks Completed	Completed By
	-Hairtube surveys; -Anabat surveys; -Harp trapping and tripline bat survey; -Bird census.	
30 September 2009	-Observations and notes on land use, vegetation types and condition; -Threatened flora species searches; and -General habitat assessment.	Cumberland Ecology
30 September – 2 October 2009	-Broad-scale vegetation ground-truthing; -General habitat assessment; and -Targeted searches of potentially suitable flora and fauna habitat for a number of threatened species recorded in neighbouring mine leases.	Cumberland Ecology
26 – 28 October 2009	-Targeted vegetation surveys; -Bird census; -Spotlighting; and -Additional threatened flora species searches.	Cumberland Ecology
2 -3 November 2009	-Targeted vegetation surveys; -Bird census; -Spotlighting; and -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 quadrats; -Threatened flora survey (with focus on *Acacia pendula*); and -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; -Macro-invertebrate sampling; and -Riparian habitat assessment.	Cumberland Ecology
20 – 24 June, 2011 (autumn/winter session)	-Systematic bird census, including winter migratory species; -Habitat assessment including tree hollows; -Mammal trapping;	Cumberland Ecology

Table 4.1 Summary of Dates for Field Surveys Completed

Dates of Survey	Tasks Completed	Completed By
9-10 August, 2011	-Diurnal and spotlighting surveys; and -Vegetation quadrats. -Vegetation mapping and quadrats.	Cumberland Ecology
23 September, 2011 (spring session)	-Targeted threatened flora survey (with focus on threatened orchids and *Acacia pendula*); and -Vegetation quadrats.	Cumberland Ecology

A summary of weather conditions in the locality (using Jerrys Plains forecasts (Bureau of Meteorology (BOM) 2011)) of the Study Area during recent surveys is provided in **Table 4.2**. Weather conditions varied from cool to hot with the daily maximum temperature varying from 21.3°C to 33.5°C. 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 4.2 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	
	2/11/2009	12.6	36.7	0	
	3/11/2009	16	39	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	
	17/03/2011	17	25.3	4.8	
	18/03/2011	18.7	25.8	18.4	Highest rainfall for March
	19/03/2011	17.1	27.5	0.2	
Aquatic	2/05/2011	7.2	20.1	0	
	3/05/2011	8.5	22.5	0	
Winter	20/06/2011	9.3	18.3	0	
	21/06/2011	-	20	0	

Table 4.2 Field Survey Weather Conditions (Jerrys Plains Forecasts)

Survey Session	Date	Min (˚C)	Max (˚C)	Rain (mm)	Notes
	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	

Source: Bureau of Meterology (2011)

4.3 Flora Surveys

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:

- Quadrat sampling (20 m x 50 m) to obtain information on floristic composition and community structure. A 1000 m^2 sampling quadrat was chosen to enable identification and assessment of Box-Gum Woodland (see **Section 4.3.1**);
- Random meander surveys to detect additional flora species not recorded within the quadrats; and
- 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.

4.3.1 Vegetation Mapping

A vegetation map prepared by Peake (2006) for the central Hunter Valley region was initially used to guide vegetation surveys in the field and delineate various communities. 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 20 m x 50 m quadrats to obtain site-specific information on floristics and community structure.

The resultant information was synthesised using Geographical Information Systems (GIS) to create a spatial database that was used to interpret and interpolate the data to produce a

vegetation map of the Study Area. Aerial, topographical and geological data were also used to interpret the survey data. Aerial data was obtained from 3-band Geo-Eye1 satellite imagery (Geoimage Pty Ltd 2010). GIS mapping was completed using MapInfo Version 10.5 (Pitney Bowes Software Inc. 2010) on a Windows XP platform.

The literature review of vegetation in the locality (Cumberland Ecology 2009) (MTP PER) and vegetation mapping by Peake (2006) indicated high potential for the occurrence of the EPBC Act- and TSC Act-listed *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland* (hereafter referred to as "Box-Gum Woodland") in the Study Area. Box-Gum Woodland occurs as a woodland community and also as a grassland community. Strict guidelines for the identification of Box-Gum Woodland are available and as such, specific surveying criteria were used to identify the community (see **Section 4.3.1ii**).

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 quadrat 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 Critically Endangered Ecological Community (CEEC) listed under the EPBC Act. This community is also listed as an Ecologically Endangered Community (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).

A flow chart that summarises the method for identifying Box-Gum Woodland is reproduced in **Appendix B**. According to this methodology, to confirm the presence of the CEEC as listed under the EPBC Act, the presence or historical presence of *Eucalyptus albens* (White Box), *Eucalyptus melliodora* (Yellow Box) or *Eucalyptus blakelyi* (Blakely's Red Gum) must first be confirmed within the area of interest. If one or more of these trees are present, irrespective of soil type, slope or aspect, or *was historically present as dominants*, a quadrat should be completed within a plot of 1,000 m^2 (0.1 ha). If the survey plot does not contain any canopy trees but does contain 12 native herb species (excluding native grasses), and if at least one is an "important" native plant as signified in the list of Box-Gum Woodland characteristic species, then the community is deemed to be present. This method was repeated across the Study Area.

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 *E. moluccana* (White Box-Grey Box intergrades) should be included in the definition of this community (provided in **Appendix B**). Thus, this ecology impact assessment includes areas containing *Eucalyptus albens* x *E. moluccana* (White Box-Grey Box intergrades) or native grasslands that are derived from communities containing *Eucalyptus albens* x *E. 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 2004u). 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, Eucalytpus 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."

The Final Determination for Box-Gum Woodland has been included within **Appendix C** for reference.

4.3.2 Floristic Census

The flora assemblage within the Study Area was recorded by quadrat sampling, random meander surveys and through targeted searches for threatened species. The flora species recorded in the Study Area are shown in **Appendix D**. 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 (2011). Any specimens that were not readily identifiable were lodged for identification with the National Herbarium of NSW at the Royal Botanic Gardens, Sydney.

4.3.3 Quadrat Sampling

A total of 35 quadrats were sampled over the course of the survey periods. As grassland areas were extensive and not easily covered in the time available, seven rapid assessment quadrats were also sampled in grassland to efficiently determine the condition and nature of these areas. Locations were chosen to reflect the condition and composition of the vegetation patch. Quadrat locations are shown in **Figure 4.1** and the quadrat dataset is provided in **Appendix E**.

In each quadrat, 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 quadrat, using a handheld GPS; and
- Photographs of the quadrat.

The relative abundance and cover of each species within the quadrat was approximated using a scoring system based on the Braun-Blanquet scoring system (Braun-Blanquet 1927). The scores used are provided in **Table 4.3** below.

Table 4.3 Braun-Blanquet Scoring System

Class	Cover-abundance	Notes
R	Rare (less than 0.1% cover)	Herbs, sedges and grasses: within 1 m^2 Shrubs and small trees: 1 individual
+	Few Individuals (less than 1% cover)	Herbs, sedges and grasses: within 10 m^2 Shrubs and small trees: <5 individuals Medium - large overhanging tree
1	Many Individuals (less than 5% cover)	Herbs, sedges and grasses: within 50 m^2 Shrubs and small trees: 5 or more individuals One medium - large tree
2	5 - less than 25% cover	-
3	25 - less than 50% cover	-
4	50 - less than 75% cover	-
5	75 - 100% cover	-
X	Incidental (adjacent but not within plot)	
(*)	Exotic species; not native to Study Area	

In rapid assessment quadrats, the following information was recorded:

- Whether the quadrat 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%.

4.3.4 Threatened Species Targeted Surveys

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.

4.3.5 Identification of Ground Water Dependent Ecosystems (GDEs)

Groundwater refers to water which has filtered down from the surface and occupies spaces within the underlying earth and geology in a saturated state (DLWC (NSW) 2002). To exclude transient and perched systems, it is further defined as groundwater that would not be available to flora and fauna should it be extracted by pumping (Hatton and Evans 1998).

Groundwater dependent ecosystems (GDEs) are defined as vulnerable ecosystems in which species composition and natural ecological processes are highly determined by groundwater (Commonwealth of Australia 1996). 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.

Vegetation-type GDEs found in NSW include:

- Terrestrial vegetation;
- River Base Flow Systems;
- Aquifer and Cave Ecosystems; and
- Wetlands.

Of these GDEs, the ecosystem with the most relevance to the Study Area is 'terrestrial vegetation' where forest and woodland may be sustained, either permanently or periodically, by shallow but high quality 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).

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. 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) and *Casuarina cunninghamiana* (River Oak). This is because floodplain and creekline communities dominated by such canopy species as *Eucalyptus camaldulensis* (River Red Gum) or *Casuarina cunninghamiana* (River Oak) are likely to have some root access to deep watertables and thus comprise a GDE.

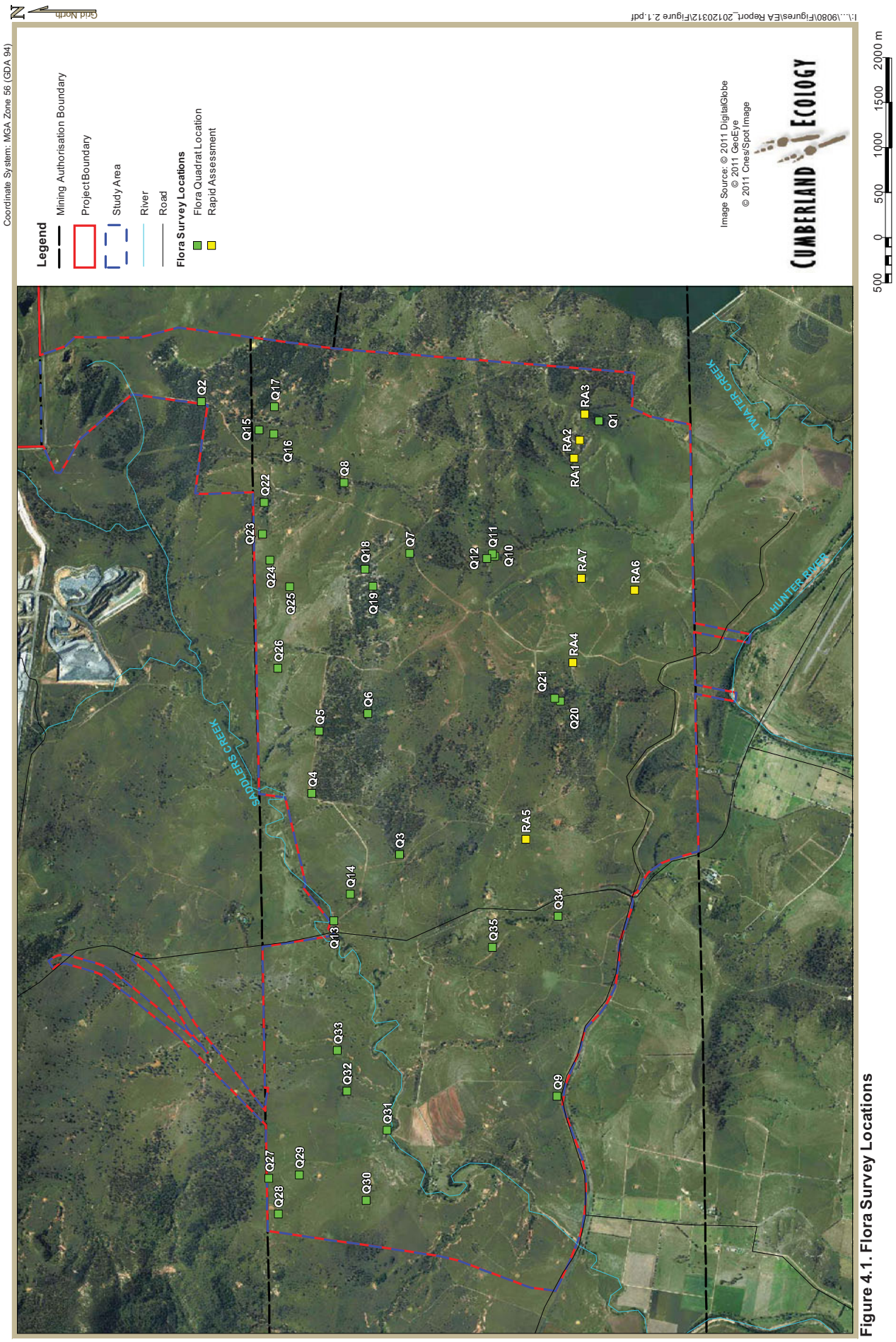


Figure 4.1. Flora Survey Locations

4.4 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.

4.4.1 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 on site 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.

4.5 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 ecology impact assessment. 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 4.4**.

Fauna surveys completed for this ecology impact 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 ecology impact assessment are described in the following sections. Fauna survey locations established for this ecology impact assessment are shown in **Figure 4.2**. A list of all the fauna species recorded in the Study Area is provided in **Appendix F**.

4.5.1 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 (**Figure 4.2**). A summary of the trapping effort is provided in **Table 4.5** at the end of **Section 4.5.1**. 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 ecology impact 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.

Table 4.4 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 Hairtubes	214	168	-	382 trap nights
Terrestrial Hairtubes	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	Opportunistically	-	>6 person hours
General Diurnal Bird Census	4	Time periods not specified	-	> 4 person hours
Systematic Diurnal Bird Census	18.6	-	-	16.6 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

ii. 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 ecology impact assessment.

iii. 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 ecology impact assessment.

iv. Hair Tubes

'Faunatech' plastic hairtubes designed to collect mammal hair were used to supplement arboreal and terrestrial traps. The plastic hairtubes were paired with Elliot traps along traplines near habitat features such as hollows, ground debris or shrubs. Each hairtube was lined with sticky wafers and baited with the rolled oats mixture. Arboreal hairtubes 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 ecology impact assessment.

Table 4.5 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 Hairtubes	4	3	5	4	10	10	10	9	214
Terrestrial Hairtubes	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

4.5.2 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.

4.5.3 Bird Surveys

Over the course of all survey sessions, incidental visual observations and calls of birds were identified and recorded in the final species list (**Appendix F**).

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 2011) (**Figure 4.2**). 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.

4.5.4 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.

4.5.5 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.

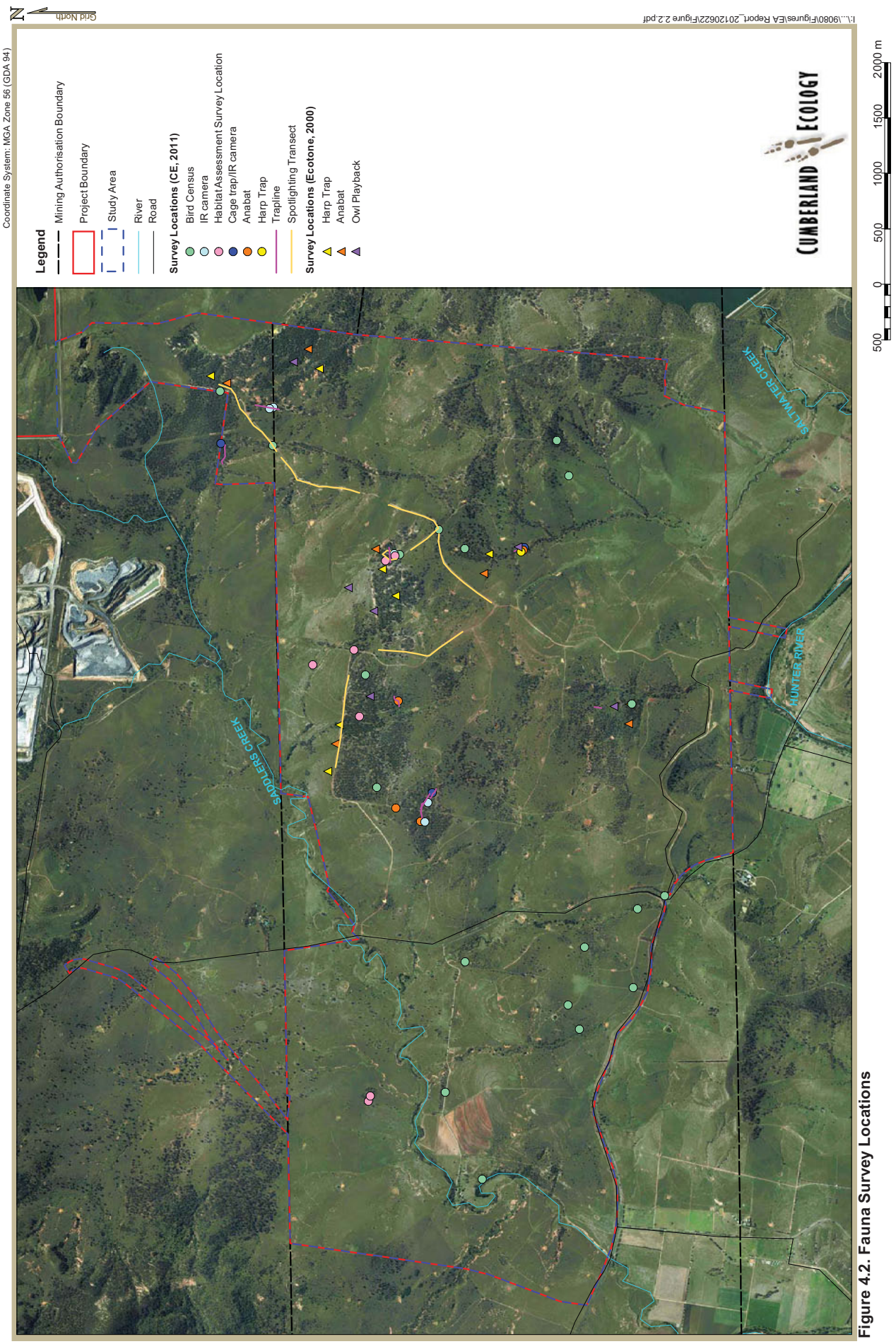


Figure 4.2. Fauna Survey Locations

4.5.6 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.

4.6 Aquatic Surveys

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 ecology impact assessment (see **Chapter 6**).

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 4.3**).

The aquatic survey was undertaken in accordance with the AUSRIVAS sampling procedures and involved undertaking habitat assessments, in-situ water quality measurements and macro-invertebrate 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.

4.6.1 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 (µS/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 (˚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 macro-invertebrate 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.

4.6.2 Macro-invertebrate Sampling

Aquatic macro-invertebrates 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, Resh et al. 2008; Utz, Hilderbrand 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. Macro-invertebrate analysis involved identification to family level. Some taxa were sorted to phylum, sub-family and class as recommended by the AUSRIVAS guide. All macro-invertebrates were identified using taxonomic keys and aquatic invertebrate guides (Hawking J H 1994; Hawking and Smith 1997; Chessman 2003).

4.6.3 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 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 (Rutherfurd, Jerie 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.

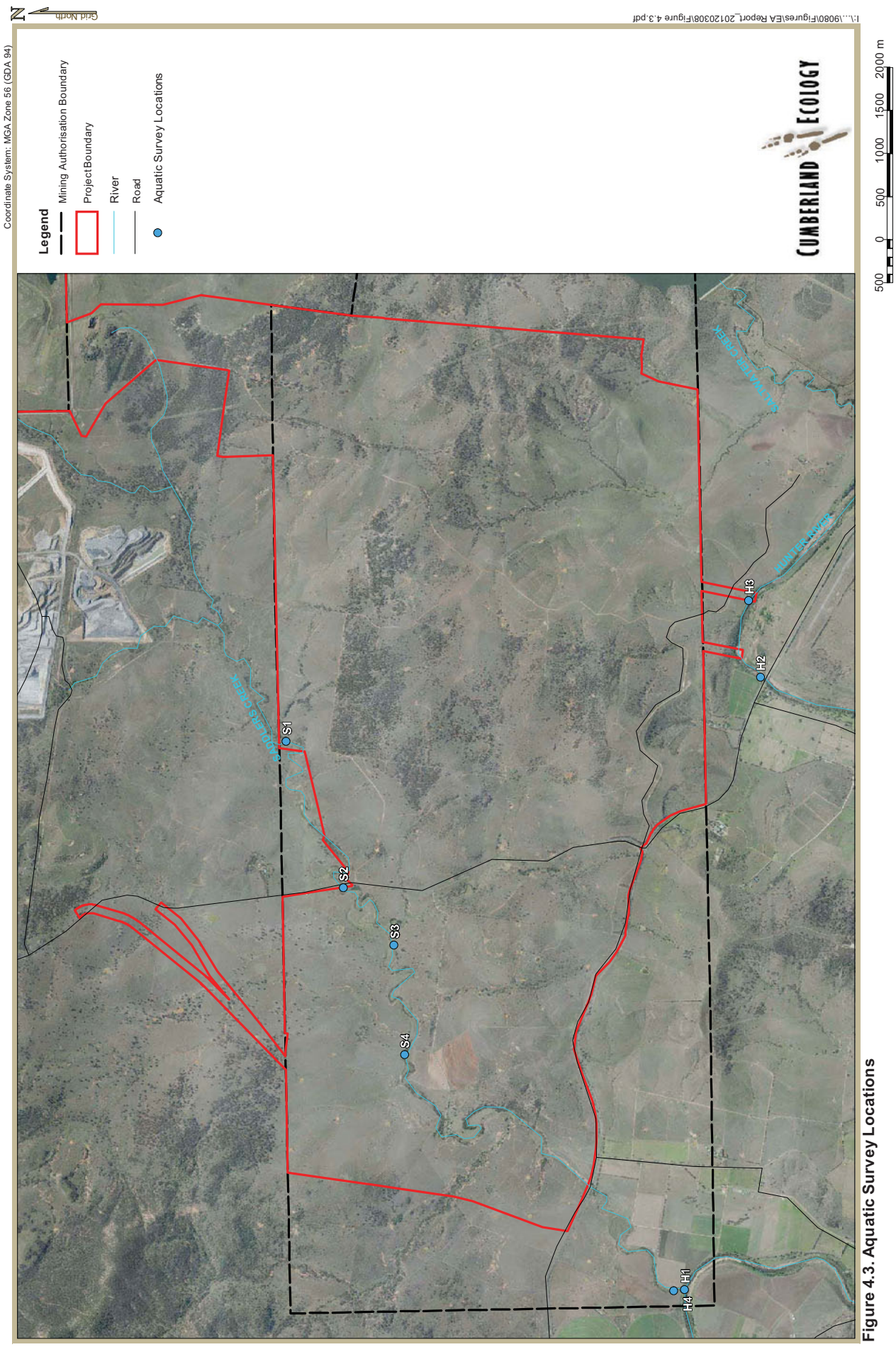


Figure 4.3. Aquatic Survey Locations

4.7 Potential Offset Site Surveys

The nature, magnitude and location of most open cut coal mining projects mean that in the majority of cases broad areas of forest, woodland, open grassland and threatened species habitat will be cleared. In this regard it was apparent during the early design and assessment phases that the Project would be required to develop an ecological offsets strategy to compensate for the residual ecological impacts of the Project, particularly those to threatened vegetation communities.

4.7.1 Onsite Surveys

Surveys of potential onsite offset areas were completed during field studies of the Study Area and included vegetation mapping, general habitat assessments and targeted surveys as part of the survey program for the Study Area. Potential areas that were investigated included onsite sections of Saddlers Creek and vegetation along the primary ridgeline in the Study Area. An assessment of suitable vegetation rehabilitation measures and predicted success of such works was undertaken by Anglo American.

4.7.2 Preliminary Offsite Field Studies

A high level desktop analysis of suitable areas in which to prioritise searches for candidate offsite offset properties was completed for the Project. This analysis was guided by consideration of the Bioregional context of the Project and any potential offset areas, as Bioregions broadly influence flora and fauna assemblages and vegetation complexes. Other important considerations included the following:

- The known occurrence or likely occurrence of Box-Gum Woodland;
- The likely availability of outstanding habitat features for native flora and fauna (including rock outcrops and waterways);
- The enhancement of existing conservation areas (including National Parks and Nature Reserves); and
- Linkages to other offsets.

Preliminary inspections and assessment of a number of properties throughout the Hunter Valley were conducted with due consideration to the above desktop analysis, to ascertain the offset potential of the land for the Project. Notes were made regarding the following: threatened species and their habitat; key habitat features (rock outcrops, streams, etc); major weed infestations; current and historical land use; dominant vegetation types and broad patterns of occurrence; and other relevant attributes or management issues. This work was supplemented with a desktop review of available information of threatened species occurrences in the vicinity of each property.

4.7.3 Detailed Offsite Offset Surveys

Following preliminary inspections of potential candidate offset properties, one property was selected for further field investigation. The investigation involved both a desktop analysis and field surveys to assess the ecological values of the property and its suitability in offsetting the impacts of the Project. The results of survey on this property are presented and discussed in more detail in **Chapter 10**.

Vegetation mapping and baseline flora and fauna surveys were conducted over three sessions in summer; 30 to 31 January; 15 to 17 February and 27 February to 1 March, 2012. The weather observations for these survey periods are listed in **Table 4.6** below.

Table 4.6 Weather Observations for Offsite Offset Surveys

Date	Min (˚C)	Max (˚C)	Rain (mm)	Notes
30/01/2012	20	28.5	1.4	
31/01/2012	21.1	25.2	2.8	
1/02/2012	16.2	19	30.8	
15/02/2012	12.1	26.3	0	
16/02/2012	9.6	26.9	0	
17/02/2012	9.7	29	0	
27/02/2012	17	27.6	0.8	
28/02/2012	17.4	29.4	0	
29/02/2012	15	30.9	0	Highest temperature for the month
1/03/2012	18.4	30	0	Highest temperature for the month
2/03/2012	16.8	18.7	37.8	

**Most observations from Murrurundi, but some from Murrurundi Gap. (Bureau of Meterology (BOM) 2012b)*

The survey methods employed and the total survey effort is summarised in **Table 4.7** below. In addition to general searches and baseline trapping, fauna survey targeted bird and bat species, which were identified during surveys of the Study Area to be highly relevant to the Project (see **Chapter 6**). The locations of survey are shown in **Figure 4.4**; data is presented in **Appendix L**.

Table 4.7 Survey Effort – Offsite Offset Property

Survey Method	Effort
Flora	
Meander transect searches	Throughout survey period
Flora sampling	22 plots
General Fauna	
Diurnal Reptile search	2 person hours
Spotlighting and call playback	3 person hours
IR camera traps	6 trap nights
Arboreal trapping	
Elliott B	108 trap nights
Hairtubes	8077 trap nights
Terrestrial trapping	
Elliott A	77 trap nights
Hairtubes	-
Bats	
Anabat	10 trap nights
Harp traps	4 trap nights
Birds	
Diurnal Bird Area Census	15 hours
Spotlighting	3 person hours
Habitat	
Systematic Habitat Assessment	26 plots
Hollow counts	26 plots
Meander transect searches	Throughout survey period

i. Flora Surveys

Vegetation mapping and floristic sampling of the offsite offset property was conducted using consistent methodology to that described in **Section 4.3** above.

Vegetation mapping was developed with due reference to the existing regional mapping supplied by the Namoi Catchment Management Authority. Vegetation community nomenclature also follows that of the Namoi Catchment Management Authority.

Twenty-two floristic quadrats were sampled across representative remnant vegetation patches.

ii. Fauna Surveys

Trap line establishment, active searches and systematic habitat assessments including hollow counts were conducted using consistent methodology to that described in **Section 4.4** above, unless where indicated below.

a. Traplines

Trapping was used to detect arboreal and terrestrial fauna that may occur on the property.

The following traps were utilised for traplines across the site:

- Medium Elliott (B) traps for small to medium sized arboreal fauna;
- Small Elliott (A) traps for small terrestrial fauna; and
- Hairtubes for arboreal mammals.

Four Elliott traplines were established in forest and woodland habitat using the previously described methodology. Traplines consisted of 10 paired arboreal/terrestrial Elliott B/A traps attached to large trees, located preferentially near hollows or midstorey vegetation. Elliott traps were closed and left on site for a period of time between the first and second sessions due to unfavourable weather conditions. The offsite offset survey involved a total of 108 Elliott trap nights.

Six arboreal hairtube traplines were established in forest and woodland habitat across the site in the third session, using the methodology described in **Section 4.5.1iv**. A total of 84 hairtubes were used, in traplines of 10 to 15 hairtubes. The offsite offset survey, involves a total of 8077 trap nights.

b. Bird Survey

A bird census was conducted by an ornithologist over 30 to 31 January, 2012 to survey for resident bird species. Survey methodology involved area searches, totalling 15 hours, at various sites in the southern central portion of the property (the north and east could not be accessed due to adverse weather conditions). Spotlighting was conducted over three person hours for nocturnal birds. Incidental records were made and systematic habitat assessments were completed throughout the survey period to provide supporting information.

c. Bat Survey

Microbats were surveyed in summer using Anabat Z-CAIM units and harp traps. Two units were used during each of the 3 survey sessions and left in different locations considered to provide suitable bat forage or roosting habitat. Two harp traps were established at creeklines and potential flyways. The offsite offset survey involved a total of 4 harp trap nights and 12 Anabat trap nights.

d. Active Searches

Active searches for reptiles, using the methodology described in **Section 4.5.4**, were conducted at two open woodland sites in which there was abundant ground debris, stags and trees with decorticating bark. Adverse weather conditions limited the hours limited opportunities for extensive searches; incidental records were made and systematic habitat assessments were completed throughout the survey period to provide supporting information.The offsite offset survey involved a total of 2 person hours for active reptile searches.

e. Spotlighting and Call Playback

Spotlighting and call playback was conducted over three person hours in a manner consistent with the methodology described in **Section 4.5.5**. Adverse weather conditions limited the hours limited opportunities for extensive survey; systematic habitat assessments were completed throughout the survey period to provide supporting information.

f. IR Camera Traps

Three IR camera traps were deployed throughout the offsite offset property for a total of six trap nights during the third session.

g. Habitat Assessment and Hollow Counts

General habitat assessments were conducted at 26 sites across the property to record the type and condition of fauna habitat features present. This included vegetation connectivity, vegetation structure and microhabitats (litter, bush rock, ground debris, watercourses, forage resources etc).

The number and size class of hollows, as well as the count and type of hollow-bearing tree, were also recorded within a 20 x 50 sample area to quantify the hollow resource on the site.

4.7.4 Biodiversity Offset Package

A Biodiversity Offset Package (BOP) for the Project has been developed that aims to address the predicted residual ecological impacts of the Project. The BOP comprises a mixture of onsite offset measures as well as offsite offsets and is discussed in greater detail in **Chapter 8** of this report.

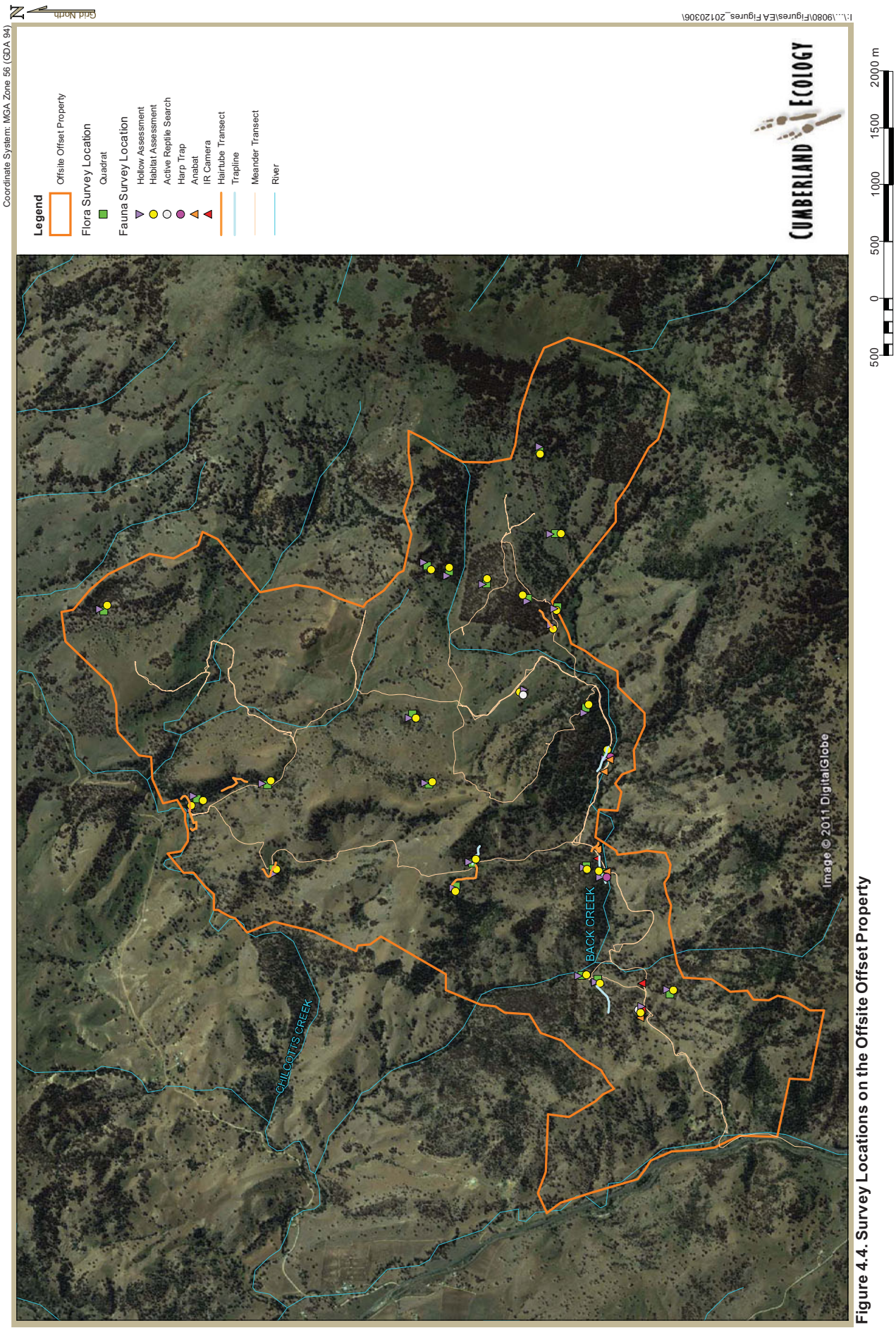


Figure 4.4. Survey Locations on the Offsite Offset Property

4.8 Survey Limitations

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 5

Flora Results

This chapter presents the results of the field investigations completed for the Project. It also discusses the results with respect to findings from surveys conducted in the locality to provide a comprehensive overview of the relevant flora and fauna biodiversity.

5.1 General 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. 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 grasslands 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 observed during this ecology impact assessment. 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 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 Study Area continues to support a suite of native flora and fauna species despite these land practices and 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 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 leuhmannii* (Bulloak) and *Acacia salicina* (Cooba) dominate the shrub and small tree stratum.

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.

5.2 Vegetation Communities

The major vegetation communities that occur within the Study Area and their distribution are listed in **Table 5.1** and shown in **Figure 5.1**. The extent of occurrence of each community has been mapped using a combination of both CMA regional mapping information and results from ground-truthing by Cumberland Ecology.

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. 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 Central Hunter Box-Ironbark Woodland.

Many of the woodland communities in the Study Area conform to communities that are listed as TECs under the TSC Act and/or the EPBC Act. Some of these vegetation communities conform to the EPBC Act and TSC Act listed Box-Gum Woodland; the distribution of this community is shown in **Figure M.5** within **Appendix M**.

Vegetation units described for the minor additional mining areas at Drayton Mine 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 (**Table 5.2**, **Figure 5.2**). The small areas of woody vegetation comprise planted trees and shrubs and very young regeneration.

A description of each of the vegetation communities that have been mapped are provided below. General structural and floristic details and community extent are based on existing community information as mapped by Peake (2006) unless otherwise referenced, and are supplemented with results of quadrat surveys and assessments undertaken within each community.

Table 5.1 Vegetation Communities within the Study Area

Vegetation Community*	Status		Conservation Listing	Area of Vegetation (ha)
	TSC Act	EPBC Act		
Central Hunter Bulloak Forest Regeneration	-	-	Not listed	26
Hunter Valley River Oak Forest	-	-	Not listed	2
Central Hunter Box-Ironbark Woodland	EEC	-	Conforms to Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions.	479
Hunter Floodplain Red Gum Woodland	EEC	CEEC	Conforms to the EPBC listing of White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Box-Gum Woodland). Conforms to TSC listing of Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions.	40
Narrabeen Footslopes Slaty Box Woodland	VEC	-	Conforms to Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion.	100
Upper Hunter White Box-Ironbark Grassy Woodland	EEC	CEEC	Conforms to White Box Yellow Box Blakely's Red Gum Woodland. This community is dominated by White Box - Grey Box intergrades.	94
Cooba Scrub	-	-	Not listed	65
Planted Vegetation	-	-	Not listed	9

Table 5.1 Vegetation Communities within the Study Area

Vegetation Community*	Status		Conservation Listing	Area of Vegetation (ha)
	TSC Act	**EPBC Act**		
Derived Native Grassland - Hunter Floodplain Red Gum Woodland	EEC	CEEC	Conforms to Box-Gum Woodland	10
Derived Native Grassland - Upper Hunter White Box-Ironbark Grassy Woodland	EEC	CEEC	Conforms to Box-Gum Woodland	159
Other Grassland	-	-	Not listed	3613
TOTAL				**4597**

**nomenclature based on Peake (2006)*

Table 5.2 Vegetation Communities 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**

5.2.1 Native Grasslands

Derived grassland (also known as secondary grassland or understorey) is an expression of an ecological community that develops when the tree canopy cover of the grassy woodland is removed or suffers dieback, and natural regeneration is prevented.

Much of the grassland in the Study Area has historically been derived from the clearing of forest and woodland to create pasture for livestock. The original native understorey within the Study Area would have been dominated by palatable grasses like *Themeda australis* (Kangaroo Grass) and various species of *Austrodanthonia* (Wallaby Grass) and a high frequency of herbaceous plants. Most areas of native derived grassland are now dominated by less palatable grasses like *Aristida* spp. (Three-awn Grass) and *Austrostipa* spp. (Spear Grass), with very minor proportions of *Themeda australis* (Kangaroo Grass) and *Austrodanthonia* spp. (Wallaby Grass) and a lower frequency of herbs present.

Two broad grassland types were distinguished in the Study Area based on groundcover floristic diversity and the tree canopy layer. These have been defined as Derived Native Grassland TEC and “other grassland”. The second grassland type, “other grassland”, was also recorded in the minor additional mining areas at Drayton Mine but no Derived Native Grassland TEC was recorded. These grassland types are described further below.

i. Derived Native Grassland - TEC

Status: This derived grassland unit is considered to conform to the TSC Act and EPBC Act listing for Box-Gum Woodland, which includes derived native grasslands derived from the clearing of Box-Gum Woodland.

Within the Study Area, approximately 169 ha of native grassland are derived from either *Upper Hunter White Box-Ironbark Grassy Woodland* or *Hunter Floodplain Red Gum Woodland*, both of which occur in the Study Area and conform to the TSC Act and EPBC Act listing for Box-Gum Woodland. These areas contain an assemblage of understorey species that characterise Box-Gum Woodland and have been derived from the clearing of canopy trees of these communities, typically *Eucalyptus melliodora* (Yellow Box) and *Eucalyptus albens* x *Eucalyptus moluccana* (White Box-Grey Box intergrades) (**Photograph 5.1**).

To be considered as conforming to Box-Gum Woodland, these grasslands support over 12 native non-grass species and at least one grazing-sensitive species within a 0.1 ha area. Examples of grazing-sensitive species include *Calotis lappulacea* (Yellow Burr-daisy) or *Cheilanthes sieberi* (Poison Rock Fern) and various lilies, daisies, pea plants and orchids. The dominant groundcover in this derived grassland unit is typically a native grass species. Derived Native Grassland is typically grassland of moderate to good condition that has a capacity for natural woodland regeneration if livestock grazing and other land disturbances were removed. Varying degrees of woodland regeneration are evident across the Study Area; and recruitment of native groundcover species, particularly in areas subject to light grazing, suggests that there is still a viable soil seed bank present.



Photograph 5.1 **Derived Native Grassland (Box-Gum Woodland) Dominated by Native Perennial Grasses in the Study Area**

Note: White Box-Grey Box intergrades (midground) and native perennial grasses (foreground).

ii. Other Grassland

Status: Not listed

The remaining grassland in the Study Area ranges from low to high condition grasslands containing varying species richness and exotic cover. Approximately 3613 ha of non-listed grassland occur in the Study Area.

Moderate to high quality non-listed grassland has been mapped across much of the Study Area to the east of Edderton Road. These areas have previously been derived from the clearance of other native woodland communities (i.e. not Box-Gum Woodland) and grazed but are currently in moderate to good condition. This is most likely due to favourable conditions in recent seasons as well as the relatively low intensity of grazing in these areas. The community typically contains high understorey diversity with at least 12 non-grass native herbs present, including grazing-sensitive species and few invasive species. Moderate to high quality non-listed native grasslands are considered to be reasonably resilient. Varying degrees of woodland regeneration are evident across the Study Area and recruitment of native groundcover species suggests that there is still a viable soil seed bank present. If left to regenerate naturally, these grasslands have a good potential to return to woodland.

Low diversity grassland, which has been subject to prolonged grazing and/or periodic cropping, often supports an altered species assemblage with typically less than 12 non-grass groundcovers. These areas are still dominated by native grasses but also contain a relatively high percentage cover of exotic species, including broad-leaved plants such as *Plantago lanceolata* (Lamb's Tongue) and *Gnaphalium* spp. (Cudweeds). Low diversity grassland has been identified across the open areas of the Study Area to the west of Edderton Road, where a higher proportion of invasive groundcovers and pasture-improved crops such as Rye Grass are evident. Low diversity grassland also typically occurs along the downstream stretches of Saddlers Creek (where heavy erosion and cropping is present) and in parts of the Study Area where the land has been heavily contoured and the soil profiles disturbed. Low diversity grassland is typically of poorer condition and would not naturally regenerate to woodland without active assistance.

In the minor additional mining areas at Drayton Mine, low diversity grassland dominated typically by *Aristida ramosa* (Threeawn Wiregrass), *Austrostipa verticillata* (Slender Bamboo Grass) and *Chloris ventricosa* (Windmill Grass) contain a much higher proportion of exotic species than low diversity grassland occurring in the Study Area. This is because these grassland areas adjoin existing disturbances such as the erection pad and associated clearings and have been actively sown with exotic species for soil stabilisation purposes. Some exotic species recorded in the low diversity grassland occurring in the minor additional mining areas include *Galenia pubescens* (Galenia), *Melinus repens* (Red Natal Grass), *Pennisetum clandestinum* (Kikuyu), *Vicia* sp. (Vetch), *Cynodon dactylon* (Couch), *Bromus* spp., *Avena* spp. (Oats), *Medicago sativa* (Lucerne), *Sorghum* spp. *(*Sorghum), *Chloris gayana* (Rhodes Grass), *Phalaris* sp. (Canary Grass), *Trifolium repens* (Clover), *Anagallis arvensis* (Scarlet Pimpernel), *Senecio madagascariensis* (Fireweed), *Carthamus lanatus* (Saffon Thistle), *Taraxacum officinale* (Dandelion), Plantago *lanceolata* (Lamb's Tongues), *Sida rhombifolia* (Paddy's Lucerne) and *Opuntia* sp. (Prickly Pear).

5.2.2 Exotic Grasslands

Exotic grassland areas were recorded only in the minor additional mining areas at Drayton Mine. In the past, these areas were rehabilitated to pasture following clearing associated with mining. The rehabilitation areas were generally sown with a seed mix of the following species (from Hansen Bailey 2007):

- *Pennisetum clandestinum* (Kikuyu);
- *Medicago* spp, including Medicago sativa (Lucerne);
- *Cynodon dactylon* (Couch Grass);
- *Phalaris* spp. (Phalaris);
- *Trifolium repens* (White Clover);
- *Vicia* spp. (Vetch);
- *Bromus* spp. (Bromegrass);
- *Sorghum* spp. (Sorghum); and
- *Avena* spp. (Oats).

Other common exotic pasture species recorded in exotic grassland during surveys include *Chloris gayana* (Rhodes Grass), *Melinis repens* (Red Natal Grass), *Senecio madagascariensis* (Fireweed), *Carthamus lanatus* (Saffon Thistle), *Taraxacum officinale* (Dandelion), Plantago *lanceolata* (Lamb's Tongues), *Sida rhombifolia* (Paddy's Lucerne), *Mimosa pudica* (Common Sensitive Plant) and *Galenia pubescens* (Galenia). These latter species are likely to have colonised the rehabilitation from adjacent areas by sedimentation, earthworks and seeding for soil erosion control. A small portion of a drainage line within one of the additional mining areas is also dominated by the exotic rush species, *Juncus acutus* (Sharp Rush).

5.2.3 Woodland Communities

The Hunter region is recognised to be an over-cleared landscape; as a result many of the vegetation communities in the Hunter Valley have been listed as TECs. Due to this, many of the woodland communities in the Study Area conform to communities that are listed as TECs under the TSC Act and/or the EPBC Act.

The woodland communities of the Study Area are present in varying stages of regeneration and include relatively young regrowth or mature woodland. The regrowth areas are structurally and floristically simple at present but are likely to recover over the long term if regeneration is allowed to progress. The understorey composition of much of the older woodland patches is reasonably diverse, particularly on the steep slopes of deeply incised dry creeklines, but do show signs of degradation in places such as hilltops where cattle commonly graze and shelter. Significant erosion is evident in the riparian woodland along

Saddlers Creek and its tributaries, particularly along cattle tracks which have exposed the root zones of many trees.

The woodland communities recorded from the Study Area are described below.

i. Upper Hunter White Box-Ironbark Grassy Woodland

Status: EEC (TSC Act) and CEEC (EPBC Act). This community conforms to Box-Gum Woodland.

Upper Hunter White Box-Ironbark Grassy Woodland typically occurs as a mid-high woodland on clay soils derived from Permian, Carboniferous or Quaternary geology on undulating slopes and hills that surround floodplains along the Hunter River. It is concentrated in the north of the Hunter region where rainfall is relatively low. The open canopy is typically dominated by *Eucalyptus albens* (White Box) and/or *Eucalyptus albens* x *Eucalyptus moluccana* (White-Box-Grey Box intergrades), *Eucalyptus crebra* (Narrow-leaved Ironbark), although *Brachychiton populneus* (Kurrajong) and various red gum species may also be present. The understorey is typically sparsely shrubby and ground cover, comprised of various grasses and herbs, can range from sparse to dense. Toward the southern extent of its range, where *Eucalyptus albens* x *Eucalyptus moluccana* (White-Box-Grey Box intergrades) displays a stronger *Eucalyptus moluccana* (Grey Box) influence and *Allocasuarina luehmannii* (Bulloak) and *Acacia salicina* (Cooba) become more dominant, Upper Hunter White Box-Ironbark Grassy Woodland grades into Central Hunter Box-Ironbark Woodland.

Upper Hunter White Box-Ironbark Grassy Woodland occurs in the Study Area as patches of remnant open woodland and is characterised by the presence of *Eucalyptus albens* x *Eucalyptus moluccana* (White Box-Grey Box intergrades) trees in the canopy (**Photographs 5.2 and 5.3**). The community occupies 94 ha of the Study Area and has been identified where the White Box-Grey Box intergrades have a predominantly White Box influence. It is found in the north and eastern portion of the Study Area in high, undulating country; on steep slopes near creeklines; and on hilltops on clay soils. No ironbarks were recorded within this community; nevertheless, the community conforms best to the description of Upper Hunter White Box-Ironbark Grassy Woodland presented in the regional mapping (Peake 2006).

The undestorey is reasonably diverse and supports species such as *Notelaea microcarpa* var. *microcarpa* (Native Olive), *Myoporum montanum* (Water bush), *Acacia decora* (Western Golden Wattle) and *Maireana microphylla* (Eastern Cottonbush). The groundcover is diverse and is generally dominated by grasses and forbs, such as *Aristida ramosa* (Threeawn Wiregrass), *Cymbopogon refractus* (Barbed Wire Grass), *Austrostipa verticillata* (Slender Bamboo Grass), *Chloris ventricosa* (Windmill Grass), *Austrodanthonia fulva* (Wallaby Grass), *Cynodon dactylon* (Couch Grass), *Calotis lappulaccea* (Yellow Burr-daisy), *Dichondra repens* (Kidney Weed), *Desmodium varians* (Variable Tick-trefoil) and *Einadia nutans* (Climbing Saltbush).

The occurrence of the community in the Study Area is distinguished from Central Hunter Box-Ironbark Woodland by its occurrence on shallower soils of upper hills and ridges and the

absence of *Allocasuarina luehmannii* (Bulloak) and *Acacia salicina* (Cooba) in the small tree layer. Other small occurrences of this community were mapped on the slopes of dry creek beds and contained *Eucalyptus teretecornis x Eucalyptus blakelyi* (Forest Red Gum-Blakely's red Gum intergrades), which is recognised to be a characteristic sub-dominant canopy species of Upper Hunter White Box-Ironbark Grassy Woodland.



Photograph 5.2 **Upper Hunter White Box-Ironbark Grassy Woodland on Slopes in the Study Area**



Photograph 5.3 **Upper Hunter White Box-Ironbark Grassy Woodland on a Hilltop in the Study Area**

ii. Hunter Floodplain Red Gum Woodland

Status: EEC (TSC Act) and CEEC (EPBC Act). This community conforms to Box-Gum Woodland

Hunter Floodplain Red Gum Forest is a floodplain woodland that occurs on deeper soils at the base of foothills and along creeklines. It has a sparse distribution in the Hunter region and is strongly associated with alluvial soils on floodplain rises along major rivers and creeks. It is generally found in locations where regular inundation occurs during river overflow and flood events. *Eucalyptus camaldulensis* (River Red Gum) can often occur as the sole canopy species; however in some areas it is common to find co-dominants of *Eucalyptus tereticornis* (Forest Red Gum), *Eucalyptus melliodora* (Yellow Box) (sometimes to the exclusion of other tree species), *Angophora floribunda* (Rough-barked Apple) and *Casuarina cunninghamiana* (River Oak). *Casuarina cunninghamiana* (River Oak) often occurs as a gallery forest in the core of drainage lines and is known as Hunter Valley River Oak Forest.

This community covers approximately 40 ha of the Study Area. It occurs as small, irregular patches of remnant vegetation in the north of the Study Area and as narrow corridors of riparian vegetation along sections of Saddlers Creek and its tributaries (**Photograph 5.4 and 5.5**). The community is dominated by *Eucalyptus melliodora* (Yellow Box). *Eucalyptus tereticornis* (Forest Red Gum) and *Angophora floribunda* (Rough-barked Apple) were associated with the community in low numbers. One individual *Eucalyptus camaldulensis* (River Red Gum) was recorded along Saddlers Creek to the west of Edderton Road; occasional occurrences of *Casuarina cunninghamiana* (River Oak) were also found along the length of Saddlers Creek in this community. On the basis of the latter two occurrences, this community is considered to be a GDE.

The mid-storey is generally very sparse or absent of any vegetation. The groundcover is dominated by native spear grasses (i.e. *Austrostipa verticillata* and *Austrostipa. scabra* ssp. *scabra*) and contains a diversity of native forbs in low frequencies. Common species include grasses, forbs, sedges and rushes such as *Cynodon dactylon*, *Austrostipa verticillata*, *Dichondra repens*, *Lepidium pseudohyssopifolium* (Peppercress), *Urtica incisa* (Stinging Nettle), *Einadia hastata*, *Cynoglossum australe* (Australian Hound's Tongue), *Cyperus gracilis*, *Carex inversa* (Knob Sedge), *Glycine tabacina*, *Oxalis exilis*, *Geranium solanderi* (Native Geranium), *Chrysocephalum apiculatum*, *Plantago debilis*, *Echinopogon caespitosus* var. *caespitosus* (Tufted Hedgehog Grass) and *Microlaena stipoides* (Weeping Meadow Grass).

The understorey is strongly influenced by surrounding vegetation types and is now highly modified in various patches. Where the community occurs in narrow drainages in open grassland, it suffers from understory infestations of *Cathamnus lanatus* (Saffron Thistle). In more intact areas of woodland, the understorey is in reasonably good condition.

The boundary between Hunter Valley River Oak Forest and Hunter Floodplain Red Gum Woodland is somewhat arbitrary and can be difficult to distinguish, as is the case in the Study Area (Peake 2006). Both communities are also highly modified in the Study Area,

having been cleared for grazing and subject to continued grazing and weed invasion. As a general rule, Hunter Floodplain Red Gum Woodland commences at the outer edge of the Hunter Valley River Oak Forest boundary.



Photograph 5.4 **Hunter Floodplain Red Gum Woodland with a Canopy Dominated by Young Yellow Box Trees**



Photograph 5.5 **Hunter Floodplain Red Gum Woodland with Mature Yellow Box Trees**

iii. Central Hunter Box-Ironbark Woodland

Status: EEC (TSC Act)

Central Hunter Box-Ironbark Woodland typically occurs as a mid to high woodland in areas of high temperatures and low rainfall on undulating hills, slopes and valleys. This community is highly variable in its assemblage and degree of floristic structure as a consequence of widespread distribution across the central Hunter Valley and variations in underlying Permian geology, soil type and landform.

Toward Muswellbrook, the community grades into Upper Hunter White Box-Ironbark Grassy Woodland. Varying levels of hybridisation between *Eucalyptus moluccana* (Grey Box) and *Eucalyptus albens* (White Box) make it highly difficult to distinguish between pure species and intergrades in the Study Area (Ecotone 2000). Mixed stands or closely occurring mixed stands of these species and intergrades of varying degrees can occur as a result of backcrossing between intergrades and parent individuals. This makes it difficult to delineate the boundaries of Central Hunter Box-Ironbark Woodland and Upper Hunter White Box-Ironbark Grassy Woodland in the Study Area. However, the lack of intergrades with particularly strong influences of White Box is notable in the Central Hunter Box- Ironbark Woodland occurrences in the Study Area.

This community is the most abundant and widespread community within the Study Area and has been calculated to cover approximately 479 ha. It occurs on all aspects of gently undulating hills, slopes and valleys on moderately deep soils (**Photographs 5.6 and 5.7**). The condition of this community is variable across the Study Area and has been influenced by historical and current patterns of land use. Where grazing intensity has been reduced for a period of time, the community shows evidence of healthy regeneration.

The tree canopy in this community typically consists of *Eucalyptus moluccana* (Grey Box) and *Eucalyptus crebra* (Narrow-leaved Ironbark), although the latter is very rare in the Study Area. The small tree layer is dominated by *Allocasuarina luehmannii* (Bulloak), with *Acacia salicina* (Cooba) and *Notelaea microcarpa* (Native Olive) commonly co-occurring in the shrub layer. Other common understorey species observed includes *Myoporum montanum* (Western Boobialla), *Acacia decora* (Western Silver Wattle) and *Maireana microphylla* (Black Saltbush).

The understorey is moderately dense and comprised of a variety of grasses, forbs, ferns and twiners. Abundant species include *Aristida ramosa*, *Cymbopogon refractus*, *Austrostipa scabra* (Corkscrew Grass), *Bothriochloadecipiens* (Red Leg Grass), *Chloris ventricosa*, *Cheilanthes sieberi* ssp. *sieberi* (Poison Rock Fern), *Cheilanthes distans* (Bristly Cloak Fern), *Calotis lappulaccea* (Yellow Burr-daisy), *Vittadinia cuneata* (Fuzzweed), *Chrysocephalum apiculatum* (Common Everlasting), *Eremophila debilis* (Winter Apple), *Brunoniella australis* (Blue Trumpet), *Ajuga australis* (Austral Bugle), *Lomandra multiflora* ssp. *multiflora* (Many-flowered Mat-rush), *Dichondra repens*, *Desmodium varians*, *Sida corrugata* (Corrugated Sida), *Einadia nutans* and *Einadia trigonos* (Fishweed).



Photograph 5.6 Central Hunter Box-Ironbark Woodland 1



Photograph 5.7 Central Hunter Box-Ironbark Woodland 2

iv. Narrabeen Footslopes Slaty Box Woodland

Status: Vulnerable (TSC Act)

The occurrence of this low-mid to high woodland community in the Hunter Valley is strongly associated with underlying geology. The community is typically situated where colluvial soils derived from younger sandstone and conglomerate lithology overly older Perminan sediments occur. It is mainly distributed around Jerrys Plain.

In the Study Area, Narrabeen Footslopes Slaty Box Woodland occurs on drier sites in the central east of the Study Area on slopes of most aspects on colluvial soils. It covers an area of 100 ha of the site. The community is dominated by *Eucalyptus dawsonii* (Slaty Box) but characteristically contains *Eucalyptus moluccana* (Grey Box) as a sub-dominant species (**Photographs 5.8 and 5.9**). *Allocasuarina luehmannii* (Bulloak) and *Acacia salicina* (Cooba) are present in some patches.

The shrub stratum is variable across patches but the following species have been recorded: *Pimelea linifolia* (Slender Rice Flower); *Acacia cultriformis* (Knife-leaf Wattle); *Acacia decora* (Western Silver Wattle); *Acacia paradoxa* (Kangaroo Thorn); and *Cryptandra amara* (Bitter Cryptandra).

The groundcover was relatively species-poor in the latest surveys but has been known to be quite species-rich in previous years. It has been characterised by a diversity of forb species like *Templetonia stenophylla* (Templetonia), *Rostellularia adscendens*, *Minuria leptophylla*, *Podolepis jaceoides* (Showy Copper-wire Daisy), *Leiocarpa websteri* and *Velleia paradoxa* (Spur Velleia) in previous years. Current surveys have recorded species such as *Dichondra repens* (Kidney Weed), *Lomandra multiflora* ssp. *multiflora* (Many-flowered Mat-rush), *Brunoniella australis* (Blue Trumpet), *Desmodium brachypodum* (Large Tick-trefoil) *Eremophila debilis* (Winter Apple), *Fimbristylis dichotoma* (Common Fringe-rush) and *Sida corrugata* (Corrugated Sida), *Cymbopogon refractus* (Barb-wire Grass) and *Aristida ramosa* (Purple Wiregrass).

The occurrence of this community contains remarkably higher understorey diversity and lower weed presence than most other vegetation remnants in the Study Area and regeneration of canopy trees is also evident. Apart from some modification as a result of past clearing, the community assemblage is relatively consistent and has a high level of floristic integrity across its onsite distribution.



Photograph 5.8 **Narrabeen Footslopes Slaty Box Woodland 1**



Photograph 5.9 **Narrabeen Footslopes Slaty Box Woodland 2**

v. Central Hunter Bulloak Forest Regeneration

Status: Not listed

The Central Hunter Bulloak Forest Regeneration is a low to mid-high open forest community typically found on degraded land that has been extensively modified by clearing, livestock grazing and weed invasion. The community occurs on poor soils susceptible to erosion that are characteristic of the underlying Permian geology of the Hunter region. The community is dominated by *Allocasuarina luehmannii* (Bulloak) in the tree canopy, although *Eucalyptus crebra* (Narrow-leaved Ironbark), *Eucalyptus moluccana* (Grey Box) and *Eucalyptus tereticornis* (Forest Red Gum) are often found to co-dominate. It has a near-absent shrub layer and sparse groundcover that is predominantly comprised of grasses and forbs.

Central Hunter Bulloak Forest Regeneration in the Study Area is approximately 26 ha in size. It occurs as regrowth forest in the western parts of the Study Area and also as small, discrete patches along the eastern side of Edderton Road (**Photograph 5.10**). It was dominated by regenerating *Allocasuarina luehmannii* (Bulloak) with occasional occurrences of old growth *Allocasuarina luehmannii* (Bulloak), *Acacia salicina* (Cooba) and the occasional *Brachychiton populneus* (Kurrajong). The understorey is variable but generally sparse and dominated by native grasses including *Bothriochloa decipiens* (Redleg Grass), *Cymbopogon refractus, Austrostipa* spp. (Spear Grasses) and *Elymus* sp. (Wheatgrass).

It was noted that *Allocasuarina luehmanii* (Bulloak) comprises the small tree or sub-canopy stratum in most areas of woodland in the Study Area, which suggests that these regenerating stands are likely to have colonised cleared areas that once contained other woodland communities.



Photograph 5.10 Central Hunter Bulloak Forest Regeneration

vi. Hunter Valley River Oak Forest

Status: Not listed

The Hunter Valley River Oak Forest is a mid to tall forest community dominated by *Casuarina cunninghamiana* (River Oak). The community is typically variable in its assemblage and degree of floristic structure as a consequence of different land conditions. The community is typically found in riparian areas along creek beds altered by disturbance events such as clearing, livestock grazing, erosion and weed invasion. On occasion it occurs on alluvial flats where *Casuarina cunninghamiana* (River Oak) tend to grow close to high energy banks. *Eucalyptus tereticornis* (Forest Red Gum), *Casuarina glauca* (Swamp Oak) and *Angophora floribunda* (Rough-barked Apple) are common co-dominant species, as is the introduced *Salix babylonica* (Weeping Willow). The mid-layer is sparse, although vines are common, and the ground layer is generally dense with native grasses and forbs.

Hunter Valley River Oak Forest occurs as a few small, linear patches in the central north portion of the Study Area totalling 2 ha. *Casuarina cunninghamiana* (River Oak) occurs along the steep banks and in the core of the creekline of one of Saddlers Creek's tributaries (**Photograph 5.11**). The community is restricted to the creek banks and is rarely found on the alluvial flats. On the terraced flats immediately beyond the deeply incised portion of the creek, the presence of *Eucalyptus melliodora* (Yellow Box) and *Angophora floribunda* (Rough-barked Apple) as a sub-dominant canopy species indicates the occurrence of Box-Gum Woodland. On the basis of the presence of *Casuarina cunninghamiana* (River Oak), this community is considered to be a GDE.



Photograph 5.11 Hunter Valley River Oak Forest in the Riparian Zone

Note: Hunter Valley River Oak Forest as a Gallery Forest (background and mid-ground) and in the riparian zone (foreground).

vii. Hunter Lowland Redgum Forest

Status: EEC (TSC Act)

Hunter Lowland Redgum Forest is an open forest that occurs on gentle slopes rising from depressions and drainage flats on Permian sediments. The most common canopy trees include *Eucalyptus tereticornis* (Forest Red Gum) and *Eucalyptus punctata* (Sydney Grey Gum), although the following trees are also frequently recorded: *Eucalyptus moluccana* (grey Box), *Eucalyptus crebra* (Narrow-leaved Ironbark), *Corymbia maculata* (Spotted Gum) and *Angophora costata* (Smooth-barked Apple). The understorey is generally open with a sparse cover of shrubs and the ground stratum is predominantly comprised of grasses and forbs.

There is approximately 0.4 ha of this community within the minor additional mining areas at Drayton Mine that occurs as a thin band of very young regrowth along the edge of a large industrial dam (**Photograph 5.12**). The area originally occupied by this community at this location was most likely completely cleared in the past, since the trees are still immature and there is little understorey. The community is bounded by a mine haul road and is adjacent to the existing ROM stockpile to the north and the industrial dam to the south.



Photograph 5.12 **Regrowth Hunter Lowland Red Gum Forest adjacent to an Industrial Dam at Drayton Mine**

viii. Cooba Scrub

Status: Not listed

Cooba Scrub is a secondary community that occurs as large patches of *Acacia salicina* (Cooba) regeneration in the southern portion of the Study Area. *Brachychiton populneus* (Kurrajong) was found to co-dominate in some areas but there is generally a lack of eucalypt species or any other tree species in this community. This community does not conform to any listings by Peake (2006). This community has been calculated to be approximately 65 ha.

ix. Planted Vegetation

Status: Not listed

Nine 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 (**Photograph 5.13**). This is not an ecological community as such but has been described because of the forage and nesting habitat it affords 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 discolour*), which depend on winter flowering eucalypt species and has been observed to feed on blossoms of *Eucalyptus sideroxylon* (Mugga Ironbark) within this planted area.

One of the minor additional mining areas also includes a very narrow strip of plantings. Plantings of young acacias, generally *Acacia salicina* (Cooba), *Acacia saligna* (Golden Wreath Wattle) and *Acacia decora* (Western Silver Wattle) (pers. comm. P. Simpson), line the road edge that runs along the south-eastern side of the Industrial Dam (**Photograph 5.14**). Grassland occurs beyond these planted acacias; this grassland contains scattered trees and shrubs and was rehabilitated in the past with exotic grasses and pasture-improvement herb species.



Photograph 5.13 Planted Vegetation along Edderton Road



Photograph 5.14 Planted Acacias along a Haul Road at Drayton Mine

5.3 Summary of Vegetation Community MNES

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. The communities listed in **Table 5.3** below were included for consideration based on incidence of suitable habitat and as indicated by the EPBC PMST (DSEWPC, 2011a) and/or known occurrences in the locality of the Study Area.

The Study Area supports known occurrences of the CEEC Box-Gum Woodland, which is present as Upper Hunter White Box-Ironbark Grassy Woodland and Hunter Floodplain Red Gum Woodland, and Derived Native Grassland associated with the clearance of these communities. No other threatened vegetation communities listed under the EPBC Act are considered likely to occur in the Study Area.

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

Table 5.3 Summary of Likely Occurrence of Relevant Community MNES in Study Area

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

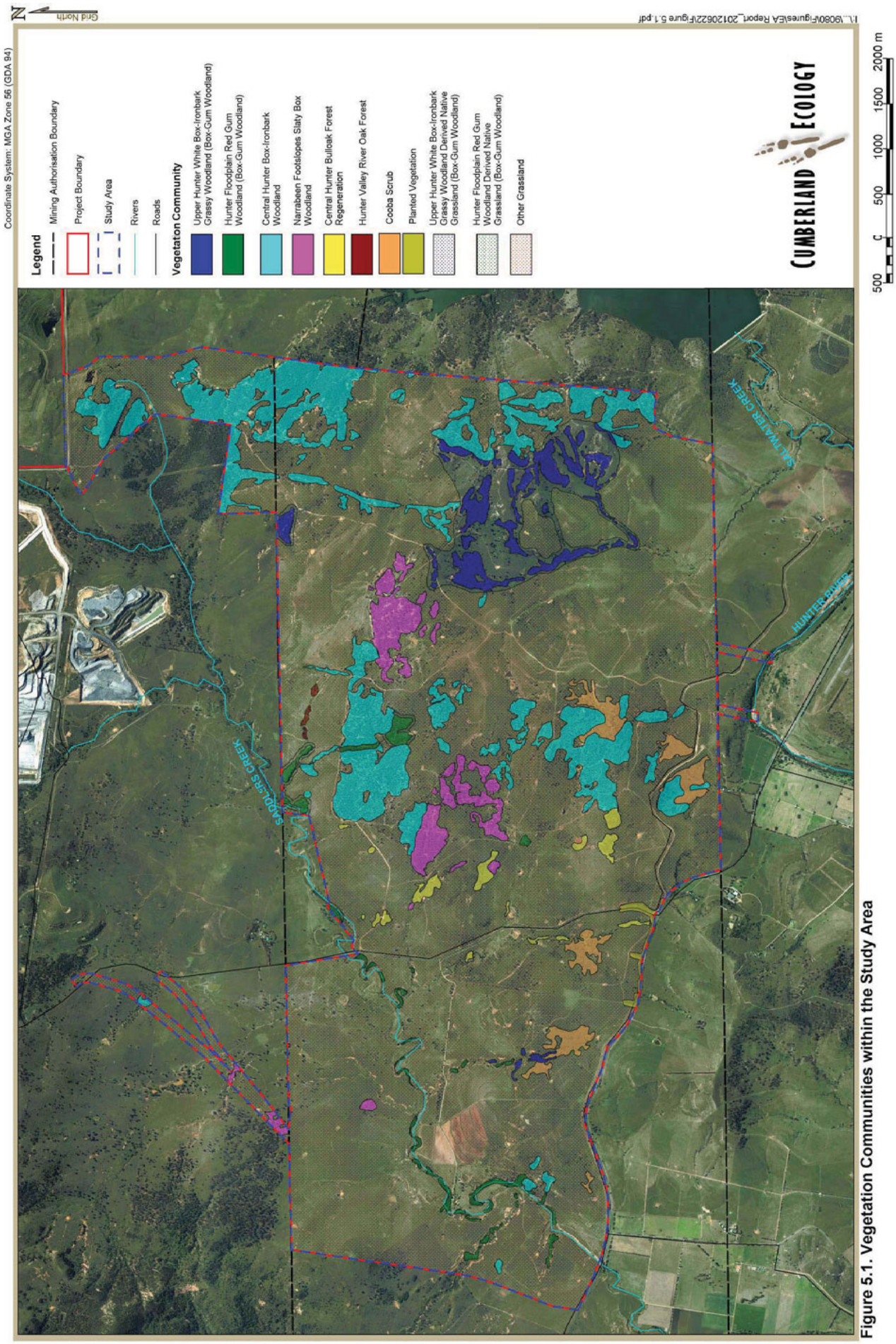


Figure 5.1. Vegetation Communities within the Study Area



Figure 5.2. Vegetation in the Minor Additional Mining Areas at Drayton Mine

5.4 Flora of the Study Area

A total of over 250 plant species, including threatened 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 D**.

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.

5.4.1 Threatened Flora Species

Threatened flora species recorded within the Study Area are discussed below and shown in **Figure 5.4**.

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 has a pendulous habit with long silver-grey phyllodes and hard, dark and fissured bark (Botanic Gardens Trust 2011). The tree has irregular flowering periods and does not reliably flower every year. The species occurs in woodlands, shrublands and grasslands and often forms low open woodland in heavy loam soils on the slopes and plains of western NSW where the tree has widespread distribution (Tame 1992).

Acacia pendula (Weeping Myall) was recorded in the Study Area in grassland at two locations (**Figure 5.3**) 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). There are 28 records of the species within the Muswellbrook LGA and 4 records within the Singleton LGA (OEH 2011).

The occurrence of regenerating *Acacia pendula* (Weeping Myall) makes it likely 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 5.4.1i**).

ii. Eucalyptus camaldulensis (River Red Gum)

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

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. It is considered likely that seedlings and other individuals are present elsewhere along the creek and floodplain. There are 107 records of the species within the Muswellbrook LGA and 505 records within the Singleton LGA (OEH 2011).

iii. Bothriochloa biloba (Lobed Blue Grass)

Status: Vulnerable (EPBC Act). This species has been delisted in NSW due to the presence of more populations than previously thought.

Lobed Blue Grass was recorded within Box-Gum Woodland in the Study Area during the 2009 surveys of the Study Area by Cumberland Ecology and the 2000 surveys by Ecotone. The species has also been recorded from surveys of the Mt Arthur Coal Mine lease just north of Saddlers Creek (Cumberland Ecology 2009). There are 28 records of the species within the Muswellbrook LGA and 4 records within the Singleton LGA (OEH 2011).

Lobed Blue Grass is fairly tolerant of grazing and grows in partially cleared eucalypt forests and grassland derived from the clearing of such forests (NSW Scientific Committee 2004c). Proximate off site distribution and the fact that the species is more widespread than previously thought make it highly likely that the species occurs in other grassland and woodland areas elsewhere within the Study Area.

iv. 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 2011). 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 2009 surveys of the Study Area in a tree on the edge of Narrabeen Footslopes Slaty Box Woodland (see **Figure 5.3**). The species has also been recorded along a tributary of Saddlers Creek and within Central

Hunter Bulloak Forest Regeneration in the southern extent of the Mt Arthur Coal Mine lease (Cumberland Ecology 2009). The species may be represented in the general area as scattered individuals in association with Saddlers Creek. There are 11 records of the species within the Muswellbrook LGA and none for the Singleton LGA (OEH 2011).

v. 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, terrestrial orchid with sparse distribution on the western slopes of NSW. The species is generally found in sclerophyll vegetation on flats or small rises, on a range of substrates including sandy or loamy soils. This species 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 km^2. The population also has particularly large flowers relative to other populations of the species. There are 13 records of the species within the Muswellbrook LGA and no records within the Singleton LGA (OEH 2011).

The Muswellbrook population occurs as individuals or localised colonies in open grassy woodland often associated with Box-Gum Woodland (DEC (NSW) 2005j) and has been recorded within 10 km of the Study Area in the Mt Arthur Coal Mine lease near the Access Road.

In the Study Area, two individuals of *Diuris tricolor* (Pine Donkey Orchid) were recorded during 2009 surveys. The plants were found in 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. The locations of recorded plants are shown in **Figure 5.3**. Photographs of the plants and the habitat they were recorded in are shown in **Photographs 5.15 to 5.17**.



Photograph 5.15 **Threatened Orchid *Diuris tricolor* Recorded within the Study Area**



Photograph 5.16 ***Diuris tricolor* in Open Grassy Understorey**

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



Photograph 5.17 **Open grassy Box-Gum Woodland Habitat where *Diuris tricolor* was Recorded**

5.4.2 Invasive Species

More than 40 invasive flora species were recorded within the Study Area. Of these, two (*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).

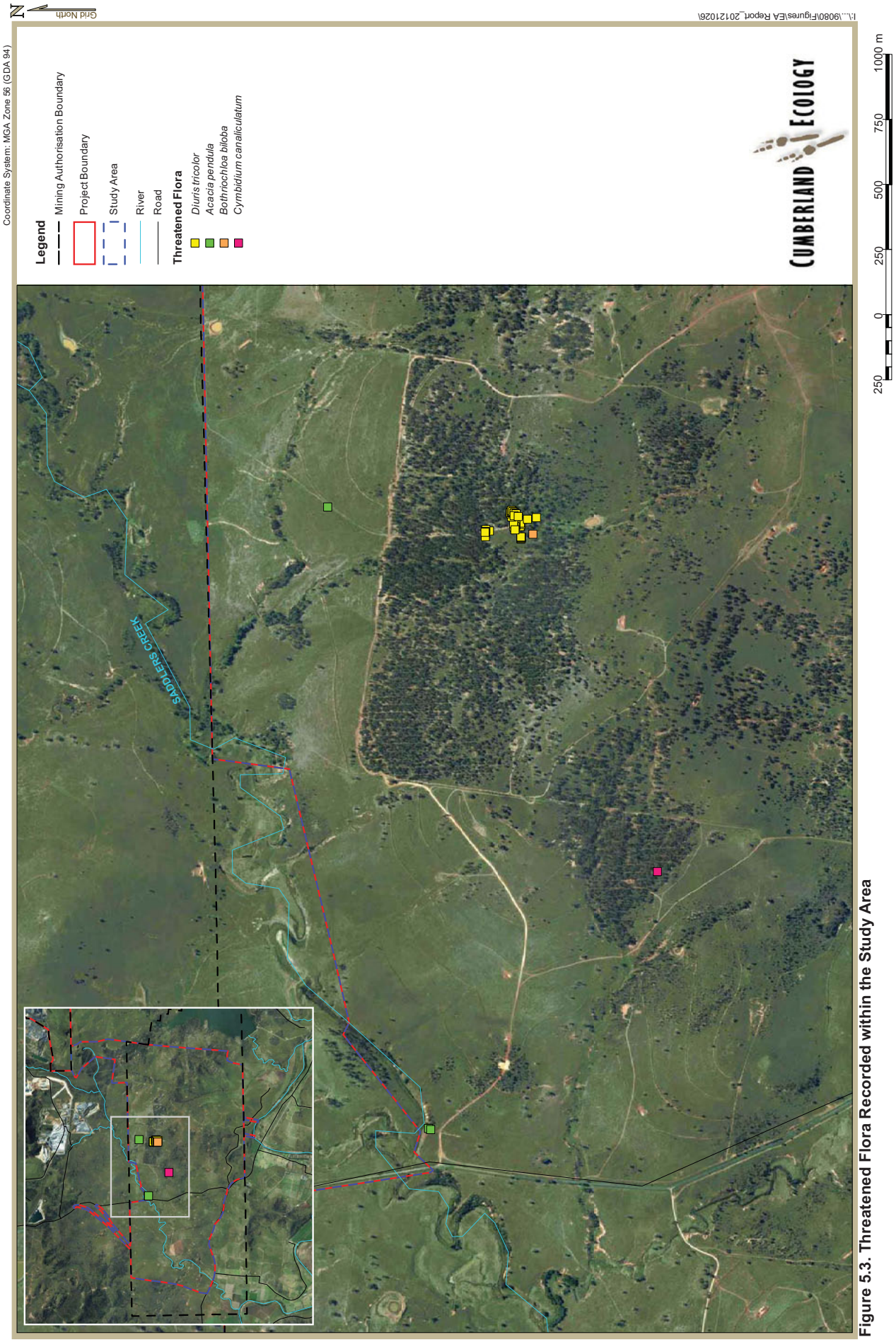


Figure 5.3. Threatened Flora Recorded within the Study Area

5.5 Potentially Occurring Threatened TECs and Flora

This section describes threatened communities and flora 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 Atlas LGA records and/or the EPBC PMST (DSEWPC, 2011a).

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

- TSC Act listed threatened flora species recorded from the Muswellbrook and Singleton LGAs (OEH 2011);
- EPBC Act listed species predicted to occur based on availability of habitat in the Muswellbrook LGA (SEWPaC 2011b); and
- 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.

5.5.1 Vegetation Communities

i. Weeping Myall Woodland

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

Weeping Myall Woodlands ecological community generally occurs on heavy soils of flats, floodplains and undulating, arable landscapes as a mosaic of sparse to open woodlands and treeless shrublands and grasslands where *Acacia pendula* trees are the sole or dominant overstorey species in these landscapes (SEWPaC 2011g). 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 2011g). The Hunter population of *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 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. Small patches of regrowth (less than 3 m tall) *Acacia pendula* (Weeping Myall) has been recorded at two locations in grassland. No *Acacia pendula* (Weeping Myall) trees were present. The understorey at one of these patches was eroded and almost absent of understorey species, including grasses. 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.

5.5.2 Flora

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 2011). However, the species is known from seven population locations including a Muswellbrook population to the north of the Study Area. These populations are highly localised.

b. Habitat and Ecology

Prasophyllum sp. Wybong is a terrestrial perennial orchid that grows to approximately 30cm high 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 2009; SEWPaC 2011f).

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 (Australe 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 Muswellbrook LGA. *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.

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, such that the species only has a very low potential to occur in the Study Area. To date those small occurrences are the only recorded occurrences within the Upper Hunter Valley.

5.6 Summary of Flora MNES

This section summarises the likelihood of occurrence of threatened communities and 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 5.4** below were included for consideration based on incidence of suitable habitat and as indicated by the EPBC PMST (DSEWPC, 2011a) and/or presence of records in the locality of the Study Area.

The Study Area supports known occurrences of *Bothriochloa biloba* (Lobed Blue-grass); and has a low potential to support *Prasophyllum* sp. Wybong (Leek-orchid) and *Thesium australe* (Austral Toadflax). No other threatened flora species are considered likely to occur in the Study Area.

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

Table 5.4 Summary of Likely Occurrence of Relevant Flora MNES in Study Area

Common Name	EPBC Status	Occurrence in Study Area	Likelihood
Lobed Blue Grass (*Bothriochloa biloba*)	V	Present. Most likely to occur in open woodland or diverse grassland areas.	Y
Finger Panic Grass (*Digitaria porrecta*)	E	Not recorded. Unlikely to occur. Not previously known from the Muswellbrook LGA.	N
Leek-orchid (*Prasophyllum* sp. Wybong (C. Phelps ORG 5269))	CE	Not recorded. Low potential to occur. Suitable habitat available but outside of the 7 known populations.	Y (low)
Illawarra Greenhood (*Pterostylis gibbosa*)	E	Not recorded. Unlikely to occur. Not detected in flora surveys, and outside of known range in the Hunter.	N
Austral Toadflax (*Thesium australe*)	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.	Y (low)

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

Chapter 6

Fauna Results

The environment within the Study Area has been greatly modified from its original character by a long history of agriculture and is now dominated by extensive areas of native perennial grassland of various diversity and floristic composition. The landscape is generally fragmented and simplified, as is typical of much of the landscape in the Hunter Valley. Despite this, the Study Area features considerable areas of native forest and woodland that, although much altered from their original condition, still provide value for the native fauna species in the locality that rely on them as habitat for roosting, breeding and/or foraging.

The results of past and present fauna field studies show that there is still a suite of native fauna species that use the habitats in the Study Area. The present fauna assemblage has been influenced by the clearing history of the Study Area and is dominated by typically mobile species, with small ground-dwelling fauna being rarer. Nevertheless, the fauna assemblage supports fauna that include a number of threatened species, which are protected under State and Commonwealth environmental legislation.

The minor additional mining areas at Drayton Mine have also been greatly modified from their original character and now exist within the matrix of the Drayton Mine landscape. In contrast to the Study Area, the minor additional mining areas contain very little native vegetation, are relatively small in size and have little to no connectivity to more substantial areas of fauna habitat. These minor additional mining areas are thus unlikely to support significant numbers of native fauna species.

This chapter describes and discusses the fauna habitats that are present in the Study Area, and also includes the findings of the surveys for the minor additional mining areas at Drayton Mine. It also lists and discusses the fauna species that occur, or are expected to occur in the Study Area, including threatened species listed under the TSC Act and EPBC Act.

6.1 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.

6.1.1 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.

6.1.2 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 6.1.2i**);
- Blossom-producing trees suitable as forage habitat for a range of nectarivores (see **Section 6.1.2ii**); and
- Woodland margin habitat at the woodland-grassland interface, which provide a combination of foraging habitat and refuge for ground-foraging fauna (see **Section 6.1.2iii**);

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 Speckled Warbler (*Pyrrholaemus saggitatus*) and Grey-crowned Babbler (*Pomatostomus temporalis temporalis*) were detected in this habitat type as well as both hollow-dependent and cave-roosting bat species (**Figure 6.1**).

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 6.1**. 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 6.1 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 6.1 to 6.4**.

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, Lindenmayer et al. 2000; Harper, McCarthy et al. ; Koch 2008; Rayner, Ellis 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 6.1 A Large Tree Hollow in the Study Area



Photograph 6.2 Australian Kestral in a Tree Hollow (Photo: D. Stojanovic, 2011)



Photograph 6.3 Stag Providing Valuable Large Hollows



Photograph 6.4 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, Norton et al. 1990; Gibbons, Lindenmayer et al. 2002; Remm, Hmus 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 6.2**.

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 6.2 Flowering Periods for Dominant Tree Species

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

(Source: Boland, Brooker 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 6.5**). 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 6.3**).

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 6.3 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 6.5 Woodland Margins and Scattered Trees

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

6.1.3 Regenerating Shrubland and Forest

Regenerating shrublands and forests, such as the regenerating Cooba Scrub and the Central Hunter Bulloak 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.

6.1.4 Grassland

Grassland habitat generally provides low fauna habitat due to a lack of woody vegetation and ground debris for cover (refer to **Table 6.4**). 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 6.6**). 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 6.4 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 6.7**). 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 6.6 **Grassland Habitat in the Study Area Containing Scattered Paddock Trees**



Photograph 6.7 **Grassland Habitat in the Minor Additional Mining Areas at Drayton Mine**

6.1.5 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 6.5**). 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 6.5 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		
Reptiles	X		

6.1.6 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 6.8**). A systematic assessment of the condition of the aquatic habitat in the Study Area is provided in **Section 6.4**.



Photograph 6.8 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 6.2.3**). 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 6.9**).

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 6.9 Industrial Dam at Drayton Mine

Note: Lack of fringing vegetation.

6.2 Fauna of the Study Area

6.2.1 General Fauna 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 F**. 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 (2010b) and NPWS Atlas LGA records (OEH 2011).

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, excepting a potential for common turtles or eels in the industrial dam. It is unlikely that there are any native visitors that make regular use of the land within the minor additional mining areas except a potential for water birds and bats that may 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 that may forage over the dam and is known from the surrounding locality (Southern Myotis, *Myotis macropus*). 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. 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 (*Smicrornis 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.

iii. 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.

iv. 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.

6.2.2 Threatened Fauna Species

Twenty-one threatened fauna species have been recorded within the Study Area since surveys conducted in 2000 and all are represented by highly mobile avifauna and microbat species (**Table 6.6**). Eighteen of these species are listed as Vulnerable under the TSC Act, one of which has a preliminary listing. Five of these species are listed under the EPBC Act.

The cumulative results of fauna surveys conducted over the Study Area show that threatened species were generally restricted to areas of remnant vegetation (**Figure 6.1**). 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 6.6 Threatened Fauna Species Recorded in the Study Area

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

Table 6.6 Threatened Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecology Study	
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009, 2011)
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	V			X
Molossidae	*Mormopterus norfolkensis*	Eastern Freetail-bat	V		X	X
Vespertilionidae	*Chalinolobus dwyeri*	Large-eared Pied Bat	V	V		X
	Miniopterus orianae oceanensis	Eastern Bentwing-bat	V		X	X
	Myotis macropus	Southern Myotis	V		X	?
	Nyctophilus corbeni	Greater Long-eared Bat	V	V	X	
	Scoteanax rueppellii	Greater Broad-nosed Bat	V		X	
	Vespadelus troughtoni	Eastern Cave Bat	V			?

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

Threatened Avifauna

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 40 records of the species within Muswellbrook LGA and 13 records within the Singleton LGA (OEH 2011).

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 2011). 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 2004b).

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 2011). 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. 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 6.10**). There are 94 records of the species within the Muswellbrook LGA and 11 records within the Singleton LGA (OEH 2011).



Photograph 6.10 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 2011).

Suitable nesting and foraging habitats such as fallen timber, hollows in stags and live trees are available within the Study Area (Garnett and Crowley 2000; DEC (NSW) 2005b). 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, Walters et al. 2002; Doerr, 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 (Garnett and Crowley 2000; DECC (NSW) 2007a).

iii. 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 6.11**). The species has also been recorded from surveys of the Mt Arthur Coal Mine lease and Drayton Mine (Cumberland Ecology 2010b). There are 35 records of the species within the Muswellbrook LGA and 36 records within the Singleton LGA (OEH 2011).

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 2004d). The species also occurs in farmland and grassland with remnant trees and a sparse understorey, and along watercourses (Birds Australia 2011).

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 on site, rather than immigration, as the capacity for a dependent juvenile to disperse is limited (Higgins, Peter 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 2011), and invasion by exotic grasses which result in the loss of key food plants.



Photograph 6.11 Diamond Firetail (Photo: D. Stojanovic, 2011)

Note: Adult (left) and juvenile (right)

iv. 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 two records of the species within the Muswellbrook LGA and four records within the Singleton LGA (OEH 2011).

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 2011). 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 2011).

v. 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 2010b). 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 6.12**). 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 45 records of the species within the Muswellbrook LGA and 250 records within the Singleton LGA (OEH 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 2004i). 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 2011).

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, Peakall 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 (Birds Australia 2011; Stojanovic 2011). Once lost from a fragment, natural recolonisation is unlikely (Garnett and Crowley 2000).



Photograph 6.12 Adult Grey-crowned Babbler (Photo: D. Stojanovic, 2011)

vi. 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 2010b). The species was also detected in regenerating box and sheoak woodland with some scattered mature trees during the 2011 survey session (**Photograph 6.13**). There are 12 records of the species within the Muswellbrook LGA and 31 records within the Singleton LGA (OEH 2011).

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 2011). 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 2010c).

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 6.13 Male Scarlet Robin (Photo: D. Stojanovic, 2011)

vii. Speckled Warbler (Pyrrholaemus saggitatus)

Status: Vulnerable (TSC Act)

a. Record Details

The Speckled Warbler has been recorded in the Study Area on multiple occasions (Ecotone 2000; Cumberland Ecology 2010b). 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 113 records of the species within the Muswellbrook LGA and 130 records within the Singleton LGA (OEH 2011).

b. Habitat and Ecology

The Speckled Warbler is a woodland species endemic to south eastern Australia (Garnett and Crowley 2000). It is a territorial, sedentary species most commonly found in eucalypt-dominated dry sclerophyll forest and woodland with a grassy understorey (Higgins and Peter 2002; NSW Scientific Committee 2004q). 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) 2005l) 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 2000), thus also impacting on genetic viability of subpopulations (Birds Australia 2011; Stojanovic 2011). 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) 2005l).

viii. 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 13 records of the species within the Muswellbrook LGA and 11 records within the Singleton LGA (OEH 2011).

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 red gums (Birds Australia 2011). 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 2011), 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 2000).

ix. Little Eagle (Hieraaetus morphinoides)

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 three records of the species within the Muswellbrook LGA and 17 records within the Singleton LGA (OEH 2011).

b. Habitat and Ecology

The Little Eagle is a small, territorial raptor, uncommon but with widespread distribution across mainland Australia (Birds Australia 2011). 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 2010b). 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 2010b). Populations may benefit from clearing, which may open new feeding grounds and thus small mammal availability, but they do not respond well to urbanisation.

x. 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 eight records of the species within the Muswellbrook LGA and five records within the Singleton LGA (OEH 2011).

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 2010d). 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).

xi. 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 6.14**). There are no records of the species within the Muswellbrook LGA and 10 records within the Singleton LGA (OEH 2011).

b. Habitat and Ecology

The Swift Parrot is a predominantly nectarivorous, migratory species endemic to south eastern Australia (Birds Australia 2011). 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 2000). 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) 2005o; 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).

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 2011), while on the mainland, agriculture and residential development has destroyed forage habitat, including over 70% of Box-Ironbark forests (Garnett and Crowley 2000). The species is also highly susceptible to climate change which impacts on the availability of flowering eucalypts and lerps.



Photograph 6.14 Swift Parrot (Photo: D. Stojanovic, 2011)

xii. 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 2010b), 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 52 records of the species within the Muswellbrook LGA and 87 records within the Singleton LGA (OEH 2011).

b. Habitat Description

The Rainbow Bee-eater is an insectivorous migratory species widespread through mainland Australia (Birds Australia 2011). 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 2011d).

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 2011d).

xiii. 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 12 records of the species within the Muswellbrook LGA and 26 records within the Singleton LGA (OEH 2011).

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:

- Eastern Bentwing-bat (*Miniopterus orianae oceanensis*) (Vulnerable under the TSC Act); and
- Eastern Freetail-bat (*Mormopterus norfolkensis*) (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);
- Large-eared Pied Bat (*Chalinolobus dwyeri*) (Vulnerable under the EPBC and TSC Acts);
- Southern Myotis (*Myotis macropus*) (Vulnerable under the TSC Act); and
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) (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 2008). 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 6.7** below.

Table 6.7 Foraging Guilds of Microbat Species Recorded in the Study Area

Foraging Guild	Description
Open Space Aerial Foragers	Typically freetail and sheathtail bats such as the Yellow-bellied Sheathtail-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 Sheathtail-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 orianae 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. Eastern Bentwing-bat (Miniopterus orianae oceanensis)

Status: Vulnerable (TSC Act)

a. Record Details:

The Eastern Bentwing-bat (*Miniopterus orianae oceanensis*, syn. *Miniopterus schreibersii oceanensis*) has been recorded within the Study Area on multiple occasions (Ecotone 2000; Cumberland Ecology 2010b).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 87 records of the species within the Muswellbrook LGA and 73 records within the Singleton LGA (OEH 2011).

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 2008). 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.

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 nine records of the species within the Muswellbrook LGA and 141 records within the Singleton LGA (OEH 2011).

b. Habitat and Ecology

The Eastern Freetail-bat is a solitary, insectivorous bat (Churchill 2008) most commonly found in open spaces in dry sclerophyll forests, woodland and swamp forests in eastern NSW (NSW Scientific Committee 2004f). 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. 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 16 records of the species within the Muswellbrook LGA and two records within the Singleton LGA (OEH 2011).

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 2008). 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 parches 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 2011e). 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.

iv. 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 11 records of the species within the Muswellbrook LGA and 21 records within the Singleton LGA (OEH 2011).

b. Habitat and Ecology

The Greater Broad-nosed Bat is a large insectivorous species with limited distribution along the east coast of Australia (Churchill 2008). 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 2004h). It is also known to prey on other microbat species (Churchill 2008).

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, Baker et al. 1999).

v. 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 (DECC (NSW) 2005d) and it has also been recorded from surveys of the Mt Arthur Coal Mine lease. There are 45 records of the species within the Muswellbrook LGA and 48 records within the Singleton LGA (OEH 2011).

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 (DECC (NSW) 2005d). 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).

vi. 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 seven records of the species within the Muswellbrook LGA, all of which have been recorded from surveys of the Mt Arthur Coal Mine lease, and 10 records within the Singleton LGA (OEH 2011).

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 2008). 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 2004m; DEC (NSW) 2005k).

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.

vii. Yellow-bellied Sheathtail-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 Muswellbrook LGA and two records within the Singleton LGA (OEH 2011).

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 2008). It is an insectivorous species that primarily forages above the tree canopy in almost all habitats (NSW Scientific Committee 2004w). 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, Thexton 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 2008).

6.2.3 Invasive Fauna

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, Sinden 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 6.4.3**. These aquatic species may also potential 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 6.1.6**). 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.

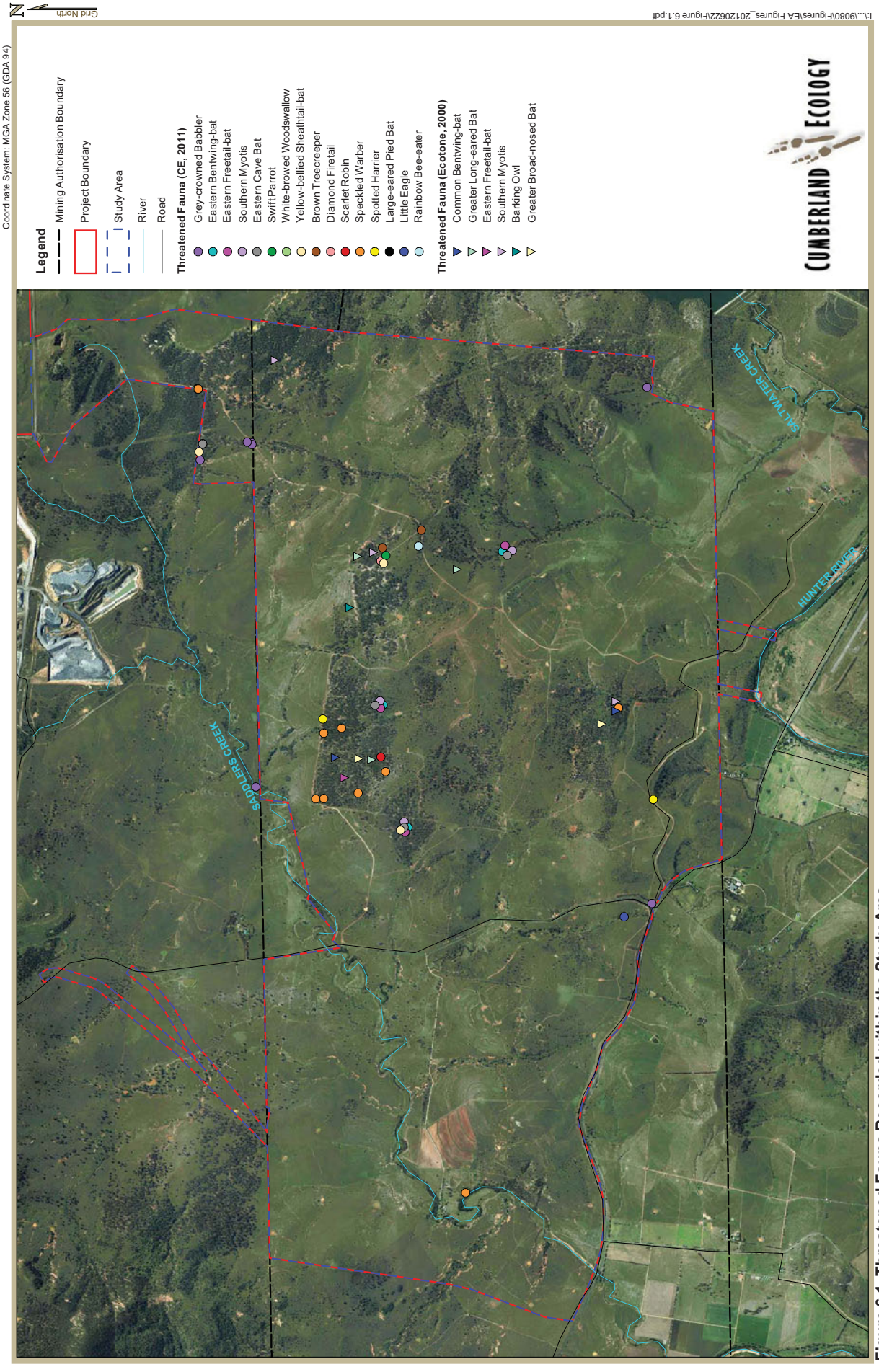


Figure 6.1. Threatened Fauna Recorded within the Study Area

6.3 Potentially Occurring 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 Atlas LGA records and/or the EPBC PMST (DSEWPC, 2011a).

A likelihood of occurrence assessment was conducted for threatened species known or predicted to occur within the locality, and thus, within the Study Area. Species that could potentially be impacted by the Project are presented within **Appendix H.** This table shows all records of TSC Act listed threatened fauna species recorded from the Muswellbrook LGA 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.

6.3.1 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 95 records of the species within the Muswellbrook LGA and 76 records within the Singleton LGA (OEH 2011).

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, Silcocks 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 49 records of the species within the Muswellbrook LGA and 10 records within the Singleton LGA (OEH 2011).

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 2004t). 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) 2005p).

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 are three records of this species within the Muswellbrook LGA and eight records within the Singleton LGA (OEH 2011).

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 2011). 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.

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 are 40 records of the species within the Muswellbrook LGA and 138 records within the Singleton LGA (OEH 2011).

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 km^2 (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 76 records of the species within the Muswellbrook LGA and 141 records within the Singleton LGA (OEH 2011).

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 2011).

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 2004g).

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 15 records of the species within the Muswellbrook LGA and 34 records within the Singleton LGA (OEH 2011).

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, Silcocks 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 2004o; 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 10 records of the species within the Muswellbrook LGA and 20 records within the Singleton LGA (OEH 2011).

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 2004n).

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 57 records of the species within the Muswellbrook LGA and 60 records within the Singleton LGA (OEH 2011).

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, Silcocks 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; Migratory (EPBC Act)

a. Record Details:

The Regent Honeyeater (*Anthochaera phrygia*) has not been recorded within the Study Area. There are 16 records of the species within the Muswellbrook LGA and 83 records within the Singleton LGA (OEH 2011).

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 2000). 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, Menkhorst et al. 1989; NSW Scientific Committee 2004p). 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.

x. 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 two records of this species within the Muswellbrook LGA and 14 records within the Singleton LGA (OEH 2011). 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, McGill et al. 1981; Blakers, Davies 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.

xi. 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 three records of the species within the Muswellbrook LGA and 120 records within the Singleton LGA (OEH 2011).

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 2004j). 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.

xii. 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 25 records of the species within the Muswellbrook LGA and 117 records within the Singleton LGA (OEH 2011).

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) 2005m).

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.

xiii. 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 23 records of the species within the Muswellbrook LGA and 44 records within the Singleton LGA (OEH 2011).

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 2004r; DEC (NSW) 2005n).

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.

xiv. 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 71 records of the species within the Muswellbrook LGA and 355 records within the Singleton LGA (OEH 2011).

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 2004v). 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.

xv. 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 6.1**). It has also been recorded from surveys of the Mt Arthur Coal Mine lease. There are 14 records of the species within the Muswellbrook LGA and nine records within the Singleton LGA (OEH 2011).

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 2004e).

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 orianae oceanensis*).

6.3.2 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. 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 Muswellbrook and Singleton LGAs (OEH 2011).

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).

ii. 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 three records of the species within the Muswellbrook LGA and nine records within the Singleton LGA (OEH 2011).

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 2011).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).

iii. Latham's Snipe (Gallinago hardwickii)

Status: Marine, Migratory (EPBC Act)

a. Record Details

Latham's Snipe (*Gallinago hadwickii*) has not been recorded within the Study Area. There are no records of the species in both the Muswellbrook LGA and Singleton LGA (OEH 2011).

b. Habitat and Ecology

Latham's Snipe (*Gallinago hadwickii*) is a non-breeding migratory wader that travels to south eastern Australia in the warmer months, typically around September (Birds Australia 2011). 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.

iv. 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 no records for this species within the Muswellbrook and Singleton LGAs (OEH 2011).

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 2011c). 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 Summary of Fauna MNES

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 species discussed in **Table 6.8** below were included for consideration based on incidence of suitable habitat and as indicated by the EPBC 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 threatened 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 M**, which contains summary of assessment of MNES as required under the EPBC Act.

Table 6.8 Summary of Likely Occurrence of Relevant Fauna MNES in Study Area

Common Name	EPBC Status	Occurrence in Study Area	Likelihood
Regent Honeyeater (*Anthochaera phrygia* (syn. *Xanthomyza phrygia*))	E, Mi	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.	Y (low)
Swift Parrot (*Lathamus discolor*)	E, Ma	Recorded in the Study Area. Likely to occur occasionally and in very low numbers but unlikely to visit regularly every year.	Y (low)
Spotted-tail Quoll	E	Not recorded. Potential to visit occasionally	Y (low)

Table 6.8 Summary of Likely Occurrence of Relevant Fauna MNES in Study Area

Common Name	EPBC Status	Occurrence in Study Area	Likelihood
(*Dasyurus maculatus maculatus*)		and in low numbers but unlikely to visit regularly every year.	
Koala (*Phascolarctos cinereus*)	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 to significant areas of habitat offsite.	N
Greater Long-eared Bat (*Nyctophilus corbeni* (syn. *N. timoriensis*))	V	Recorded in the Study Area. Suitable roosting and foraging habitat available.	Y
Green and Golden Bell Frog (*Litoria aurea*)	E	Not recorded. Unlikely to occur. Some suitable summer habitat is available along sections of Saddlers Creek, however there is no suitable winter shelter habitat.	N

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

6.5 Aquatic Study

6.5.1 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 6.9**. 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” (Rutherfurd, Jerie 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 course 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; Rutherfurd, Jerie 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; Rutherfurd, Jerie 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, Mazari et al. 1998; Brooks, Brierley 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 (Rutherfurd, Jerie et al. 2000).

Four locations were surveyed and are referred to as S1, S2, S3 and S4 (see **Figure 4.3** from **Chapter 4**). The sites have experienced high levels of disturbance and are degraded (**Photographs 6.15** and **6.16**). 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 6.15 Low-value Habitat at Site S1 along Saddlers Creek



Photograph 6.16 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, Legalle et al. 2004; Robson, Hogan et al. 2005; Marshall, Sheldon 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 6.17** and **6.18**).

Depending on the survey location, the substratum ranges from rocks and pebbles to sand, silt and clay, providing suitable habitat for a variety of macro-invertebrates 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 6.17 **Habitat at site H3 (Proposed Water Outflow Pipeline) along the Hunter River**



Photograph 6.18 **Habitat Upstream of the Confluence of the Hunter River and Saddlers Creek**

Table 6.9 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

6.5.2 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, Waddell 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 **Tables 6.10 and 6.11**. Input components and results are explained in further detail in the subsections below.

Table 6.10 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 6.11 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 6.12**. 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 170 to 970ppm. Watercourses can be naturally alkaline if minerals derived from the underlying geology leach out of the soil. Levels of at least 20ppm 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 3ppm. 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 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 6.12 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 CaCO3)	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, most likely due to a lack of flowing water and limited habitat availability. SIGNAL results of macro-invertebrate sampling are summarised in **Table 6.13** below.

Table 6.13 SIGNAL Macroinvertebate 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 **Figure 6.2** and explained below. The scores represent general environmental conditions based on the abundance and diversity of taxa collected at each site. The figure 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.

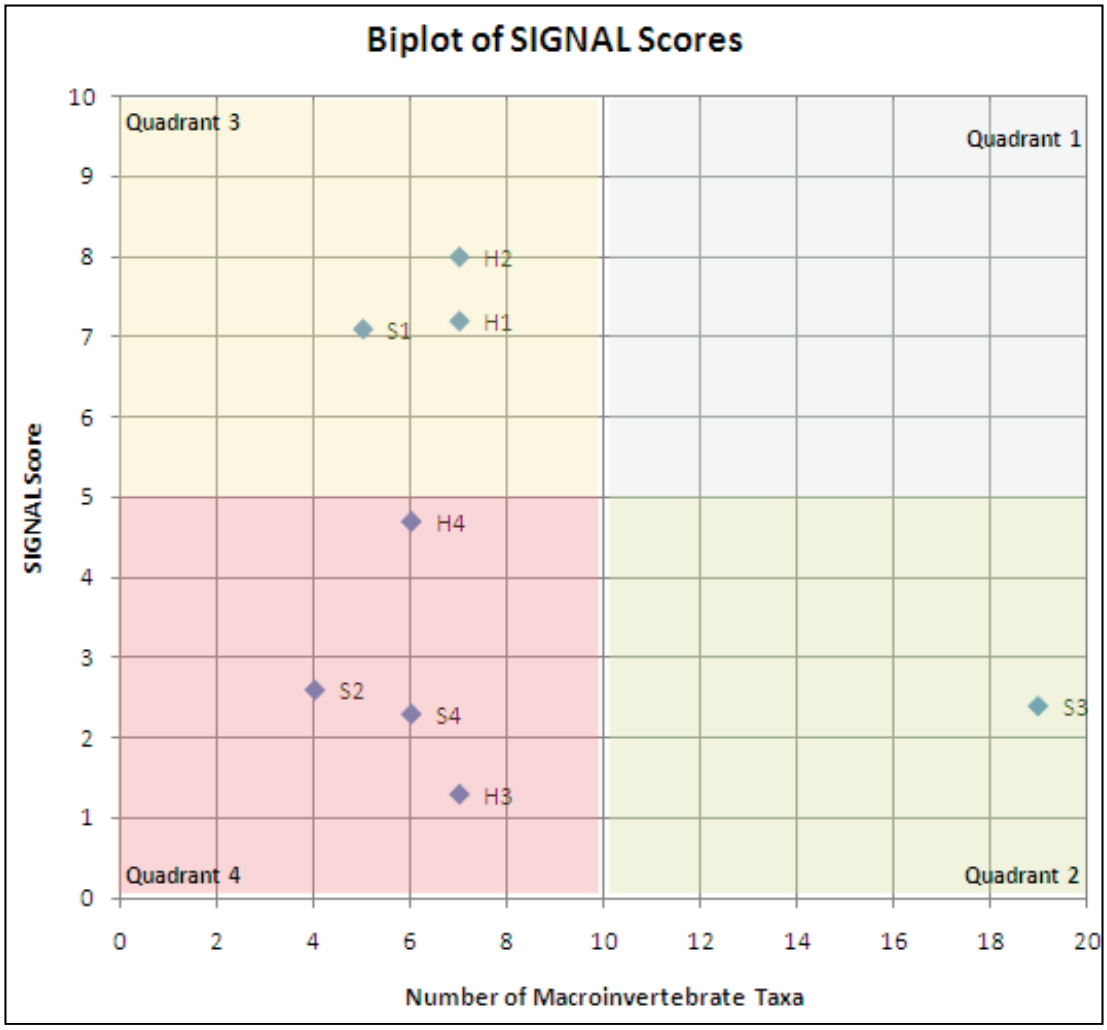


Figure 6.2 Biplot of the Condition of Each Aquatic Survey Site According to SIGNAL Scores

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.

6.5.3 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 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 6.14** 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).

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; Rutherfurd, Jerie 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.

Table 6.14 Vertebrate Fauna Recorded in the Hunter River

Scientific Name	Common Name	Native/ Introduced	Most recent record
Anguilla australis	Short-finned Eel	N	2010
Anguilla reinhardtii	Long-finned Eel	N	2010
Craterocephalus amniculus	Darling River Hardyhead	Species of concern- locally threatened	2010
Potamalosa richmondia	Freshwater Herring	N	2010
Cyprinus carpio	Common Carp	Alien	2009
Gobiomorphus australis	Striped Gudgeon	N	2010
Gobiomorphus coxii	Cox's Gudgeon	N	2010
Hypseleotris klunzingeri	Western Carp Gudgeon	N	1971
Hypseliotris compressa	Empire Gudgeon	N	2010
Philypnodon grandiceps.	Flathead Gudgeon	N	2009
Philypnodon macrostomus	Dwarf Flathead Gudgeon	N	2009
Galaxias brevipinnis	Climbing galaxias	N	2001
Galaxias olidus	Mountain galaxias	N	2001

Table 6.14 Vertebrate Fauna Recorded in the Hunter River

Scientific Name	Common Name	Native/ Introduced	Most recent record
Mugil cephalus	Sea Mullet	N	2010
Trachystoma petardi (syn. Myxus petardi)	Freshwater Mullet/ Pink-eye Mullet	N	2010
Macquaria novemaculeata	Australian Bass	N (Stocked)	2009
Tandanus tandanus	Freshwater Catfish / Eel-tailed Catfish	N	2009
Gambusia holbrooki	Plague Minnow/ Mosquito Fish	Alien	2009
Retropinna semoni	Australian Smelt	N	2009
Oncorhynchus mykiss	Rainbow Trout	Alien (Stocked) 2010	2010
Salmo trutta	Brown Trout	Alien (Stocked)	2010
Notesthes robusta	Bullrout	N	2010
Chelodina longicollis	Eastern Snake-necked Turtle/ Long-necked Tortoise		2008

Source: (Howell and Creese 2010)

6.5.4 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

Impact Assessment

This Chapter considers the ecological impacts of the Project on the Study Area and surrounding landscape, including the minor additional mining areas at Drayton Mine. This Chapter focuses particularly on the Study Area, which has been shown to retain an important degree of biodiversity value.

The Study Area is located within a region that has already been substantially altered by long-term vegetation clearing for agriculture, thoroughbred horse breeding, vineyards and coal mining. This has resulted in a highly disturbed and fragmented landscape. Despite this, the Study Area has been shown to support a high diversity of threatened flora and fauna and ecological communities, as described in **Chapter 5** and **Chapter 6**.

The ecological impacts of the Project are largely related to direct habitat loss and degradation of remaining habitat in the context of the locality. The loss of native vegetation and habitat that is necessitated by the Project will directly and indirectly impact on flora and fauna assemblages. Cumulative impacts to flora and fauna within the locality, the duration and timing of impacts, and the permanence and reversibility of impacts are also discussed.

The Project will be staged such that vegetation clearing will be conducted progressively over the life of the Project in concurrence with rehabilitation and revegetation works, so that the impacts can be minimised as far as practicable at all stages of the Project. Rehabilitation and revegetation work will aim to restore grassland and tree cover on mined land throughout the course of the Project.

7.1 Direct Loss of Vegetation and Habitat

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, McIvor et al. 2002). Approximately 1928 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 389 ha of forest and woodland communities and 107 ha of Derived Native Grassland will impact the vegetation communities of the Study Area, both threatened and non-listed, by reducing their overall extent. 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 7.1**.

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 7.1.3**);
- 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 7.1.4**);
- Reducing connectivity by removing areas of woodland and forest that would serve as "stepping stones" for mobile fauna in an otherwise cleared landscape (**Section 7.1.5**);
- Increasing edge effects, particularly along linear patches (**Section 7.1.6**);
- 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.

Offset strategies have been developed to address and counter such predicted impacts. These are discussed in **Chapter 9**.

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 5.2**). 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

Vegetation Community*	Status		Area of Vegetation (ha)		Proportion to be Disturbed
	TSC Act	EPBC Act	Within Study Area	Within Disturbance Footprint	
Central Hunter Bulloak Forest Regeneration	-	-	26	25	96%
Hunter Valley River Oak Forest	-	-	2	2	100%
Central Hunter Box-Ironbark Woodland	EEC	-	479	181	38%
Hunter Floodplain Red Gum Woodland	EEC	CEEC	40	11	28%
Narrabeen Footslopes Slaty Box Woodland	VEC	-	100	98	98%
Upper Hunter White Box-Ironbark Grassy Woodland	EEC	CEEC	94	63	67%
Cooba Scrub	-	-	65	9	14%
Planted Vegetation	-	-	9	0	0%
Derived Native Grassland - Hunter Floodplain Red Gum Woodland	EEC	CEEC	10	4	40%
Derived Native Grassland - Upper Hunter White Box-Ironbark Grassy Woodland	EEC	CEEC	159	103	65%
Other Grassland	-	-	3613	1432	40%
TOTAL			**4597**	**1928**	**42%**

**nomenclature based on Peake (2006)*

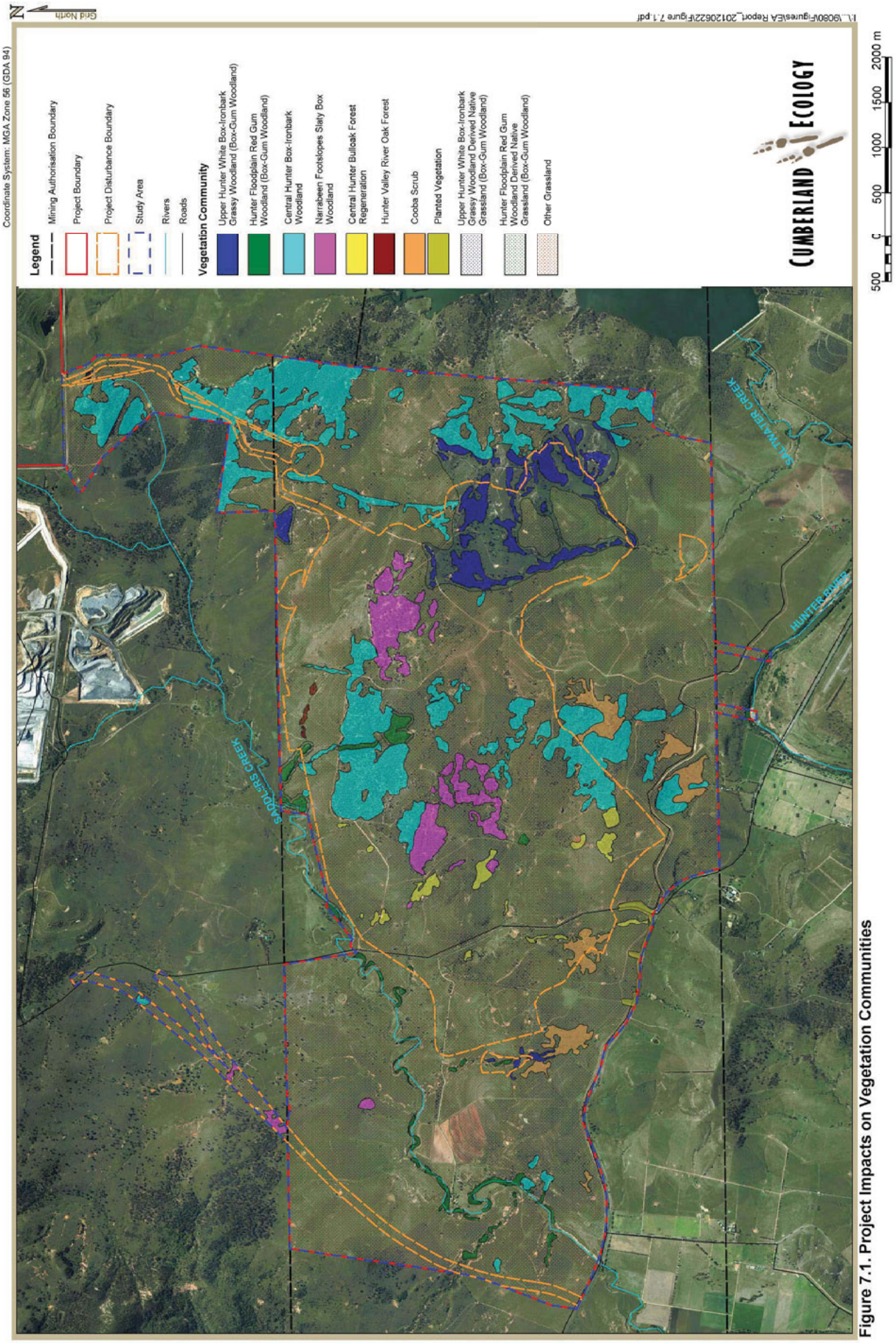


Figure 7.1. Project Impacts on Vegetation Communities

7.1.1 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 community (see **Appendix I**).

i. Box-Gum Woodland

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

- Approximately 63 ha of Upper Hunter White Box-Ironbark Grassy Woodland and 103 ha of native grassland derived from this community, which represent a respective 67% and 65% of the total extent of these communities in the Study Area; and

- Approximately 11 ha of Hunter Floodplain Red Gum Woodland and 4 ha of native grassland derived from this community; which represent a respective 28% and 40% 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 181 ha, which would represent approximately 60% of the onsite extent of the community (*c.f.* **Figure M.1** and **Figure M.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 2.9% of the Central Hunter distribution estimated for Upper Hunter White Box-Ironbark Grassy Woodland; and 3.4% 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 only 0.07% of the estimated State-wide distribution (DECCW (NSW) 2010b).

Notwithstanding the above, Box-Gum Woodland is a Commonwealth-listed CEEC and a State-listed EEC 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 (NSW) 2010b). 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 (NSW) 2010b).

In NSW, Box-Gum Woodland has suffered a large decline; less than 10% of its original extent is estimated to remain (DECCW (NSW) 2010b). 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 (NSW) 2010b). 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 (NSW DECCW, 2010). 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 181 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.

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 **Chapter 9**). 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 181 ha of Central Hunter Box – Ironbark Woodland from the Study Area. This represents approximately 38% of the total extent in the Study Area and 1.1% 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 Central Hunter Box – Ironbark 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 Central Hunter Box – Ironbark Woodland.

iii. Narrabeen Footslopes Slaty Box Woodland

The Project will remove approximately 98 ha of Narrabeen Footslopes Slaty Box Woodland, which represents approximately 98% of the total extent in the Study Area and 3.6% of the estimated extent in the Central Hunter region.

Narrabeen Footslopes 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 Footslopes 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 Footslopes 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 Footslopes 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 Footslopes 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 9.1**). 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 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 8.2.2**).

7.1.2 Groundwater Dependent Ecosystems (GDEs)

As described in **Chapter 5**, the occurrence of GDEs in the Study Area is likely to be represented by two communities: *Hunter Floodplain Red Gum Woodland* and *Hunter River Oak Forest* as indicated by the presence of *Eucalyptus camaldulensis* (River Red Gum) and *Casuarina cunninghamiana* (River Oak).

It is difficult to ascertain the degree of dependence of terrestrial ecosystems on groundwater. In the Hunter region where watercourses are typically ephemeral and historically have been degraded due to surrounding land use and water extraction, it is likely that communities characterised by *Eucalyptus camaldulensis* (River Red Gum) and *Casuarina cunninghamiana* (River Oak) trees have a moderate reliance, but not a complete dependence, on groundwater. It is unlikely that the Project will have a significant impact on GDEs.

7.1.3 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,

Fischer et al. 2006; Rawlings, Freudenberger 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, Crane 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, Freudenberger 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, McCarthy 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, Lindenmayer 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, Lindenmayer et al. 2002). As such, hollows are a resource in disproportionately high demand compared to the availability of suitable cavities (Lindenmayer, Cunningham et al. 1990; Newton 1994; Gibbons and Lindenmayer 2002; Heinsohn, Murphy 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, hmus 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, Martin 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-listed winter migrants Regent Honeyeater and Swift Parrot (ECC 2001; Gibbons and Lindenmayer 2002; Gibbons, Lindenmayer 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 eel, 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 8.2.1**).

7.1.4 Habitat Fragmentation and Patch Size

The impacts of direct habitat loss can be exacerbated by fragmentation of nearby vegetation that is not cleared (Lindenmayer, Cunningham 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, Fischer 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, Cunningham 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, Cunningham 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.

7.1.5 Reduction or Loss of Habitat Connectivity

Habitat connectivity refers to the connectedness between patches of suitable habitat (Franklin 1993; Taylor, Fahrig et al. 1993; Keitt, Urbah 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, Cunningham 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 mobiles 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.

7.1.6 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, Peach 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, Franklin 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 *Phythopthora 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 Impacts to 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 on site, are regarded to have potential to occur.

There is no legal requirement to prepare an Assessment of Significance (also called the "Seven-part Test") when preparing an Environmental Assessment under Part 3A of the EP&A Act. However, a number of "Seven-part Tests" have been prepared as a risk assessment tool to determine which threatened flora and fauna listed under the TSC Act are most at risk from the Project (**Appendix I**). These tests examine TECs, populations and species that are known or have a high potential to occur within the Study Area, as assessed in a Likelihood of Occurrence Table (**Appendix G** and **H**).

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 Seven-part Test 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.

Five flora species and 21 fauna species have been recorded in the Study Area. The Seven-part Test indicates that without additional mitigation or compensation measures, the Project will have a significant impact upon Box-Gum Woodland, TSC-listed communities and a selection of the aforementioned woodland fauna. Without mitigation or compensatory measures, the Project will result in a net loss of forest and woodland habitat (approximately 380 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 and compensation measures to minimise adverse impacts resulting from the Project.

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 these small 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 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. Bothriochloa biloba (Lobed Blue Grass)

Lobed Blue Grass is listed as Vulnerable under the EPBC Act and was delisted from the TSC Act listing. Although it was only recorded in one location of the Study Area, the species is most likely to be more widespread. The species was recorded in Box-Gum Woodland that will be removed by the Project.

Individuals of the species will be removed by the Project; however, Anglo American has proposed a substantial Offsets Package to compensate for the loss of Lobed Blue Grass and its habitat. As such, the Project is not considered to result in a significant impact to the species.

iv. Diuris tricolor (Pine Donkey Orchid)

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) 2005j). 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 km^2. 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. However, 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.

v. Cymbidium canaliculatum (Tiger Orchid)

A single Tiger Orchid was recorded within the study area in habitat that will be removed by the Project.

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 has proposed a substantial Offsets Package to compensate for the loss of 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 I**).

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 (refer to **Table 6.2**).

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, Doerr et al. 2011); while Grey-crowned Babblers appear unable to travel over distances greater than 900 m (Blackmore, Peakall 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, Main 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, Lindenmayer 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 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 200m. 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, Judge 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 2004p; 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 Sheathtail-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 they have been recorded within the Muswellbrook and Singleton LGAs, with 21 and 77 species records respectively.

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 and Singleton LGAs are identified as localities 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 (**Table 3.2**), *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) is 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 M**, which contains a detailed summary of the assessment of MNES as required under the EPBC Act.

Table 7.2 Direct Loss of Native Vegetation and Habitat for MNES in the Study Area

Common Name	Preferred Habitat	Used For	Present or Likely to be Present	Area of Direct Impact (ha)
Box-Gum Woodland	-	-	Y	181
Weeping Myall Woodland	-	-	N	0
Regent Honeyeater	F, W	Infrequent Foraging; low	Y (low)	389

Table 7.2 Direct Loss of Native Vegetation and Habitat for MNES in the Study Area

Common Name	Preferred Habitat	Used For	Present or Likely to be Present	Area of Direct Impact (ha)
		numbers		
Swift Parrot	F, W	Infrequent Foraging; low numbers	Y (low)	389
Spotted-tailed Quoll	F, W	Foraging; low density	Y (low)	389
Koala	F, W	Foraging or movement	N	389
Greater Long-eared Bat	F, W	Foraging and roosting	Y	389
Green and Golden Bell Frog	Wetland	Foraging and breeding	N	0
Lobed Blue-grass	F, W, G	-	Y	1928
Finger Panic Grass	F, W, G on basalt	-	N	0
Leek-orchid	F, W, G	-	Y (low)	1928
Illawarra Greenhood	F, W, G	-	N	0
Austral Toadflax	F, W, G	-	Y (low)	0

7.4 Indirect Impacts

The Project is likely to have indirect impacts (Dale, Joyce et al. 2001) on the ecological values of the Study Area and surrounds. Many of these impacts are forms of environmental pollution (Spellerberg 1998; Rabin, McCowan 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, Main 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, Smith 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 Americas Limited 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 Americas Limited 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, Giraldo-Perez 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, McCowan et al. 2003; Chan, Giraldo-Perez et al. 2010).

The Project will generate significant noise during the construction of infrastructure and through routine mining operations. Traffic, particularly from large mining trucks and excavation machinery; explosions used during the mining phase; and noise from generators and machinery will elevate noise levels in the environment. This may potentially impact on various fauna species and affect the value of the habitats that remain (AMEC Americas Limited 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).

Research into impacts from altered lighting indicates that prolonged exposure can trigger behavioural and physiological responses that include but are not limited to:

- Disorientation and/or temporary blindness;
- Changes in foraging behaviour, such as when diurnal species extend foraging into the night-time (Longcore and Rich 2010);
- A disruption of seasonal day length cues which trigger critical behaviours (Longcore and Rich 2004; Saleh 2007; Longcore and Rich 2010);
- Suppression of the immune function (Bedrosian, Fonken et al. 2011);
- Alteration in the timing of reproduction which can decrease successful breeding and reduce fitness (Bedrosian, Fonken et al. 2011); and
- Interference with predator-prey relationships.

While the construction and operation phases of the Project will have some effect on the surrounding forest and woodland environment, the impacts from light pollution 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. It also has the potential to extend the area of impact beyond the mine footprint.

Plants will be 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 flora and fauna of the Study Area as the occurrence of regular meteorological events such as rainfall and wind will prevent dust accumulation becoming a serious problem. Any effects will be highly localised and unlikely to cause serious harm.

Over the duration of the project dust will diminish within areas that are progressively rehabilitated and, in the long term, dust levels should return to normal following rehabilitation of the total mined area and cessation of mining.

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 soil and land capability impact assessment (Drayton South EA, **Appendix Q**).

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 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, Joyce et al. 2001; Garkaklis, Calver et al. 2004) such as the fungus *Phytophthora cinnamon* which causes dieback (NSW Scientific Committee 2004l).

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, Thexton 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 presence of the feral 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).

Weeds and exotics 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 8.4** provides details regarding the BAP.

7.5 Impacts to the Hunter River Catchment

7.5.1 Water Quality and Habitat

The Project 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. As indicated by the FM Act, no threatened species, populations or ecological communities are expected to occur in the Study Area, and none will be impacted by the Project. 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.

7.5.2 Water Extraction and Discharge

As part of the Project, two water pipelines and associated pumping infrastructure will be installed from Drayton South down to the Hunter River, for the purpose of water extraction and discharge. 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 surface water model predicts that there is less than a 1% chance that offsite supplies will be required for the Project. That is, runoff from the Drayton Mine site catchments and dewatered groundwater can supply all of Drayton South's water requirements over the life of the Project (unless conditions were drier than the 99 percentile conditions). This is consistent with the existing operations at Drayton Mine, which has not needed to source water from offsite supplies over the life of the Project (WRM, 2012).

Further details with regard to the Projects water extraction requirements are detailed in the surface water impact assessment (Drayton South EA, **Appendix M**).

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.

ii. Water Discharge

It has also been determined by the Project's surface water impact assessment that during wetter periods there will be a requirement to discharge water into the Hunter River. This will be undertaken in strict accordance with the Hunter River Salinity Trading Scheme (HRSTS) for which Anglo American currently hold credits. In accordance with the HRSTS licence holders are only permitted to release water from site during peak flood flows in the Hunter River when salinity levels in the river are low. Further details of the Projects water discharge requirements are detailed in the surface water impact assessment (Drayton South EA, **Appendix M**).

As the discharges will occur during times of high flow, when salinity levels are low it is not expected that the increased salt will have any adverse impacts on the ecology of the Hunter River or on water quality.

7.6 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 1928 ha of vegetation, of which 389 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 5113 ha of forest and woodland and derived grassland. Approximately 1073 ha of this vegetation is Box-Gum Woodland. Another 835 ha of TSC-listed communities 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 **Chapter 9**.

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 Surrounding Locality (Muswellbrook LGA)

Vegetation Community	Development Project																			Total
	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	63	-	-	-	-	116.45	-	38	-	-	-	-				1.3				219
Hunter Floodplain Red Gum Woodland	11	-	-	-	-	-	0.3	10	0.66	-	<1	-				0.2				22
Total Box-Gum Woodland Communities	**74**	**0**	**0**	**0**	**0**	**116**	**0**	**48**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**241**
Central Hunter Box-Ironbark Woodland	181	-	-	-	-	2	-	-	24	-	473	22	9.62				1.02	0.8		713
Narrabeen Footslopes Slaty Gum Woodland	98	-	-	-	-	24.21	-	-	-	-	-	-						0.1		122
Other Native Forest & Woodland	36	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	586
Total Other Native Forest & Woodland	**315**	**6**	**8**	**38**	**0**	**124**	**53**	**49**	**48**	**0**	**559**	**24**	**14**	**7**	**10**	**25**	**2**	**1**	**140**	**1421**
Upper Hunter White Box-Ironbark Grassy Woodland Derived Native Grassland	103	-	-	-	-	699.54	-	-	-	-	-	-				24				827
Hunter Floodplain Red Gum Woodland Derived Native	4	-	-	-	-	-	-	-	-	-	-	-				0.6				5

Table 7.3 Cumulative Impacts on Vegetation in the Surrounding Locality (Muswellbrook LGA)

Vegetation Community	Development Project																			Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Grassland																				
Non-TEC Derived Native Grassland	1432	-	-	-	22	49.8	280	-	678	1.2	-	46	103.6			6.4				2619
Total Derived Grasslands	**1539**	**0**	**0**	**0**	**22**	**749**	**280**	**0**	**678**	**1**	**0**	**46**	**104**	**0**	**0**	**31**	**0**	**0**	**0**	**3451**
Total Native Forest, Woodland and Derived Grasslands	**1928**	**6**	**8**	**38**	**22**	**990**	**333**	**97**	**727**	**1**	**559**	**70**	**118**	**7**	**10**	**58**	**2**	**1**	**140**	**5113**
TOTAL BOX-GUM WOODLAND (incl. Grassland) (CEEC)	**181**	**0**	**0**	**0**	**0**	**816**	**0**	**48**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**26**	**0**	**0**	**0**	**1073**

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	*Mt Arthur Coal Ventilation Shaft (2006)*
11	*Ravensworth Operations (2010)*
12	*Ravensworth Narama Extended Project (2009)*
13	*Bayswater B Powerstation (2009)*
14	*Mangoola Mine Modification 4 (2010)*
15	*Bayswater to Mt Piper transmission line relocation - modification to Mangoola Coal Mine Plans and Relocation of 500kV electricity transmission line (2010)*
16	*Mount Pleasant Modification (2010)*
17	*Liddell Power Station North-South Gas Pipeline (2009)*
18	*Liddell Power Station East-West Gas Pipeline (2008)*
19	*Hunter Valley Operations South Coal Project (2008)*

7.7 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.

Mining operations at Drayton South will commence in the Whynot, Blakefield, Redbank and Houston mining areas generally progressing north to south. Approximately 1928 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 some 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 27 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.

7.8 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, 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. 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.

7.9 Summary of Impacts

The major impact of the Project will be from the clearance of broad areas of remnant forest and open woodland and removal of biodiverse habitats and important resources such as tree hollows and ground debris for a range of flora and fauna species. Despite the already altered nature of the Study Area, without substantial ameliorative measures the Project would add significantly to ecological impacts within the locality by exacerbating the loss of native vegetation and habitat for many species. For this reason, substantial ameliorative measures, including avoidance, mitigation and compensation, are an integral part of the Project.

With the implementation of these mitigation measures it is not expected that the Project will have a significant impact on threatened species, endangered populations or TECs. These measures are discussed in detail in **Chapter 8** and **Chapter 9**.

Chapter 8

Impact Mitigation

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 onsite and offsite biodiversity offsets to minimise the impact of the Project on biodiversity.

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, have been compensated to offset what would otherwise be a net loss of habitat.

The following sections of this chapter outlines the impact avoidance and mitigation measures proposed for the Project, and **Chapter 9** contains details of the Biodiversity Offsets Package (BOP) that has been developed to compensate for the residual impacts of 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 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. The mine layout has been limited to the ridgeline, which has considerably limited the coal resource for the Project but which has important ecological and visual benefits. 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.

8.2 Measures to Mitigate Impacts

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 – protects 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 – benefit fauna by reducing the potential for disturbance of animals in habitat patches around the mine; and
- Lighting management – benefit fauna by reducing the potential for disturbance of nocturnal 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.

8.2.1 Minimising Vegetation and Habitat Loss

During the detailed design stage, opportunities to further minimise vegetation disturbance will be considered. However, disturbance to areas of native vegetation and habitat is likely to be largely unavoidable during the construction process. 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* (Tiger Orchid) 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.

8.2.2 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 (see **Chapter 9**).

A number of guidelines are currently being proposed by DP&I and OEH for the restoration of ecosystems of the Hunter Valley, including endangered ecological communities. Anglo American is committed to conducting all restoration works generally in accordance with any relevant guidelines that may be made available by DP&I and OEH. Such guidelines are likely to provide guidance on:

- Improving biodiversity outcomes for areas that have been mined where the mine approval completion criteria for rehabilitation requires the establishment of functioning ecosystems on the mine disturbance site, and ongoing management and monitoring;
- Achieving restoration and improved biodiversity outcomes for offset lands, including the following:
  - Land secured as offsets that may be within the mining lease that are not disturbed by mining activities; and
  - Land secured as an offset on privately owned land under a Biobanking Agreement, conservation covenant or another appropriate mechanism.

Restoration of forest and woodland to a structural complexity with diverse age classes comparable to the original community structure will take many decades, but natural regeneration will be achieved with supplemented revegetation in a manner consistent with the above guidelines. Furthermore, 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.

Further details of specific areas that will be rehabilitated within the Study Area are presented in **Chapter 9**.

8.3 Monitoring and Reference Sites

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 (see **Chapter 9**). 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. More detailed prescriptions for reference sites and monitoring strategies will be incorporated into the BAP (see **Section 8.4**), including a framework for reporting on the results of the monitoring.

8.3.1 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 (International Council on Mining and Metals, 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 (International Council on Mining and Metals, 2006). Appropriate locations for reference sites will be determined in consultation with relevant government agencies as part of the finalisation of the BAP.

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 during the preparation of the BAP.

8.3.2 Monitoring

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.

i. 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.

ii. 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).

8.4 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:

- Detailed design of mitigation measures such as fencing, rehabilitation and soil conservation;
- Pre-clearing surveys and fauna rescue or translocation where practical;
- Vegetation clearing protocols;
- Rehabilitation and restitution of adjoining habitat where possible;
- Control and ongoing management of environmental and noxious weeds;
- Control and ongoing management of feral animals;
- Restoration and rehabilitation methods and protocols; and
- Details of the ecological monitoring program.

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.

Chapter 9

Biodiversity Offset Package

9.1 Introduction

This chapter presents the Biodiversity Offset Package (BOP) that has been developed to offset the residual impacts of the Project on flora and fauna, once the avoidance and mitigation measures outlined in **Chapter 8** have been implemented. The BOP addresses the residual impacts of the Project in a strategic and meaningful way that will deliver a real biodiversity outcome, and will ensure that the Project does not result in a net loss of biodiversity values. The Project adopts a "maintain or improve" approach, which is defined as:

> "*…increasing the net area and condition of ecological communities within the locality of the proposed development in the medium to long term by permanently conserving and improving the condition of representative examples of vegetation communities and habitats for threatened species that are to be impacted by the proposed development.*"

The BOP will also 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 BOP is based upon the key principles of offsetting summarised in **Appendix J**, particularly that:

- Offsets should be targeted to the ecological communities and threatened species that will be impacted by the Project;

- Offsets should be commensurate with the magnitude of the impacts; that is, there should be a net increase in the size and condition of the community types, populations or habitat types that will be impacted by the Project; and

- Offsets should be lasting; that is, there should be a level of legal protection for offset areas.

An evaluation of the BOP against the key offsetting principles outlined in the NSW and Commonwealth offsetting policy documents (OEH 2011a; SEWPaC 2012) is provided at the end of **Chapter 10**.

9.1.1 BOP Components

The BOP consists of two main components that together ensure the best compensatory outcomes are achieved for the predicted ecological impacts of the Project. These measures have been designed to meet State and Commonwealth offsetting requirements and protect and improve biodiversity within the locality with the most efficient utilisation of resources.

The first component is referred to as the **onsite offsets**. The BOP will concentrate on rehabilitation efforts on available land within the Study Area as a priority. The onsite offsets will involve the following:

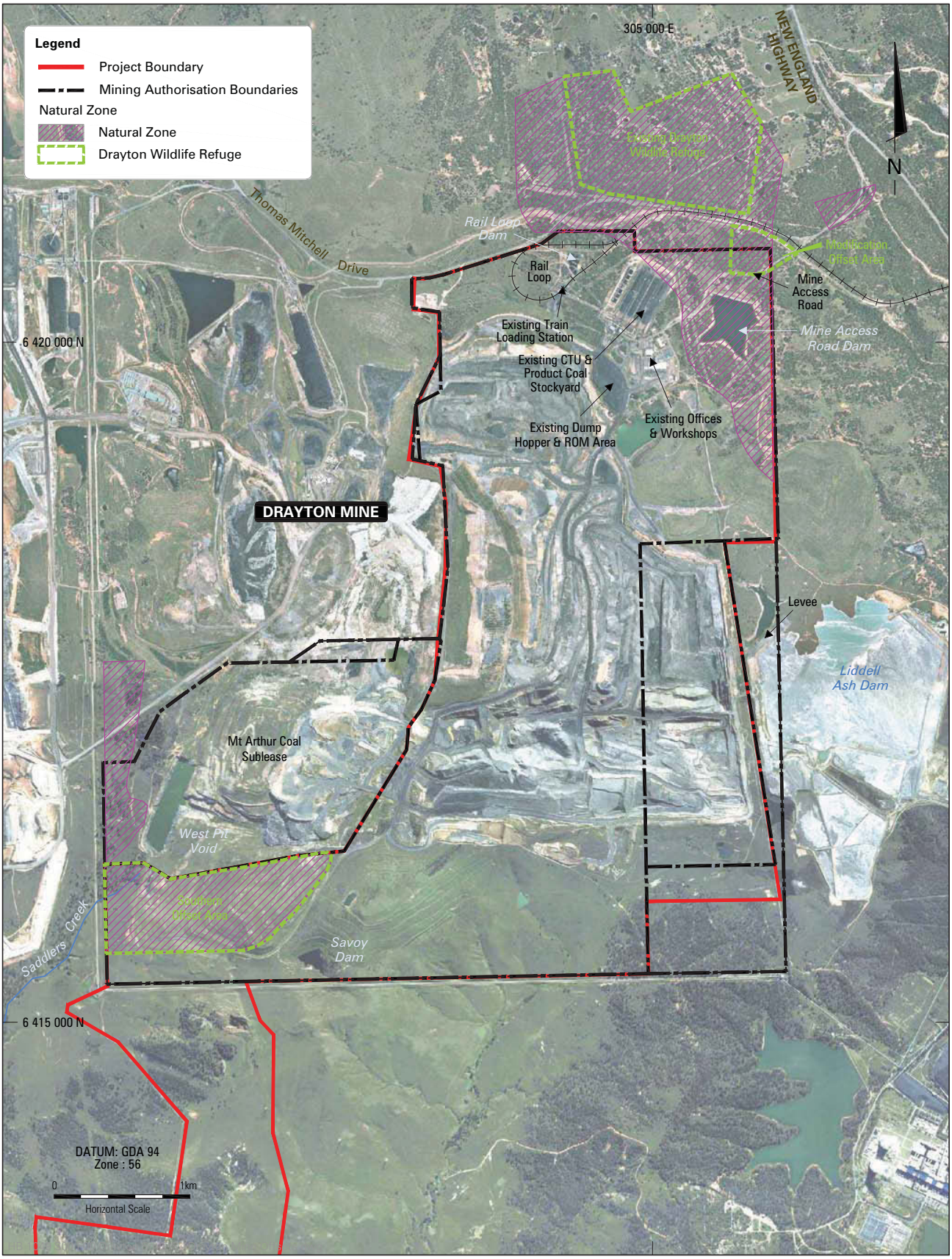
- Restoration of Saddlers Creek;

- Conservation of areas proposed for retention along the primary ridgeline of the Study Area; and

- Rehabilitation of the Project Disturbance Footprint

The onsite offsets have been developed to maximise the opportunities for conservation *in situ* and will address a significant proportion of the Project's offsetting commitments. Notwithstanding this, the onsite offsets will not meet all of the Project's requirements and additional offsets are necessary to ensure that the Project will not result in a net loss in biodiversity.

Anglo American explored opportunities to expand on Drayton Mine's current offsets, which are proximate to the Study Area. Drayton Mine's current offsetting commitments include the Drayton Wildlife Refuge, which was established and gazetted the Drayton Wildlife Refuge in 1987 under Section 68 of the *National Parks and Wildlife Act 1974* (NP&W Act). The refuge designates specific areas for wildlife conservation whilst reserving other areas for mining and grazing purposes. Following the approval of MOD1 in 2009, two additional offset areas were created; the Modification Offset Area and the Southern Offset Area. Both areas have been incorporated into and managed in accordance with the Drayton Wildlife Refuge (see **Figure 9.1**).



DRAYTON SOUTH COAL PROJECT

Drayton Mine Existing Offsets

FIGURE 9.1

Further areas of natural remnant vegetation, also referred to as the '*Natural Zone'*, are also managed to improve the condition of native flora and fauna.

As such, there is little opportunity to expand on the Drayton Wildlife Refuge. Therefore, Anglo American has decided that **offsite offsets** should form a second component of the BOP to complement the onsite offsets proposed for the Study Area. Anglo American is committed to the targeted acquisition of an offsite offset property for use as biodiversity offsets.

9.1.2 Minimum Offset Requirements

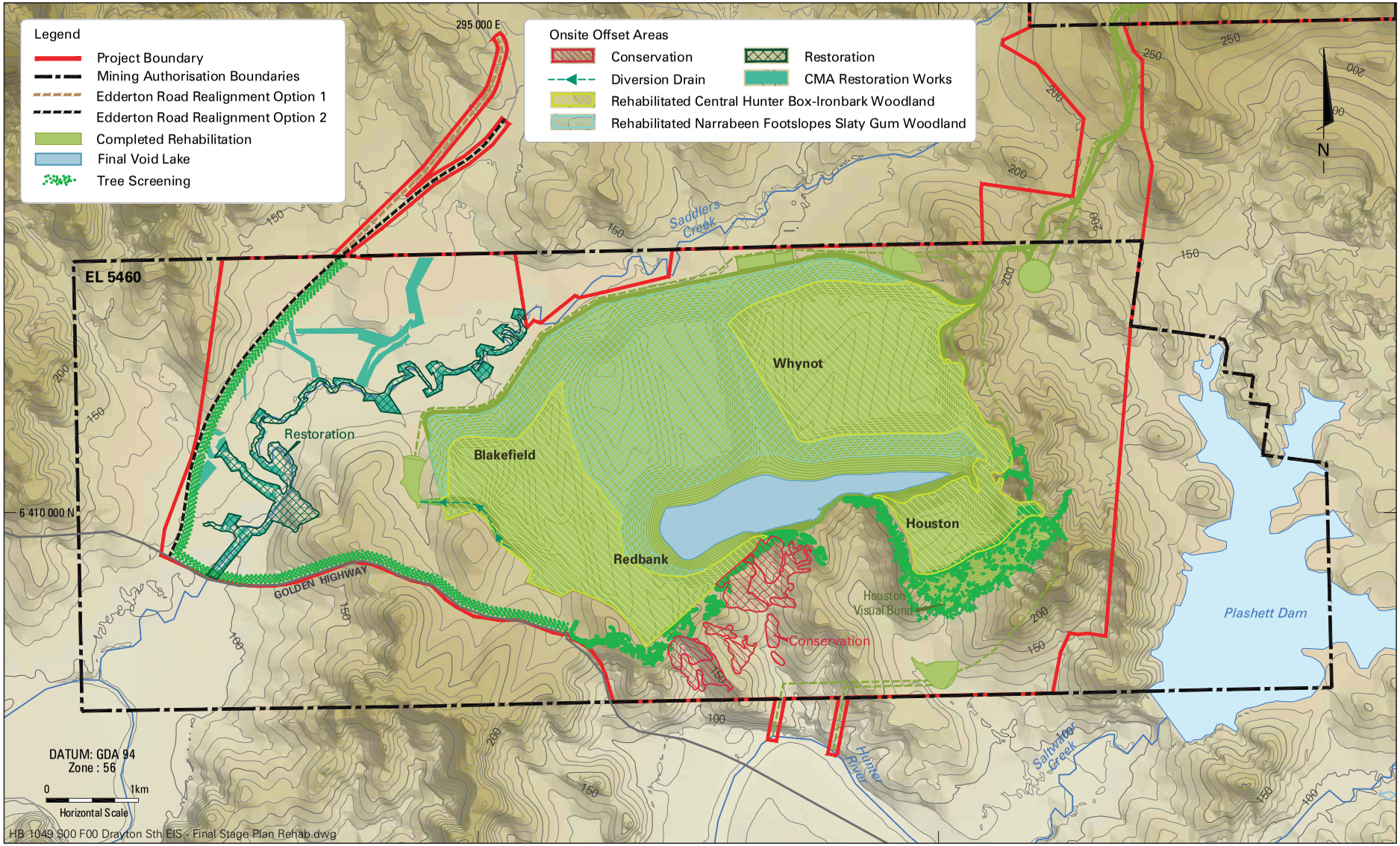
For the purpose of establishing minimum size thresholds for the BOP, a ratio of 6:1 for Box-Gum Woodland and a ratio of 3:1 for the remaining native vegetation, including State-listed and non-listed communities, have been adopted. Considering that the anticipated loss of Box-Gum Woodland is 181 ha and the loss of remaining native forest and woodland vegetation is 315 ha, the minimum offset area required to compensate for the Project impacts is 2031 ha (i.e. the sum of 1086 ha of Box-Gum Woodland and 945 ha of other native vegetation). A detailed summary of the minimum offsetting requirements for the Project is provided in **Table 9.1** and a summary of the component areas proposed by the BOP is presented in **Table 9.2**. These components are illustrated in **Figure 9.2** and are described in more detail in the following sections.

Table 9.1 Total Offset Areas Required for the Project

Vegetation Community	Area of Vegetation within Disturbance Footprint (ha)	Ratio	Offsets Required (ha)
Central Hunter Bulloak Forest Regeneration	25	3:1	75
Hunter Valley River Oak Forest	2	3:1	6
Upper Hunter White Box-Ironbark Grassy Woodland	63	6:1	378
Hunter Floodplain Red Gum Woodland	11	6:1	66
Central Hunter Box-Ironbark Woodland	181	3:1	543
Narrabeen Footslopes Slaty Gum Woodland	98	3:1	294
Cooba Scrub	9	3:1	27
Planted Vegetation	0	N/A	N/A
Derived Native Grassland - Hunter Floodplain Red Gum Woodland	4	6:1	24
Derived Native Grassland - Upper Hunter White Box-Ironbark Grassy Woodland	103	6:1	618
Other Grassland	1432	N/A	N/A
TOTAL	**1928**		**2031**

Table 9.2 Offsetting Areas Proposed within the BOP

Vegetation Community	Offsets Required (ha)	Saddlers Creek Restoration (ha)		Ridgeline (ha)	Onsite Rehabilitation (ha)		Min. Offsite Offsets Required (ha)
	(from Table 9.1)	Existing Available Offsets	Restoration Offsets	Existing Available Offsets	Ratio	Existing Available Offsets	
Central Hunter Bulloak Forest Regeneration	75	0	0	0		0	75
Hunter Valley River Oak Forest	6	0	0	0		0	6
Upper Hunter White Box-Ironbark Grassy Woodland	378	0	0	0		0	378
Hunter Floodplain Red Gum Woodland	66	20	62	0		0	0
Central Hunter Box-Ironbark Woodland	543	4	0	50	0.5:1	777	0
Narrabeen Footslopes Slaty Gum Woodland	294	0	0	0	0.5:1	626	0
Cooba Scrub	27	0	0	35		0	0
Planted Vegetation	N/A	N/A	N/A	N/A		N/A	N/A
Derived Native Grassland - Hunter Floodplain Red Gum Woodland	24	0	0	0		0	24
Derived Native Grassland - Upper Hunter White Box-Ironbark Grassy Woodland	618	0	0	0		0	618
Other Grassland	N/A	N/A	N/A	N/A		N/A	N/A
TOTAL	**2031**	**24**	**62**	**85**		**1403**	**1101**



DRAYTON SOUTH COAL PROJECT

Conceptual Drayton South Final Landform

FIGURE 9.2

9.2 Onsite Offsets

Anglo American is committed to meeting a significant portion of their offset requirements onsite through the restoration of Saddlers Creek, rehabilitation of the Project Disturbance Footprint and retention and protection of vegetation along the primary ridgeline of the Study Area. These are discussed in more detail below.

9.2.1 Restoration of Saddlers Creek

The restoration of Saddlers Creek will involve the retention and improvement of 24 ha of existing vegetation that is situated within the immediate vicinity of Saddlers Creek. In addition to this, there is an opportunity to restore an additional 62 ha of Hunter Floodplain Red Gum Woodland through the planting of native vegetation. This restoration work will be carried out in conjunction with the CMA (see **Appendix K**). Various aspects of the proposed Saddlers Creek restoration program are discussed below.

i. Wildlife Corridor Values

Connectivity of new and existing offsets will be provided for in the long term through implementation of a connected system of corridors and habitat patches across the Project, and linkages to other wildlife reserves and areas of native habitat in the locality. Wildlife corridors connecting key areas of habitat increase the effective amount of habitat that is available for species and reduces the impacts of habitat fragmentation. This is especially important for migratory animals and those with large home ranges. Larger habitats support greater biodiversity, larger populations, and a wider range of food sources and shelter. Corridors also allow populations to interbreed, improving long-term genetic viability.

The key wildlife corridor being established by the Project is around Saddlers Creek, where the implementation of an intensive creek corridor restoration program will enhance its ability to act as a wildlife corridor. This strategy has been developed in consultation with the CMA and involves the rehabilitation of the lower reaches of Saddlers Creek to the west of Edderton Road and restoration of riparian vegetation and Box-Gum Woodland around the core creekline. This will improve the area and condition of existing vegetation communities such as Central Hunter Box-Ironbark Woodland and Hunter Floodplain Red Gum Woodland in this area.

ii. Improvement of Creekline Condition and Function

Due to extensive agricultural practices and erosion, natural recruitment of native plant species along Saddlers Creek is low, and continues to be suppressed by grazing cattle and feral animals. A wide, dense riparian zone comprised of local provenance species will be regenerated along the length of Saddlers Creek to provide habitat for native fauna and flora, stabilise the channel banks and link with already existing communities to form broader habitat corridors. To minimise erosion, the upper banks and flats of Saddlers Creek will be stabilised with rapid growing native groundcover. The exclusion of stock will be critical for the rehabilitation of vegetation around Saddlers Creek as cattle exacerbate soil erosion by direct soil disturbance from their hooves, and by removing ground cover vegetation that stabilises the soil. Therefore fencing will be installed to exclude stock, but allow native

animals to utilise the revegetated areas for forage and nesting habitat and as a movement corridor.

These efforts will collectively enhance the ecological function of Saddlers Creek by:

- Extending riparian communities along the extent of Saddlers Creek and its tributaries that lie within the Study Area. This will improve the habitat and water quality of Saddlers Creek and stabilise highly eroded creek banks;
- Establishing fully viable and self-sustaining ecological communities, such as Central Hunter Box-Ironbark Woodland and Hunter Floodplain Red Gum Woodland, in cleared agricultural areas within the corridor by excluding cattle, implementing assisted natural regeneration methods and supplementary planting from tube stock to create and/or increase structural complexity;
- Building on wildlife movement and offset corridors along Saddlers Creek by linking other parts of the catchment that are already being managed and restored for conservation within land owned by Mt Arthur Coal and Drayton Mine. Extending green corridors from these sites in the north, through the Study Area to the Hunter River in the south, will secure a substantial area of high quality habitat for native fauna that will be conserved in the long-term; and
- Reducing the extent of invasive weed species and feral animal abundance within the Saddlers Creek corridor to both remove pressures from regenerating species and improve native biodiversity in the locality.

Adjacent gullies and watercourses to Saddlers Creek that also are within the Study Area will also be rehabilitated. There may be some potential to return the creeks to close to their natural condition by rehabilitating the incised channels and stabilising 'chains of ponds' where possible. Some sections of Saddlers Creek still show evidence of this morphology in deep, permanent pools separated by sediment, however most are lacking native vegetation to stabilise the channels and are subject to further degradation by cattle.

Actions to be taken in the restoration of Saddlers Creek and adjacent gullies include:

- Protecting existing ponds from damage by excluding livestock and fencing riparian areas;
- Densely vegetating the instream within Phragmites and other aquatic vegetation to trap sediment and prevent erosion;
- Creating pools and sediment bars by creating rock weirs;
- Soil conservation earthworks; and
- Reinstating snags and woody debris to provide habitat complexity for aquatic fauna.

Soil conservation earthworks are required in the proposed Saddlers Creek rehabilitation area to ensure the stability of soils and long term viability of the land. A number of soil conservation measures for Class IV to VII soils, as recommended by CMA, will be implemented including graded contour banks and contour ripping. Existing contour banks will be reshaped and extended, or removed if they are no longer functionally viable. Additional low gradient contour banks will be constructed across creek and tributary slopes with the aim of increasing the amount of water retained in the Saddlers Creek catchment. These banks will intercept and slow runoff, spread water across grassed floodplain areas, and will divert flows from degraded areas to minimise channel flow velocity and limit further gully and bank erosion. Graded banks can also help prevent contamination of the waterways by filtering and trapping sediment brought from overland flow, particularly from rills and old gully lines (Department of Environment and Resource Management 2004).

To enhance the effectiveness of the contour banks, native groundcover plants will be sown between contour banks to reduce run off velocities of water and trap sediment and help reduce their maintenance costs (Department of Environment and Resource Management 2004). Groundcover species will be locally endemic and suitable for the soil type.

Further details of the actions required to be implemented in the restoration of Saddlers Creek will be contained in the BAP (**Section 8.4**).

iii. Augmentation of Adjacent Conservation Works

The restoration of the Saddlers Creek corridor and improving the condition of existing vegetation within the immediate vicinity is a valuable compensatory measure as it represents "like for like" or better as an outcome. Anglo American in association with the CMA, has established credentials for previous project work with *Eucalyptus camaldulensis* (River Red Gum) restoration along the Hunter River and Dart Brook at the Dartbrook Mine, and has the necessary expertise to conduct this work (see **Section 9.1.1iv** below). Furthermore, there is potential to create a catchment-based offset, which is the CMA's approach to land management. This will build on and complement existing offsets along Saddlers Creek managed by Mt Arthur Coal, and CMA works in other tributaries of Saddlers Creek. Mt Arthur Coal's proposed Saddlers Creek Conservation Area is approximately 295 ha in size, and includes the main channel of Saddlers Creek, running along the southern and south eastern boundaries of the Mt Arthur Coal Boundary. By building on Mt Arthur Coal's biodiversity offset areas, the Project will add value and help create a substantial conservation area in the locality that is of ecological significance as it contains:

- Known threatened species;
- Known regionally significant species;
- Presence of a substantial number of tree hollows;
- Known examples of the Tiger Orchid (*Cymbidium canaliculatum*) Endangered Population;
- Riparian corridor values along Saddlers Creek;

- Linkages to Drayton Mine's southern offset area over the offsite portion of Saddlers Creek and proximity to Drayton Wildlife Refuge; and
- Remnants of threatened vegetation communities including:
  - White Box Derived Native Grassland;
  - Hunter Floodplain Red Gum Woodland; and
  - Central Hunter Box - Ironbark Woodland.

Furthermore, the restoration of Saddlers Creek will address the following EAR:

> *"An offset strategy to ensure that the project maintains or improves the biodiversity values of the region in the medium to long term (in accordance with NSW and Commonwealth policies), paying particular attention to the existing Saddlers Creek Conservation Area and Mt Arthur Coal's biodiversity offset areas".*

iv. Case Study - Success of Anglo American's Dartbrook River Restoration Project

In 2005, a joint project between Anglo American and the CMA was established to improve the health of a 6.5 km section of the Hunter River and Dart Brook, both degraded watercourses in the region, at Dartbrook Mine north of Muswellbrook. The objectives of the 5 year project were various riverbank and stream bed rehabilitation and restoration works at 7 sites that aimed to:

- Protect and enhance a 12 ha area containing one of the largest remaining populations of River Red Gum (*Eucalyptus camaldulensis*), an endangered population in the Hunter Catchment;
- Promote natural regeneration within natural and artificial (through irrigation and bunds) flood areas in conjunction with the planting of 4000 seedlings amidst the remnant population, such that the River Red Gum community is self-sustaining;
- Increase native vegetation density and diversity;
- Provide habitat and a habitat corridor for native fauna, particularly birds, by planting dense patches of habitat species in all strata;
- Minimise further riparian and stream biodiversity loss;
- Manage introduced species and weed infestations;
- Prevent further bank instability and erosion by excluding stock and planting along the riparian corridor; and
- Improve channel bed stability, water quality and flow regimes, protect upstream Chain-of-Ponds streams and restore fish habitat (fish 'hotels') and native fish

stocks through the strategic in-stream placement of large logs (with I&I (NSW) and CMA).

Ongoing management, including periodic inspections by the CMA and monitoring undertaken by external consultants using methodology determined with the CMA, has determined that these works are progressing well. Further rehabilitation and restoration works were allowed in 2011, subsequent to completion of the project in 2010, with the renewal of a Scientific Licence issued under Section 132C of the NPW Act. As of the beginning of 2011, successfully completed activities included:

- River Red Gums that had naturally regenerated during a 2007 flooding event were found to be thriving within the constructed bunds;
- Tree growth such that tree guards could be removed;
- Strategic removal of Weeping Willows (*Salix* sp.) and the ongoing management of noxious weeds including African Boxthorn, Bathurst Burr and Green Cestrum;
- Trapping of feral pigs, undertaken in conjunction with Livestock Health and Pest Authority (LH&PA);
- Placement of fish hotels;
- Ongoing maintenance including weed and pest control, as well as infill planting in areas that have a low survival rate of seedlings.

Thus, Anglo American has a proven track record for creekline restoration works. The Saddlers Creek Restoration Project will be undertaken by Anglo American in conjunction with the CMA in a similar partnership as that at Dartbrook Mine and is expected to be effective and deliver on the conservation objectives outlined for the BOP.

9.2.2 Onsite Conservation of Vegetation

In addition to the rehabilitation of native vegetation along Saddlers Creek, approximately 85 ha of existing vegetation along the primary ridgeline in the Study Area will be conserved, including Central Hunter Box-Ironbark Woodland (which is an EEC) and Cooba Scrub. These areas will have direct connectivity with adjacent revegetated communities established as part of the mine rehabilitation.

Areas of native vegetation that will be conserved in the Study Area will be managed for conservation including weed and feral animal control and other management actions as required for maintaining and enhancing their conservation value. Details of the management procedures to be implemented in these areas of retained native vegetation will be contained within the BAP (see **Section 8.4**).

9.2.3 Rehabilitation and Revegetation of the Project Disturbance Footprint

The Project Disturbance Footprint will be progressively rehabilitated over the life of the Project and will total an area of 1928 ha. The principle objective of the mine site rehabilitation strategy will be to replace to the extent possible, through revegetation and rehabilitation strategies, the original native vegetation communities that will be lost within the Project Disturbance Footprint. This includes the recreation of 777 ha of Central Hunter Box-Ironbark Woodland and 555 ha of Narrabeen Footslopes Slaty Box Woodland, which constitutes a 0.5:1 ratio for the impacted communities in this area.

The mine site rehabilitation strategy will aim to recreate native vegetation that is self-sustaining in the long term and is capable of supporting a diverse range of viable flora and fauna populations. The mine site rehabilitation strategy will also contribute to maintaining a vegetated landscape in the Study Area in the long term that provides a "stepping stone" corridor between larger remnant patches of vegetation in the locality (DSE (VIC), 2008).

The importance of maintaining treed habitats in disturbed landscapes as corridors for fauna movement and seed dispersal is well-known (Cooper *et al.*, 2002; Fischer and Lindenmayer, 2002; DSE (VIC), 2008; Goldingay and Taylor, 2009). "Stepping stones" have been shown to be important in maintaining landscape connectivity and maintaining gene flow between separate populations because it facilitates the movement of pollen and seed vectors such as animals and insects (Lindenmayer, 2006).

Rehabilitation trials of targeted vegetation communities are soon to commence at Drayton Mine to ensure efforts on the Drayton South disturbance footprint are successful.

The BAP (**Section 8.4**) will contain further information on the staged rehabilitation of the Project Disturbance Footprint and will specify how the Study Area will be closed to mining and returned to other land uses.

9.2.4 Likely Success of Rehabilitation

The proposed vegetation conservation and rehabilitation measures have been designed to produce measurable biodiversity outcomes and are based on recognised principles of rehabilitation and land management (McIntyre, McIvor et al. 2002). Despite this, it is difficult to predict how long it will take a given rehabilitation area to regenerate into a fully functioning ecosystem, as this is dependent on many factors including disturbance history, proximity of nearby remnant vegetation, condition of the soil and the management regime implemented. There are few areas of mature rehabilitation in Australia, which means that there is little information currently available on the long-term ecological development of rehabilitated communities (Nichols 2005; Nichols, Grant et al. 2005). Due to the inherent variability of ecological systems, the ability to predict long-term successional trends in rehabilitation is low, and it is difficult to accurately predict the composition and structure of vegetation beyond 10 years (Nichols 2005). Nevertheless, it is clear that ceasing agricultural activities and the implementation of appropriate management techniques such as weed control and supplementary planting have the potential to substantially increase biodiversity.

9.3 Offsite Offsets

Offsite land containing suitable remnant open forest and woodland habitats will be acquired to address residual impacts that cannot be addressed through onsite offsetting and amelioration measures, namely impacts to Box-Gum Woodland. This land will be secured permanently for conservation and managed under a site-specific management plan to improve and maintain the conservation values of the offsite offset land (see **Section 9.2.2**).

Cumberland Ecology has conducted preliminary investigations of several properties to assess their potential offset value for the Project. Of the three potential candidate properties inspected, one property from the Upper Hunter has been identified as being the most suitable to meet the Project's specific offset requirements (see **Section 9.1.2**). Baseline flora and fauna surveys were subsequently conducted on this offset property in early 2012; the results are presented and discussed in **Chapter 10** with detailed data provided in **Appendix L**.

9.4 Biodiversity Offset Management Plan

Site-specific Biodiversity Offset Management Plans (BOMPs) will be prepared as part of the BOP to prescribe ongoing management actions for the onsite offsets and offsite offset property. This is a key component of the BOP to ensure that the biodiversity values of the Project's offsets can be maintained and improved.

Each BOMP will explain the key management approaches and expected gains of the onsite and offsite offsets and prescribe a suite of measures that will be implemented. The BOMP will contain a description and plan of conservation measures (long and short term) and will include measures to protect local biodiversity values and address specific values of significance such as the occurrence of threatened species. The BOMP will include details of appropriate areas for rehabilitation and conservation, details of revegetation priorities and techniques, reference sites, monitoring methodology and key performance indicators against which to measure progress, and specify appropriate review periods where progress is reviewed and the BOMP updated as required.

The key objective of the BOMP will be to improve the condition of existing vegetation and to increase the area of Box-Gum Woodland and species habitat so that a gain in biodiversity value can be achieved. This includes the following specific aims:

- Maintenance and improvement of the condition of existing forest and woodland within all offset areas, specifically to improve conditions for threatened flora and fauna;
- Maintenance and improvement of derived native grassland areas to promote, through management of grazing pressure, natural succession towards woodland and or open forest;

- Rehabilitation of selected areas of low diversity native grassland by replanting trees and shrubs to promote a more rapid regeneration towards forest or woodland; and

- Improvement of habitat connectivity across offset lands, and from offset lands to adjacent native vegetation and mine rehabilitation in order to improve wildlife movement in the long term.

The BOMP will also be designed in accordance with the latest offset management guidelines made available by SEWPaC. As such, the BOMP will include:

- A description of the threatened species and habitats within the offsite offset;

- A description of the freshwater habitats present;

- An assessment of the general condition and extent of the offset area and the identification of the key threats and risks;

- An assessment of the capacity of the offsite property for natural regeneration from soil seed banks and adjacent seed sources;

- A prescription of the most appropriate measures to restore forest, woodland and aquatic habitats;

- A prescription of an appropriate monitoring programme like that described in **Section 8.3** and adaptive management strategies;

- Details of appropriate timeframes and achievable completion criteria to allow Anglo American to effectively plan, cost, measure and monitor the progress of the management works; and

- Details of the auditing and reporting arrangements for the BOMP.

All restoration works will be conducted generally in accordance with any restoration and biodiversity enhancement guidelines that may be made available by DP&I and OEH (see **Section 8.2.2**). Some of the measures that will be employed to promote successful regeneration of woodland and forest will include weed and feral animal management, phased reduction of livestock management, track and trail management, active replanting and reseeding of vegetation within selected areas and monitoring; fire management; and ongoing monitoring. These will be guided by best practice guidelines and will be consistent with the desired outcomes of the draft National Recovery Plan for Box-Gum Woodland and Derived Native Grassland (DECCW (NSW) 2010b), and incorporated as appropriate into the BOMP.

The offset properties contain extensive areas of existing woodland and open forest that will form nuclei for ongoing regeneration of trees and shrubs into grassland areas. Such habitats will provide immediate and ongoing habitats for native plants and animals. Existing forest and woodland areas are currently mature, functioning examples of natural

ecosystems, but their condition is expected to improve with time as trees mature, tree hollows are generated and as regeneration of understorey takes place when livestock grazing techniques are implemented (McIntyre et al., 2002).

Derived native grasslands conforming to Box-Gum Woodland within the offsite offsets exhibit significant floral diversity, including scattered trees and shrubs. It is intended that grazing management, combined with the management of weeds and feral animals will be able to accelerate regeneration of these grassland areas to forest and woodland areas. Such habitats are semi-natural and cannot currently be considered fully functional as they generally lack trees and shrubs. However, in the medium to long term, trees and shrubs are expected to regenerate into such areas if the condition of the land is improved through grazing and weed management (Lindenmayer, Bennett et al. 2010). It is expected that substantial regeneration will occur within the life of the Project and a mature, functional ecosystem will be established across much of these grassland areas within 50 years.

Low diversity native grasslands have low diversity of native ground covers and essentially no trees and shrubs. However, to overcome this, trees and shrubs will be planted into such areas to form nuclei of regenerating woody habitats that will then be able to progressively grow back into woodland or open forest. Replanting of such areas will take place early in the life of the Project (within the first five years) and it is expected that substantial regeneration of woody plants will occur within the life of the Project.

9.5 Security of the Offset Properties

The offset lands will be permanently protected by an appropriate mechanism. There are a number of options that are available to permanently protect land for conservation and these include:

- Conservation Agreements (CA), which are a joint agreement between landowners and the Minister for the Environment under the *National Parks and Wildlife Act 1974*;
- Conservation convenants under Section 88 of the *Conveyancing Act 1919*; this is a joint agreement between the landowner and an authorised body;
- Application to change zoning regulation that dictates land use;
- Dedication of land to the National Parks reserve estates; and
- Land acquisition and management of the land under private ownership with conditions of commitment.

The final method of security will be decided on by Anglo American in consultation with OEH and other relevant agencies.

9.6 Cumulative Offsets

All of the mines in the area propose to rehabilitate mined areas and return them to forest and woodland. The mined landscaped will be progressively returned as flora and fauna habitat in the medium to long term. Additionally, all of the mines have provisions for offsetting ecological impacts. All of the mines will or have purchased additional surrounding lands that contain forest, woodland and Derived Native Grasslands. These will collectively and significantly increase the total areas of native vegetation that exist in the locality in the future and will significantly increase the total area of native vegetation within conservation reserves in the locality.

9.7 Summary of the Biodiversity Offset Package

The BOP has been developed to compensate for the residual impacts on threatened species and ecological communities that cannot be addressed by avoidance and mitigation. The BOP also aims to satisfy the requirements stated in the EARs for the Project.

The BOP provides a significant conservation outcome for the Project by providing a suite of measures, both onsite and offsite, to mitigate and compensate for the ecological impacts of the Project. The focus of the BOP is on onsite restoration and rehabilitation of Saddlers Creek, which will be supplemented by conservation and ongoing management of offsite offset properties.

Some of the measures presented in the BOP include the following:

- Management of land that contains and/or can be regenerated to provide Box-Gum Woodland at a minimum ratio of approximately 6 ha of conserved land for each hectare to be cleared (i.e. a ratio of 6:1);
- Provision of land that contains or could be regenerated to provide Central Hunter Box-Ironbark Woodland, Narrabeen Footslopes Slaty Box Woodland and other non-TEC vegetation at a minimum ratio of 3:1;
- Provision of land that includes habitat for all relevant threatened flora and fauna species that could be impacted by the Project;
- Provision of land that contributes to an existing regional biodiversity conservation strategy; and
- Re-establishment of habitat linkages to existing areas of habitat in the locality including existing native vegetation within and closely adjacent to the Study Area.

Chapter 10

The Offsite Offset Property

This chapter presents the results of baseline ecological surveys of an offsite offset property that was selected for inclusion in the BOP for the Project. The chapter describes the biodiversity values of this offsite offset property and discusses its suitability as a biodiversity offset for the Project. Key considerations in assessing the suitability of the property include the following, which are discussed in the latter sections of the chapter:

- Provision of EPBC Act and TSC Act listed Box-Gum Woodland communities;
- Provision of suitable habitat for threatened species that will potentially be affected by the Project;
- Management potential; and
- Regenerative potential.

The provision of adequate habitat for relevant threatened species will be assessed across the whole of the BOP at the end of this chapter. An evaluation of the overall BOP against the OEH and Commonwealth offsetting policy documents is also provided at the end of the chapter.

10.1 General Description of the Offsite Offset Property

The offsite offset property (approx. 2079 ha) is a grazing property situated in the undulating hills near the township of Murrurundi in the Liverpool Plains LGA. It is located approximately 75 km north of the Project Boundary within the southern extremity of Nandewar Bioregion, at its boundary with the Sydney Basin Bioregion. It is within the Liverpool Ranges close to the Pages River (**Figure 10.1**).

Although the offsite offset property does not adjoin a conservation reserve, several are located within the locality. The closest conservation area is the Murrurundi Pass National Park (215 ha), located approximately 900 m to the south of the property. Towarri National Park (6074 ha) and Wingen Maid Nature Reserve (1096 ha) are approximately 10 km and 14 km to the south respectively; and Wallabadah Nature Reserve (1132 ha) is located approximately 13 km to the north east of the offsite offset property.

The property features relatively steep country that ranges from 500 to 900 metres in elevation and receives a high annual rainfall. The eastern half of the property occurs on

soils derived from basalt whilst the western half occurs on soils derived from mudstone. The original woodland and forest vegetation on both the fertile basalt soils and the less fertile mudstone soils have been partially cleared or modified for livestock grazing, particularly sheep grazing.

Two semi-permanent creeks and their tributaries, Chilcotts Creek and Back Creek, flow through the property and contain water for the majority of the year. The property largely drains to the Namoi catchment, although a small proportion of the property is within the Hunter catchment. Dams have been established throughout the property to supply water for livestock.

The property is currently used for stock grazing (sheep and cattle) and some areas have been improved, producing a mixture of native and improved pastures. Nevertheless, the property is well vegetated and continues to support extensive areas of diverse remnant woodland and open forest with a natural or semi-natural understorey. Natural regeneration of a number of tree species is prolific across the property and regular ringbarking to provide grazing pasture for livestock is evident. Overall, the property has a very good potential for habitat improvement if it becomes managed for conservation rather than farming. The vegetation of the offsite offset property is described in more detail below.

10.2 Vegetation Communities of the Offsite Offset Property

The property contains approximately 1100 hectares of remnant forest and woodland that are dominated by a mixture of Box, Gum and Stringybark eucalypt species. The remainder of the property (approximately 900 hectares) consists of grassland areas. The vegetation communities present on site are listed in **Table 10.1** and are shown in **Figure 10.2**. Descriptions of the communities mapped for the property are provided in the following sections.

Table 10.1 Vegetation Communities of the Offsite Offset Property

Vegetation Community	EPBC Act	TSC Act	Area (ha)
Silvertop Stringybark - gum open forest on basalts of the Liverpool Range, Brigalow Belt South and Nandewar			71
Silvertop Stringybark grassy open forests, eastern Nandewar and New England Tablelands	Box-Gum Woodland CEEC	Box-Gum Woodland EEC	253
Box - gum grassy woodlands, Brigalow Belt South and Nandewar	Box-Gum Woodland CEEC	Box-Gum Woodland EEC	67
White Box - stringybark shrubby woodlands, Brigalow Belt South and Nandewar			336
White Box grassy woodland, Brigalow Belt South and Nandewar	Box-Gum Woodland	Box-Gum Woodland	396

Table 10.1 Vegetation Communities of the Offsite Offset Property

Vegetation Community	EPBC Act	TSC Act	Area (ha)
	CEEC	EEC	
River Oak riparian woodland, eastern NSW	Box-Gum Woodland CEEC	Box-Gum Woodland EEC	33
Rough-barked Apple - Blakely's Red Gum riparian grassy woodlands, Brigalow Belt South and Nandewar	Box-Gum Woodland CEEC	Box-Gum Woodland EEC	25
Total Forest and Woodland			**1181**
Derived grasslands, Brigalow Belt South and Nandewar	Box-Gum Woodland CEEC	Box-Gum Woodland EEC	343
Low Diversity Derived Native Grassland		Box-Gum Woodland EEC	555
Total Grassland			**898**
Grand Total			**2079**

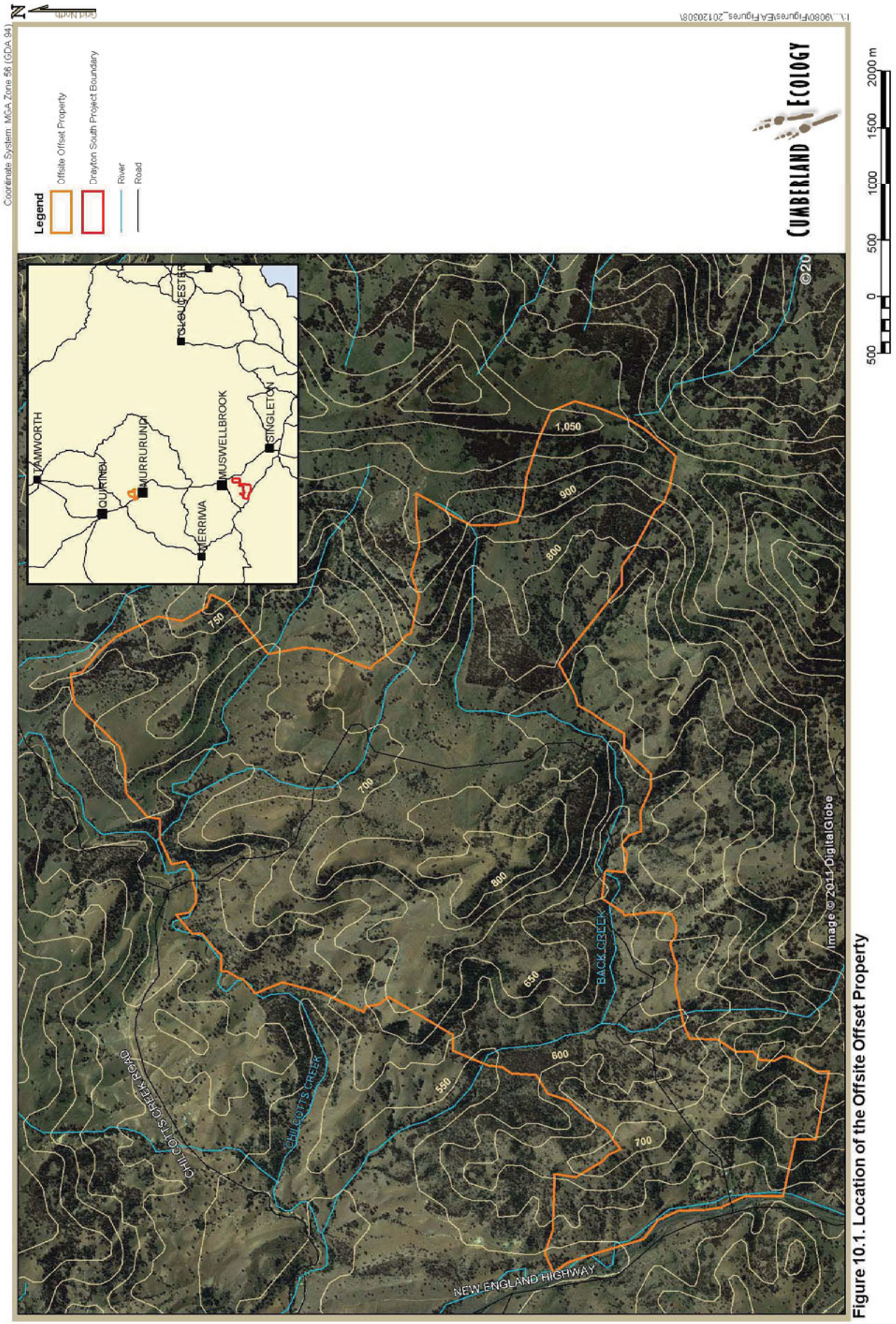


Figure 10.1. Location of the Offsite Offset Property

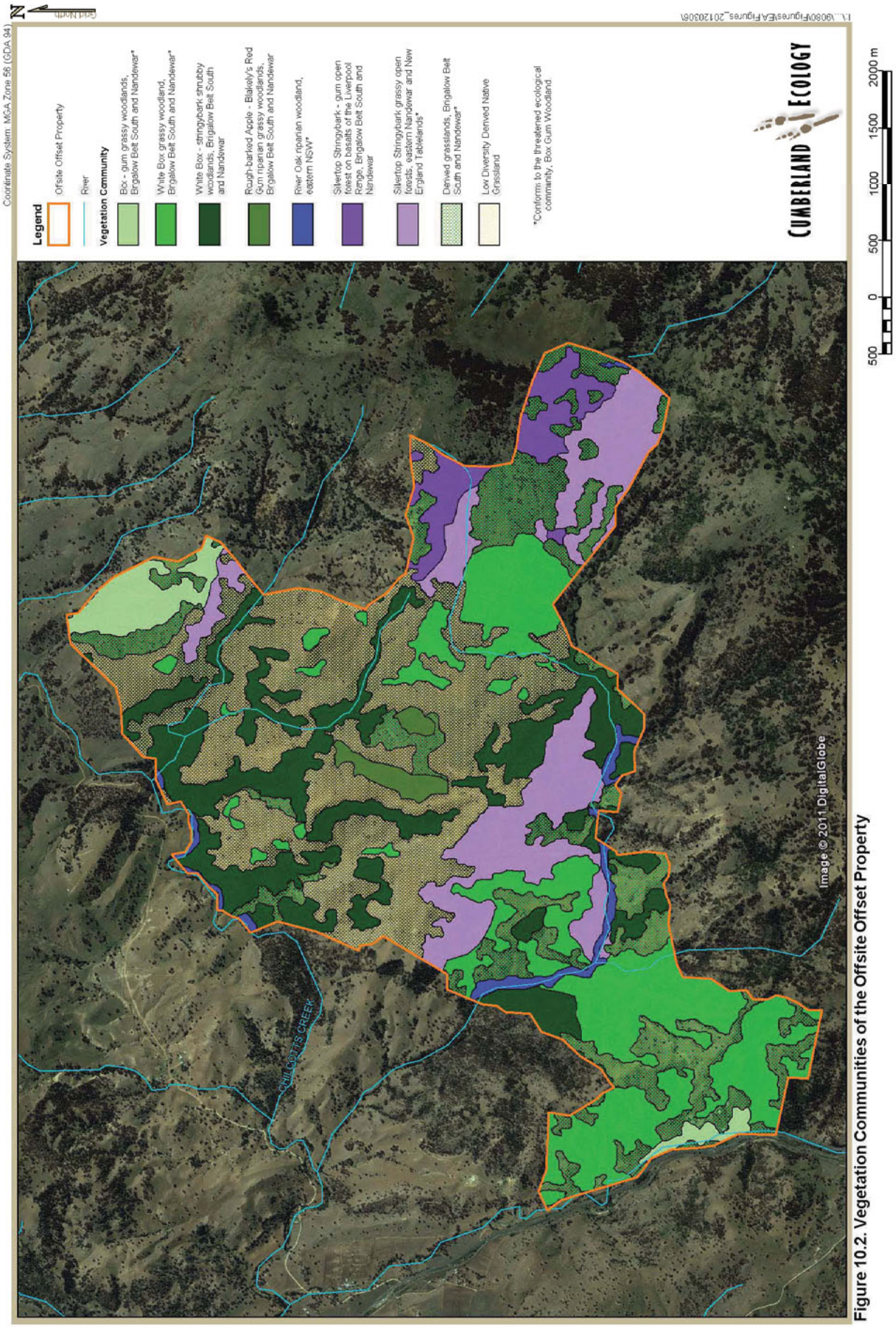


Figure 10.2. Vegetation Communities of the Offsite Offset Property

10.2.1 Silvertop Stringybark - gum open forest on basalts of the Liverpool Range, Brigalow Belt South and Nandewar

This is a grassy open forest that is dominated by *Eucalyptus laevopinea* (Silvertop Stringybark) and *Eucalyptus dalrympleana* (Mountain Gum). In patches, *Eucalyptus melliodora* (Yellow Box) occurs as a co-dominant canopy species. The understorey is open and contains a few shrub species like *Melicytus dentatus* (Tree Violet), *Pittosporum undulatum* (Sweet Pittosporum) and *Olearia elliptica* (Sticky Daisy Bush). The ground layer is diverse and includes species such as *Poa labillardieri* (Tussock Grass), *Microlaena stipoides* (Weeping Meadow Grass), *Echinopogon ovatus* (Hedgehog Grass), *Dichondra repens* (Kidney Weed) and *Geranium solanderi* (Native Geranium).

This community is typically restricted to mid-high elevation slopes on basalt substrate and was recorded at elevations above 800 metres in the eastern-most parts of the property (**Photographs 10.1** and **10.2**). It does not conform to any TSC Act or EPBC Act listed threatened ecological community.



Photograph 10.1 Silvertop Stringybark - Gum Open Forest (Quadrat T9)



Photograph 10.2 Silvertop Stringybark - Gum Open Forest (Quadrat T14)

10.2.2 Silvertop Stringybark grassy open forests, eastern Nandewar and New England Tablelands

This is a grassy open forest that is dominated by *Eucalyptus laevopinea* (Silvertop Stringybark). On the property, this community is co-dominated by *Eucalyptus melliodora* (Yellow Box). Other tree species that were also recorded include *Angophora floribunda* (Rough-barked Apple) and *Eucalyptus blakelyi* x *teretecornis* (Blakely's Red Gum-Forest Red Gum intergrade). The understorey is open and contains a few shrub species like *Melicytus dentatus* (Tree Violet), *Pittosporum undulatum* (Sweet Pittosporum) and *Olearia elliptica* (Sticky Daisy Bush). The ground layer is diverse and includes species such as *Poa labillardieri* (Tussock Grass), *Microlaena stipoides* (Weeping Meadow Grass), *Echinopogon ovatus* (Hedgehog Grass), *Acaena nova-zelandiae* (Bidgee-widgee), *Dichondra repens* (Kidney Weed) and *Geranium solanderi* (Native Geranium).

This community was recorded on a variety of substrates at intermediate elevations of up to 800 metres, generally on southern facing slopes (**Photographs 10.3** and **10.4**).

As this community is co-dominated by *Eucalyptus melliodora* (Yellow Box) and supports an open grassy understorey, it is considered to conform to the TSC Act and EPBC Act listings for Box-Gum Woodland.



Photograph 10.3 **Silvertop Stringybark Grassy Open Forests, Eastern Nandewar and New England Tablelands (Quadrat T4)**



Photograph 10.4 **Silvertop Stringybark Grassy Open Forests, Eastern Nandewar and New England Tablelands (Quadrat T13)**

10.2.3 Box - gum grassy woodlands, Brigalow Belt South and Nandewar

This grassy woodland is dominated by *Eucalyptus melliodora* (Yellow Box) and *Eucalyptus blakelyi* x *teretecornis* (Blakely's Red Gum-Forest Red Gum intergrade). Other tree species recorded included *Eucalyptus albens* x *Eucalyptus moluccana* (White Box-Grey Box intergrade) and *Angophora floribunda* (Rough-barked Apple). The understorey is open with few shrubs and the ground layer includes species such as *Bothriochloa decipiens* (Redleg Grass), *Microlaena stipoides* (Weeping Meadow Grass), *Poa sieberiana* (Snowgrass), *Acaena nova-zelandiae* (Bidgee-widgee), *Dichondra repens* (Kidney Weed) and *Geranium solanderi* (Native Geranium).

The community was recorded in the north eastern corner of the property in more gently undulating country (**Photograph 10.5**). As this community is dominated by *Eucalyptus melliodora* (Yellow Box) and *Eucalyptus blakelyi* x *teretecornis* (Blakely's Red Gum-Forest Red Gum intergrade) and supports an open grassy understorey, it is considered to conform to the TSC Act and EPBC Act listings for Box-Gum Woodland.



Photograph 10.5 **Box - Gum Grassy Woodlands, Brigalow Belt South and Nandewar (Quadrat T7)**

10.2.4 White Box - stringybark shrubby woodlands, Brigalow Belt South and Nandewar

This is a shrubby open forest or woodland that is dominated by *Eucalyptus albens* x *moluccana* (White Box-Grey Box intergrade), *Eucalyptus laevopinea* (Silvertop Stringybark) and *Angophora floribunda* (Rough-barked Apple). In steeper parts of the property, *Eucalyptus melliodora* (Yellow Box) was recorded as a co-dominant. The understorey layer is well developed and supports a diversity of species including *Notelaea microcarpa* (Native Olive), *Melicytus dentatus* (Tree Violet) and *Pittosporum undulatum* (Sweer Pittosporum) and *Olearia elliptica* (Sticky Daisy Bush). The ground layer is usually sparse to moderately dense and includes a mixture of grasses like *Poa sieberiana* (Snowgrass), *Aristida ramosa* (Purple Wiregrass), *Cymbopogon refractus* (Barb-wire Grass), and *Desmodium brachypodum* (large Tick-trefoil), *Dichondra repens* (Kidney Weed) and *Geranium solanderi* (Native Geranium).

This community is widespread across the property and was typically recorded on steep slopes on a range of substrates (**Photograph 10.6**). Despite the dominance of *Eucalyptus albens* x *moluccana* (White Box-Grey Box intergrade), this community is too shrubby to conform to the TSC Act and EPBC Act listings for Box-Gum Woodland.



Photograph 10.6 **White Box - Stringybark Shrubby Woodlands, Brigalow Belt South and Nandewar (Quadrat T20)**

10.2.5 White Box grassy woodland, Brigalow Belt South and Nandewar

This grassy woodland is dominated by *Eucalyptus albens* x *Eucalyptus moluccana* (White Box-Grey Box intergrade) and *Eucalyptus laevopinea* (Silvertop Stringybark). Other tree species that were recorded in this unit include *Angophora floribunda* (Rough-barked Apple) and *Eucalyptus melliodora* (Yellow Box). The understorey is open and the shrub layer is generally sparse with *Notelaea microcarpa* (Native Olive), *Olearia elliptica* (Sticky Daisy Bush) and *Cassinia quinquefaria* (Cough Bush) the most common. The ground layer supports a mixed diversity of species like *Poa labillardieri* (Tussock Grass), *Austrodanthonia* spp. (the Wallaby Grasses), *Bothriochloa decipiens* (Redleg Grass), *Desmodium varians* (Tick Tre-foil), *Dichondra repens* (Kidney Weed) and *Geranium solanderi* (Native Geranium).

The community was recorded mostly in the western portion of the property in low elevation areas. Pockets of the community are retained as remnant patches on hilltops but would once have been widespread across the property (**Photographs 10.7** and **10.8**).

As this community is dominated by *Eucalyptus albens* x *Eucalyptus moluccana* (White Box-Grey Box intergrade) and supports an open grassy understorey, it is considered to conform to the TSC Act and EPBC Act listings for Box-Gum Woodland.



Photograph 10.7 **White Box Grassy Woodland, Brigalow Belt South and Nandewar (Quadrat T5)**



Photograph 10.8 **White Box Grassy Woodland, Brigalow Belt South and Nandewar (Quadrat T8)**

10.2.6 River Oak riparian woodland, eastern NSW

This community is an open forest or woodland that occurs along the creeks on the property (**Photographs 10.9** and **10.10**). The community is dominated by *Casuarina cunninghamiana* (River Oak) and *Angophora floribunda* (Rough-barked Apple) but is also co-dominated by other eucalypt species including *Eucalyptus melliodora* (Yellow Box) and *Eucalyptus blakelyi* x *Eucalyptus teretecornis* (Blakely's Red Gum-Forest Red Gum intergrade). The shrub layer is sparse and includes *Melicytus dentatus* (Tree Violet) and *Notelaea microcarpa* (Native Olive). The ground layer is dense and is dominated by *Microlaena stipoides* (Weeping Meadow Grass) and *Lomandra longifolia* (Siny-headed Mat-rush); *Urtica dioica* (Stinging Nettle) is locally abundant.

The community conforms to the TSC Act or EPBC Act listings for Box-Gum Woodland as it is generally co-dominated by either *Eucalyptus melliodora* (Yellow Box) or *Eucalyptus blakelyi* x *Eucalyptus teretecornis* (Blakely's Red Gum-Forest Red Gum intergrade) and has an open grassy understorey.



Photograph 10.9 River Oak Riparian Woodland, Eastern NSW (Quadrat T1)



Photograph 10.10 River Oak Riparian Woodland, Eastern NSW (Quadrat T1)

10.2.7 Rough-barked Apple - Blakely's Red Gum riparian grassy woodlands, Brigalow Belt South and Nandewar

This grassy woodland or open forest is dominated by *Angophora floribunda* (Rough-barked Apple) and *Eucalyptus blakelyi* x *Eucalyptus teretecornis* (Blakely's Red Gum-Forest Red Gum intergrade). Other tree species that were also recorded include *Callitris glaucophylla* (White Cypress Pine) and *Eucalyptus laevopinea* (Silvertop Stringybark). The understorey is open and a shrub layer of *Dodonaea viscosa* ssp. *angustifolia* (Sticky Hop-bush), *Melicytus dentatus* (Tree Violet) and/or *Bursaria spinosa* (Blackthorn) is present. The ground layer is variable but common species include *Lomandra confertifolia* ssp. *rubiginosa* (a Mat-rush), *Carex appressa* (Tall Sedge), *Microlaena stipoides* (Weeping Meadow Grass) and *Dichondra repens* (Kidney Weed).

This community was recorded in a gully and along a nearby flat in the centre of the property (**Photographs 10.11** and **10.12**). It conforms to the TSC Act or EPBC Act listings for Box-Gum Woodland as it is generally co-dominated by *Eucalyptus blakelyi* x *Eucalyptus teretecornis* (Blakely's Red Gum-Forest Red Gum intergrade) and has an open grassy understorey.



Photograph 10.11 **Rough-barked Apple - Blakely's Red Gum Riparian Grassy Woodlands, Brigalow Belt South and Nandewar (Quadrat T15)**



Photograph 10.12 **Rough-barked Apple - Blakely's Red Gum Rparian Grassy Woodlands, Brigalow Belt South and Nandewar (Quadrat T15)**

10.2.8 Derived grasslands, Brigalow Belt South and Nandewar

Derived grasslands refer to native grasslands that have resulted from the clearing of woodland or forest types dominated by *Eucalyptus melliodora* (Yellow Box), *Eucalyptus blakelyi* x *Eucalyptus teretecornis* (Blakely's Red Gum-Forest Red Gum intergrade) or *Eucalyptus albens* x *Eucalyptus moluccana* (White Box-Grey Box intergrades). These areas occur largely around the fringes of existing remnant woodland or forest, in the extremities of the property where grazing is comparatively less intense or where paddocks have not been improved (or have not been improved for a long time) (**Photographs 10.13** and **10.14**).

These grasslands are of sufficient diversity to conform to the the TSC Act and EPBC Act listings for Box-Gum Woodland.



Photograph 10.13 Derived Grasslands on the Offsite Offset Property



Photograph 10.14 Derived Grasslands on the Offsite Offset Property

10.2.9 Low Diversity Derived Native Grassland

This term refers to native pastures that are currently or were recently improved for livestock grazing. Low Diversity Derived Native Grassland was recorded throughout the low to intermediate elevations in the central portion of the property where the larger cleared grazing paddocks are located (**Photograph 10.15** and **10.16**).

Where derived from the clearing of woodland or forest types dominated by *Eucalyptus melliodora* (Yellow Box), *Eucalyptus blakelyi* x *Eucalyptus teretecornis* (Blakely's Red Gum-Forest Red Gum intergrade) or *Eucalyptus albens* x *Eucalyptus moluccana* (White Box-Grey Box intergrades), this unit is not sufficiently diverse to meet the EPBC Act listing for Box-Gum Woodland.

However, the TSC Act listing for Box-Gum Woodland includes poorer condition grassland areas where natural regeneration is likely. Since natural regeneration of canopy and shrub species is evident throughout the property and the soil profile over much of the property has not been significantly altered (e.g. ploughing for crop farming), some areas are likely to conform to the TSC Act listing for Box-Gum Woodland (**Photograph 10.17**).



Photograph 10.15 Low Diversity Derived Grassland on the Offsite Offset Property



Photograph 10.16 Low Diversity Derived Grassland on the Offsite Offset Property



Photograph 10.17 Regeneration of Canopy Eucalypts in Low Diversity Derived Grassland

10.3 Fauna Habitat Values of the Offsite Offset Property

The offsite offset property provides sizable remnant forest and woodland patches with a natural or semi-natural understorey that provides valuable habitat for fauna. The habitat values associated with mature remnant forest and woodland on the property include the provision of tree hollows, flowering food resources and shelter. In addition to this, the property contains frontage to Chilcotts and Back Creeks, the riparian vegetation associated with these creeklines and other permanent watering points such as farm dams. Large areas of native derived grassland dominated by large tussock grasses such as *Poa labillardieri* (Tussock Grass) also provide foraging habitat for ground-foraging fauna species. Nearby cliff lines and rock outcrops are also habitat attributes that add to value of the property for native fauna.

Key habitat attributes of the offsite offset property are discussed in more detail in the following sections.

10.3.1 Hollow Resources

Tree hollows are an important resource for many species of wildlife including birds, bats and gliders. An estimate of hollow availability per hectare, which was extrapolated from field data, is provided below in **Table 10.2**. Actual hollow abundance will vary between vegetation patches depending on the age class, species and number of trees; however, the estimates provide a useful indication of the hollow resource across the whole site. The full hollow dataset is provided in **Appendix L**.

Hollow-bearing trees were recorded at all 26 of the habitat assessment sites and in all forest and woodland communities. Hollows were found to range in size from less than 5 cm to over 30 cm in living trees and stags, and included broken branch spouts, trunk holes, fire scars, basal cavities and stags that were hollow throughout (**Photographs 10.18**, **10.19** and **10.20**).

Stags were found to contain the highest number of hollows which is expected as a result of ongoing decay. Of the living trees, *Eucalyptus laevopinea* (Stringybark) and *Eucalyptus albens* x *Eucalyptus moluccana* (White Box-Grey Box intergrade) individuals were found to support the majority of tree hollows. Tree hollows were generally small in size and this reflects the history of timber clearing of the larger remnant individuals that has occurred in the past.

As discussed in **Chapter 6**, hollow specificity will affect how the hollows are utilised by native fauna (Lindenmayer et al., 1990, Gibbons et al., 2002). Nonetheless, the abundance and variety of hollows present, including the retention of future hollow-bearing trees under conservation management is certainly an asset for many fauna species and will contribute considerably to the habitat values of property.

Table 10.2 Hollow Count Data – Offsite Offset Property

Hollow Size Class	Tree species	No. hollows over 26 x 0.1 ha plot (i.e. 2.6 ha)	No. hollows per 0.1 ha	No. hollows/ha
<5cm	*E. blakelyi x E tereticornis*	2	0.1	0.8
	E. melliodora	1	0.0	0.4
	E. albens x moluccana	7	0.3	2.7
	Stag	8	0.3	3.1
	E. laevopinea	11	0.4	4.2
	A. floribunda	0	0.0	0.0
	Unidentified	2	0.1	0.8
5-10cm	*E. blakelyi x E tereticornis*	5	0.2	1.9
	E. melliodora	1	0.0	0.4
	E. albens x moluccana	21	0.8	8.1
	Stag	6	0.2	2.3
	E. laevopinea	15	0.6	5.8
	A. floribunda	2	0.1	0.8
	Unidentified	1	0.0	0.4
11-15cm	*E. blakelyi x E tereticornis*	1	0.0	0.4
	E. melliodora	2	0.1	0.8
	E. albens x moluccana	7	0.3	2.7
	Stag	7	0.3	2.7
	E. laevopinea	1	0.0	0.4
	A. floribunda	2	0.1	0.8
	Unidentified	0	0.0	0.0
16-20cm	*E. blakelyi x E tereticornis*	0	0.0	0.0
	E. melliodora	0	0.0	0.0
	E. albens x moluccana	8	0.3	3.1
	Stag	0	0.0	0.0
	E. laevopinea	3	0.1	1.2
	A. floribunda	0	0.0	0.0
	Unidentified	0	0.0	0.0
21-25cm	*E. blakelyi x E tereticornis*	1	0.0	0.4
	E. melliodora	2	0.1	0.8
	E. albens x moluccana	4	0.2	1.5

Table 10.2 Hollow Count Data – Offsite Offset Property

Hollow Size Class	Tree species	No. hollows over 26 x 0.1 ha plot (i.e. 2.6 ha)	No. hollows per 0.1 ha	No. hollows/ha
	Stag	0	0.0	0.0
	E. laevopinea	1	0.0	0.4
	A. floribunda	0	0.0	0.0
	Unidentified	0	0.0	0.0
26-30cm	*E. blakelyi x E tereticornis*	2	0.1	0.8
	E. melliodora	0	0.0	0.0
	E. albens x moluccana	4	0.2	1.5
	Stag	0	0.0	0.0
	E. laevopinea	0	0.0	0.0
	A. floribunda	0	0.0	0.0
	Unidentified	0	0.0	0.0
>30cm	*E. blakelyi x E tereticornis*	0	0.0	0.0
	E. melliodora	0	0.0	0.0
	E. albens x moluccana	1	0.0	0.4
	Stag	10	0.4	3.8
	E. laevopinea	0	0.0	0.0
	A. floribunda	0	0.0	0.0
	Unidentified	0	0.0	0.0
	Total (nearest whole)	**138**	**5**	**53**



Photograph 10.18 Multi-branched Stag with Numerous Hollows



Photograph 10.19 An Example of a Basal Hollow on the Offsite Offset Property



Photograph 10.20 Hollowed Stags on the Offsite Offset Property

10.3.2 Flowering Resource

The property offers a range of forage resources, particularly in the form of abundant mistletoes in box eucalypt trees, flowering eucalypt trees and casuarinas (e.g. **Photograph 10.21**). Flowering times for the dominant canopy species generally overlap, and, due to their size and maturity, collectively provide reliable forage material over all seasons (**Table 10.3**).

Eucalypt mistletoe species occur in canopy trees across the property; such species are also an important food resource for native fauna (Turner 1991, Southern New England Landcare Ltd 2008). These tree parasites provide nectar-rich, long-lived and abundant flowers, fruits and nutritious leaves for species such as gliders, possums, honeyeaters and parrots (Turner 1991, Southern New England Landcare Ltd 2008). They also provide additional nesting resources, both directly and indirectly by promoting hollow formation (Turner 1991, Southern New England Landcare Ltd 2008).

As such, the property can support resident nectarivorous fauna species throughout the year, and winter non-breeding species such as the Swift Parrot that may move through the region during migrations.

Native tussock grass species also provide abundant seed for granivores, and midstorey species such as *Olearia elliptica* (Sticky Daisy-bush) and *Pittosporum undulatum* (Sweet Pittosporum) also provide fruit and flowers in abundance (**Photograph 10.22**).



Photograph 10.21 Flowering and Budding Trees

Note: Eucalyptus nortonii (Large-flowered Bundy) are common on the offsite offset property



Photograph 10.22 Flowering Understorey Shrubs

Table 10.3 Flowering Schedule for Canopy Species that are Present on the Offsite Offset Property

Scientific Name	Common Name	Flowering Time											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Amyema miquelii	Box mistletoe		X	X	X	X							
Amyema pendula	Drooping mistletoe								X	X	X	X	X
Angophora floribunda	Rough-barked Apple	X	X	X								X	X
Brachychiton populneus	Kurrajong	X	X										X
Casuarina cunninghamiana	River Sheoak			X	X	X							
Eucalyptus albens x moluccana	White Box-Grey box intergrade			X	X	X	X						
Eucalyptus blakelyi x teretecornis	Blakely's Red Gum-Forest Red Gum intergrade						X	X	X	X	X	X	
Eucalyptus dalrympleana	Mountain Gum			X	X	X							
Eucalyptus laevopinea	Silver Top Stingybark						X	X	X				
Eucalyptus melliodora	Yellow Box	X	X							X	X	X	X
Eucalyptus nortonii	Large-flowered Bundy								X	X	X		
Eucalyptus viminalis	Ribbon Gum	X	X	X	X	X						X	X

**From Brooker and Kleinig (1990)*

10.3.3 Ground Debris and Understorey Complexity

Vegetation structure and complexity on the property is variable and includes open grasslands, open woodland, shrubby woodland and dense riparian communities. The vegetation features a diverse and complex understorey structure, containing native groundcover tussock grasses like *Poa labillardierii* (Tussock Grass) and localised areas of shrubby understorey largely represented by daisy-bushes (*Olearia* spp.) and Hop Bushes (*Dodonea* spp). The overstorey structure is also complex as the canopy is supported by small trees and mixed aged stands of regenerated trees.

These different characteristics have the potential to support a range of fauna and their various habitat requirements. For example, the grassland and open forest suits larger terrestrial macropods, while many native woodland bird species are strongly associated with shrub and tall tussock grass understorey. Understorey vegetation (and thus woodland structural complexity) provides nesting sites, refuge from predators and food for many small species (McIntyre et al., 2002). Taller canopy species with large hollows over a midstorey are preferred by species such as larger parrots and raptors.

Due to the history of felling and thinning activities by ringbarking, large fallen trees, stags, logs and smaller woody debris including branches and bark, are abundant on the property (**Photographs 10.23** and **10.24**). Such debris is also typical of box eucalypts that readily drop their limbs.

Within the 26 habitat assessment plots, over 200 pieces of woody debris (at least a half metre long and with a diameter of over 10 cm) totalling over 800 m, were recorded. This ground debris provides important habitat for terrestrial mammals, reptiles and ground-foraging birds. Such woodland birds include the threatened Brown Treecreeper (*Climacteris picumnus*) and Specked Warbler (*Pyrrholaemus saggitatus*), which was recorded on site. The amount of woody debris is expected to increase significantly as the property becomes managed for conservation purposes rather than farming.



Photograph 10.23 Woody Ground Debris



Photograph 10.24 Woody Ground Debris

10.3.4 Rock Outcrops

Rock outcrops with minor cliffs and caves occur on several of the hilltop areas (**Photograph 10.25**) and these are considered likely to afford habitat to cave roosting bats and to other fauna. Species that can potentially find roosting habitat in these areas include threatened microchiropteran bats of the family Vespertilionidae. Four such cave roosting species have been detected on the property including:

- Large-eared Pied Bat (*Chalinolobus dwyeri*)
- Little Bent-wing Bat (*Miniopterus australis*)
- Eastern Bentwing-bat (*Miniopterus orianae oceanensis*)
- Eastern Cave Bat (*Vespadelus troughtoni*)



Photograph 10.25 **Example of Rocky Outcrop at Ridgetop, in the Eastern Section of the Offsite Offset Property**

10.3.5 Riparian Corridors and Dams

Due to the undulating and steep topograpy of the property, a number of ephemeral drainage lines and unnamed creeks flow through the property and drain into two more permanent Chilcotts and Back Creeks (**Figure 10.1** and **Photograph 10.26**). The creeklines and gullies have fringing and riparian vegetation that provide shelter habitat and movement corridors for a range of fauna. These riparian corridors, although narrow, still exist and are comprised of remnant eucalypt species and casuarinas. These riparian corridors and connecting woodland patches provide a means for mobile fauna to traverse the landscape and utilise habitat on the property and elsewhere in the locality.

Multiple small farm dams are also present and provide more substantive and permanent water sources for wildlife (**Photograph 10.27**).

These watercourses provide valuable sources of drinking water for all fauna support reptiles and amphibians.



Photograph 10.26 Chilcotts Creek

Note: Fringing vegetation and rocky instream, which changes water flow and can create deeper pools.



Photograph 10.27 Farm Dam on the Offsite Offset Property

10.4 Regenerative Potential of the Vegetation on the Offsite Offset Property

There is high potential for the regeneration of native vegetation across the property and there is considerable evidence that grazing lands are actively maintained by such procedures as ringbarking (**Photograph 10.28**). Regeneration potential is high for all strata of vegetation including the canopy, subcanopy, understorey and ground stratum.

Regeneration of canopy species was evident at most assessment locations visited (22 of 26 sites). Seedlings of *Eucalyptus albens* (White Box), *E. laevopinea* (Silver Top Stringybark) and *E. tereticornis x blakelyi* (Forest Red Gum - Blakely's Red Gum intergrade) were recorded, indicating much of the forest and woodland areas of the property have good natural regeneration potential and that the soil and canopy seed banks are viable.

Grasslands are generally dominated by native perennial grasses with various mixtures of native perennial and annual herbaceous plants. When livestock are removed to make way for conservation management it is expected that all all native strata will regenerate naturally.

Weeds occur across the property and include species such as *Ailanthus ailtissima* (Tree of Heaven), *Rubus fruticosus* (Blackberry), *Hypericum perforatum* (St Johns Wort), *Rosa rubiginosa* (Sweet Briar) and Thistles. These will need active management when livestock grazing is phased out for conservation. Some species such as St John's Wort will need

special active management as they tend to proliferate in ungrazed and unmanaged old farmland.

Some areas of grassland have been extensively cleared meaning that trees are either absent or extremely widely scattered. Such areas may require active replanting in the future to speed up the process of regeneration towards woodland or open forest.



Photograph 10.28 **Recent Ringbarking of Canopy Trees on the Offsite Offset Property**

10.5 Threatened Species on the Offsite Offset Property

Surveys have verified the presence of a suite of threatened and migratory birds and bats on the property (**Table 10.4**). The surveys provide a brief snapshot of fauna and it is expected that many more threatened species would occur on the property based upon the condition of habitat and the frequency of threatened species records from the LGA. An individual occurrence of *Cymbidium canaliculatum* (Tiger Orchid) was also recorded on the offsite offset property. Whilst the *Cymbidium canaliculatum* (Tiger Orchid) population is not listed outside of the Hunter Catchment, the property is on the border between the Namoi and Hunter Catchments and therefore, any potential habitat for the species is considered to be relevant to the Project.

Most of the threatened and migratory species found or considered likely to occur within the Study Area are also considered likely to occur on the property, as indicated in **Table 10.5**.

As discussed above, the regenerative potential of the vegetation on the offsite offset property is high and it is considered likely that the current faunal habitats can be increased markedly in area and condition with active habitat management when farming makes way for conservation. **Table 10.6** provides a broad indication of the areas of actual or potential habitat available for threatened species and also indicates how much habitat can be eventually provided in the longer term as grassland areas are regenerated to open forest and woodland.

Table 10.4 Threatened and Migratory Species Recorded on the Offsite Offset Property

Family	Scientific Name	Common Name	TSC Act Status	EPBC Act Status
Acanthizidae	*Pyrrholaemus saggitatus*	Speckled Warbler	V	
Accipitridae	*Hieraaetus morphinoides*	Little Eagle	V	
Meropidae	*Merops ornatus*	Rainbow Bee-eater		Mi
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella	V	
Dasyuridae	*Dasyurus maculatus*	Spotted-tailed Quoll*	V	E1
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	V	
Vespertilionidae	*Chalinolobus dwyeri*	Large-eared Pied Bat	V	V
	Miniopterus australis	Little Bent-wing Bat	V	
	Miniopterus orianae oceanensis	Eastern Bentwing-bat	V	
Orchidaceae	*Cymbidium canaliculatum*	Tiger Orchid	E2	

** Anecdotal record from land manager (pers. comm. P. Swain)*

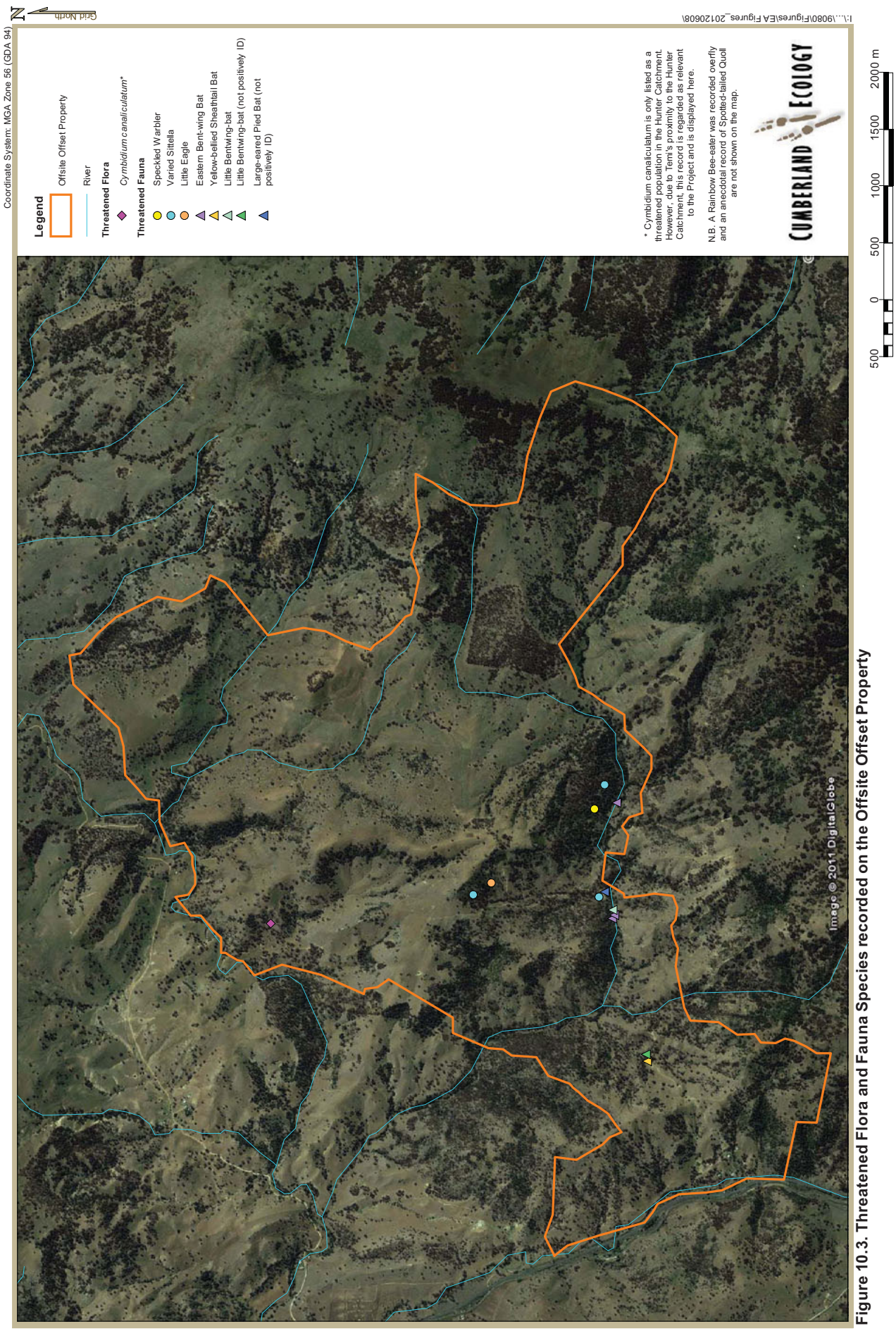


Figure 10.3. Threatened Flora and Fauna Species recorded on the Offsite Offset Property

Table 10.5 Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area

Family	Scientific Name	Common Name	Status		Study Area	Offsite Offset Property	
			EPBC	TSC	Likelihood of occurrence	Liverpool Plains LGA Records	Likelihood of Occurrence
Aves							
Acanthizidae	*Pyrrholaemus saggitatus*	Speckled Warbler	-	V	**Presence confirmed.** Records from multiple surveys of the Study Area and MAC mine lease.	20	**Presence confirmed.** Recorded during diurnal bird surveys.
Accipitridae	*Circus assimilis*	Spotted Harrier	-	V	**Presence confirmed.** Records from surveys of the Study Area.	No records	**Potential to occur**. Suitable habitat available within the offsite offset property.
	Hieraaetus morphnoides	Little Eagle	-	V	**Presence confirmed.** Recorded foraging in scattered paddock trees during 2011 surveys of the Study Area.	3	**Presence confirmed.** Recorded during diurnal bird surveys.
Ciconiidae	*Climacteris picumnus victoriae*	Brown Treecreeper (eastern subspecies)	-	V	**Presence confirmed.** Records from multiple surveys of the Study Area and MAC mine lease.	38	**Potential to occur.** Suitable habitat available within the offsite offset property.
Estrildidae	*Stagonopleura guttata*	Diamond Firetail	-	V	**Presence confirmed.** Records from multiple surveys	12	**Potential to occur.** Suitable habitat, in the form of shrubby understorey and ground

Table 10.5 Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area

Family	Scientific Name	Common Name	Status		Study Area	Offsite Offset Property	
			EPBC	TSC	Likelihood of occurrence	Liverpool Plains LGA Records	Likelihood of Occurrence
					of the Study Area and from MAC mine lease and Drayton Mine.		debris, is available within the offsite offset property.
Meliphagidae	*Melithreptus gularis gularis*	Black-chinned Honeyeater (eastern subspecies)	-	V	**Presence confirmed.** Tentatively recorded from previous surveys of the Study Area.	2	**Potential to occur.** Suitable box eucalypt habitat available within the offsite offset property; may occur as part of larger feeding territory.
	Anthochaera phrygia	Regent Honeyeater	E1, Mi	E1	**Potential to occur.** Not detected in fauna surveys of the Study Area; however the species may forage in dry open forest, woodland and riparian forests within the Study Area during migratory movements.	8	**Potential to occur.** Strongly nomadic in response to forage resource availability; abundant mistletoes, box eucalypt and River Oak habitat available within the offsite offset property.
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella	-	V	**Potential to occur.** Recorded from MAC mine lease. Suitable habitat available within the study area.	9	**Presence confirmed.** Recorded during diurnal bird surveys.
Petroicidae	*Melanodryas cucullata*	Hooded Robin (south-eastern	-	V	**Presence confirmed.** Recorded from surveys of the	2	**Potential to occur.** Suitable habitat, in the form of lightly wooded, shrubby and open

Table 10.5 Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area

Family	Scientific Name	Common Name	Status		Study Area	Offsite Offset Property	
			EPBC	TSC	Likelihood of occurrence	Liverpool Plains LGA Records	Likelihood of Occurrence
		form)			Study Area and from MAC mine lease.		areas, is available within the offsite offset property.
Petroicidae	*Petroica boodang*	Scarlet Robin	-	V	**Presence confirmed.** Recorded from previous surveys of the Study Area.	5	**Potential to occur.** Suitable habitat, in the form of eucalypt woodland, shrubby and open areas on ridges and slopes, is available within the offsite offset property.
Pomatostomidae	*Pomatostomus temporalis temporalis*	Grey-crowned Babbler (eastern subspecies)	-	V	**Presence confirmed.** Recorded from multiple surveys of the Study Area and from MAC mine lease.	15	**Potential to occur.** Suitable habitat, in the form of open box-gum woodland and ground debris, is available within the offsite offset property.
Psittacidae	*Lathamus discolor*	Swift Parrot	E1; Ma	E1	**Presence confirmed.** Recorded from 2011 surveys of the Study Area, foraging in winter-flowering mistletoe.	1	**Potential to occur.** Species is migratory and forage on winter-flowering mistletoes and eucalypt species which are abundant within the offsite offset property.
Psittacidae	*Glossopsitta pusilla*	Little Lorikeet	-	V	**Potential to occur.** Not detected in surveys of the Study Area. Recorded from MAC mine lease. Suitable foraging habitat available.	22	**Potential to occur.** Nomadic in response to food availability; suitable forage habitat, in the form of mistletoes and eucalypt species, is available within the offsite offset property.
	Neophema	Turquoise Parrot	-	V	**Potential to occur.** Suitable	19	**Potential to occur.** Suitable habitat, in the

Table 10.5 Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area

Family	Scientific Name	Common Name	Status		Study Area	Offsite Offset Property	
			EPBC	TSC	Likelihood of occurrence	Liverpool Plains LGA Records	Likelihood of Occurrence
	pulchella				habitat exists within the Study Area, within remnant and regenerating patches of Box-Gum Woodland. Recorded from MAC mine lease.		form of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland, is available within the offsite offset property.
Strigidae	*Ninox connivens*	Barking Owl	-	V	**Presence confirmed.** Recorded from previous surveys (Ecotone, 2000) of the Study Area.	No records	**Low potential to occur.** No records for the species within the LGA. However, timbered creeklines in eucalypt woodland and Casuarina stands are available within the offsite offset property.
Migratory Aves							
Monarchidae	*Myiagra cyanoleuca*	Satin Flycatcher	Mar. M	-	**Potential to occur.** Previously recorded within the MAC mine. On occasion may potentially utilise habitat within the Study Area.	No records	**Low potential to occur.** No records for the species within the LGA and sparsely scattered on the western slopes and plains. Some suitable habitat, in the form of eucalypt woodland and vegetated gullies, is available within the offsite offset property.
Apodidae	*Hirundapus caudacutus*	White-throated Needletail	Mar. M	-	**Presence confirmed.** Recorded from previous surveys of the Study Area and from MAC mine lease and	No records	**Potential to occur.** No records for the species within the LGA; exclusively aerial migratory species that occurs over most habitat types.

Table 10.5 Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area

Family	Scientific Name	Common Name	Status		Study Area	Offsite Offset Property	
			EPBC	TSC	Likelihood of occurrence	Liverpool Plains LGA Records	Likelihood of Occurrence
					Drayton mine lease.		
Meropidae	*Merops ornatus*	Rainbow Bee-eater	Mar. M	-	**Presence confirmed.** Recorded from previous surveys of the Study Area. Also known from MAC mine lease and Drayton mine lease.	No records	**Presence confirmed.** Recorded during diurnal bird surveys; migratory species found over a range of habitats including open forests and woodlands, shrubland and in various cleared or semi-cleared habitats.
Mammalia							
Dasyuridae	*Dasyurus maculatus*	Spotted-tailed Quoll	E1	V	**Potential to occur.** Not detected in fauna surveys but may utilise open forests, woodlands and riparian forest within the Study Area. Previously recorded in the MAC mine lease.	5	**Presence confirmed anecdotally.** Some suitable habitat, in the form of open forest, woodland and riparian forest, adjacent rocky cliff-faces and potential den sites, is available within the offsite offset property.
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	-	V	**Presence confirmed**. Recorded during 2011 surveys of the Study Area. Also known from the MAC mine lease and Drayton mine lease.	14	**Presence confirmed.** Calls recorded using Anabat unit and positively identified.
Molossidae	*Mormopterus*	Eastern Freetail-	-	V	**Presence confirmed.**	No records	**Low potential to occur.** No records from

Table 10.5 Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area

Family	Scientific Name	Common Name	Status		Study Area	Offsite Offset Property	
			EPBC	TSC	Likelihood of occurrence	Liverpool Plains LGA Records	Likelihood of Occurrence
	norfolkensis	bat			Recorded during 2011 and previous surveys of the Study Area. Also known from MAC mine lease and Drayton mine lease.		the LGA. Distributed east of the Great Divide to the coastline.
Petauridae	*Petaurus norfolcensis*	Squirrel Glider	-	V	**Potential to occur.** Known from MAC mine lease and Drayton mine lease	4	**Potential to occur.** Suitable habitat, in the form of remnant box eucalypt woodland, abundant hollows and forage resources, is available within the offsite offset property.
Phascolarctidae	*Phascolarctos cinereus*	Koala	V	V	**Low potential to occur.** Not detected in fauna surveys. Some suitable habitat is available within the surrounding area. An individual was recorded in early 2011 on a haul road in the MAC mine lease.	46	**Potential to occur.** Suitable habitat, in the form of eucalypt woodland and feed trees, is available within the offsite offset property. Species distribution generally limited to elevations of less than 800m; the offsite offset property ranges from some gully lines of 600m to slopes and ridges of over 1000m.
Vespertilionidae	*Chalinolobus dwyeri*	Large-eared Pied Bat	V	V	**Presence confirmed.** Recorded during 2011 surveys of the Study Area. Also known from MAC mine lease.	2	**Presence likely.** Calls recorded on Anabat unit could not be positively identified but based on call frequency and pattern, are considered probable from this species.

Table 10.5 Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area

Family	Scientific Name	Common Name	Status		Study Area	Offsite Offset Property	
			EPBC	TSC	Likelihood of occurrence	Liverpool Plains LGA Records	Likelihood of Occurrence
	Miniopterus australis	Little Bentwing-bat	-	V	**Unlikely to occur.** Not detected in fauna surveys of the Study Area. Sub-optimal habitat exists within the study area.	No records	**Presence confirmed.** Calls recorded using Anabat unit and positively identified.
	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	-	V	**Presence confirmed.** Recorded from surveys of the Study Area. Recorded from the MAC mine lease and Drayton mine lease.	3	**Presence confirmed.** Calls recorded using Anabat unit and positively identified.
	Myotis macropus	Southern Myotis	-	V	**Presence confirmed.** Recorded during 2011 and previous surveys of the Study Area. Also recorded in MAC mine lease	No records	**Low potential to occur.** No records from the LGA. Rarely found more than 100km inland, except along major rivers; the offsite offset property is located 180km from the coast.
	Nyctophilus corbeni	Greater Long-eared Bat	V	V	**Presence confirmed.** Recorded from previous surveys of the Study Area.	No records	**Potential to occur.** No records from the LGA; however suitable habitat, in the form of box eucalypt woodland and abundant hollows, is available within the offsite offset property.

Table 10.5 Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area

Family	Scientific Name	Common Name	Status		Study Area	Offsite Offset Property	
			EPBC	TSC	Likelihood of occurrence	Liverpool Plains LGA Records	Likelihood of Occurrence
	Scoteanax rueppellii	Greater Broad-nosed Bat	-	V	**Presence confirmed.** Recorded from surveys of the Study Area. Recorded from Drayton mine lease.	No records	**Potential to occur.** No records from the LGA; however suitable habitat, in the form of box eucalypt woodland and abundant hollows, is available within the offsite offset property.
	Vespadelus troughtoni	Eastern Cave Bat	-	V	**Potential to occur.** Calls recorded during 2011 surveys of the Study Area but not positively identified. Recorded from MAC mine lease and Drayton mine lease.	3	**Potential to occur.** Some suitable roosting and forage habitat exists in the locality.
Plants							
Fabaceae - Mimosoideae	*Acacia pendula*	Acacia pendula population in the Hunter catchment	V	E2	**Presence confirmed.** Individuals recorded from previous surveys. Also known from two locations in MAC mine lease. The individuals do not conform to the listing for EPBC Weeping Myall Woodland; however there is potential for the community to	No records	**Potential to occur.** Typically grows on the floodplains of major rivers in heavy clay soils. However, could possibly occur in some of the basalt-rich parts of the property. The population is not listed outside of the Hunter Catchment but since the property is on the border between the Namoi and Hunter Catchments, any potential habitat for the species is

Table 10.5 Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area

Family	Scientific Name	Common Name	Status		Study Area	Offsite Offset Property	
			EPBC	TSC	Likelihood of occurrence	Liverpool Plains LGA Records	Likelihood of Occurrence
					occur within the Project area.		considered to be relevant to the Project.
Myrtaceae	*Eucalyptus camaldulensis*	Eucalyptus camaldulensis population in the Hunter catchment	-	E2	**Presence confirmed.** One mature individual was recorded along Saddlers Creek and others are considered likely to occur.	No records	**Potential to occur.** Typically on deep rich alluvial soils adjacent to large permanent water bodies. Could possibly occur along creeklines, particularly at the New England Hwy frontage. The population is not listed outside of the Hunter Catchment but since the property is on the border between the Namoi and Hunter Catchments, any potential habitat for the species is considered to be relevant to the Project.
Orchidaceae	*Cymbidium canaliculatum*	Cymbidium canaliculatum population in the Hunter Catchment	-	E2	**Presence confirmed.** Recorded from surveys of the Project area. Also known from two locations in MAC mine lease.	No records	**Presence confirmed.** The population is not listed outside of the Hunter Catchment but since the property is on the border between the Namoi and Hunter Catchments, any potential habitat for the species is considered to be relevant to the Project.
	Diuris tricolor	Diuris tricolor Fitzg., the Pine Donkey Orchid, in	-	E2	**Presence confirmed.** Recorded from surveys of the Project area. Also known from	No records	**Potential to occur.** Suitable habitat present, in the form of Box-Gum Woodland, cleared eucalypt forests, relict grassland

Table 10.5 Comparison of the Likelihood of Occurrence of Threatened Species on the Offsite Offset Property with the Study Area

Family	Scientific Name	Common Name	Status		Study Area	Offsite Offset Property	
			EPBC	TSC	Likelihood of occurrence	Liverpool Plains LGA Records	Likelihood of Occurrence
		the Muswellbrook local government area			the MAC mine lease.		and moderately disturbed or conservatively grazed areas. The population is not listed outside of the Hunter Catchment but since the property is on the border between the Namoi and Hunter Catchments, any potential habitat for the species is considered to be relevant to the Project.
Poaceae	*Bothriochloa biloba*	Lobed Blue-grass	V	-	**Presence confirmed.** Recorded from surveys of the Project area. Also known from the MAC mine lease.	27	**Potential to occur.** Suitable habitat present, in the form of Box-Gum Woodland, cleared eucalypt forests, relict grassland and moderately disturbed or conservatively grazed areas.

Key: V = Vulnerable; E1 = Endangered; E2 = Endangered Population; CE = Critically Endangered; Mi = Migratory; Ma = Marine

Table 10.6 Habitat Available to Threatened Species on the Offsite Offset Property

Scientific Name	Common Name	EPBC Act	TSC Act	Preferred Habitat	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)
Aves						
Pyrrholaemus saggitatus	Speckled Warbler	-	V	F, W	1181	2079
Circus assimilis	Spotted Harrier	-	V	F, W, G	2079	2079
Hieraaetus morphnoides	Little Eagle	-	V	F, W, G	2079	2079
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	-	V	F, W	1181	2079
Stagonopleura guttata	Diamond Firetail	-	V	F, W	1181	2079
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	-	V	F, W	1181	2079
Anthochaera phrygia	Regent Honeyeater	E1,Mi	E1	F, W	1181	2079
Daphoenositta chrysoptera	Varied Sittella	-	V	F, W	1181	2079
Melanodryas cucullata	Hooded Robin (south eastern form)	-	V	F, W	1181	2079
Petroica boodang	Scarlet Robin	-	V	F, W	1181	2079
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	-	V	F, W, G	2079	2079
Lathamus discolor	Swift Parrot	E1; Ma	E1	F, W	1181	2079
Glossopsitta pusilla	Little Lorikeet	-	V	F, W	1181	2079

Table 10.6 Habitat Available to Threatened Species on the Offsite Offset Property

Scientific Name	Common Name	EPBC Act	TSC Act	Preferred Habitat	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)
Neophema pulchella	Turquoise Parrot	-	V	F, W	1181	2079
Ninox connivens	Barking Owl	-	V	F, W	1181	2079
Migratory Aves						
Myiagra cyanoleuca	Satin Flycatcher	Mar. M	-	F, W	1181	2079
Hirundapus caudacutus	White-throated Needletail	Mar. M	-	F, W, G	2079	2079
Merops ornatus	Rainbow Bee-eater	Mar. M	-	F, W	1181	2079
Mammalia						
Dasyurus maculatus	Spotted-tailed Quoll	E1	V	F, W	1181	2079
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	-	V	F, W	1181	2079
Mormopterus norfolkensis	Eastern Freetail-bat	-	V	F, W	1181	2079
Petaurus norfolcensis	Squirrel Glider	-	V	F, W	1181	2079
Phascolarctos cinereus	Koala	V	V	F, W	1181	2079
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	F, W	1181	2079
Miniopterus australis	Little Bentwing-bat	-	V	F, W	1181	2079
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	-	V	F, W	1181	2079
Myotis macropus	Southern Myotis	-	V	F, W	1181	2079
Nyctophilus corbeni	Greater Long-eared Bat	V	V	F, W	1181	2079
Scoteanax rueppellii	Greater Broad-nosed Bat	-	V	F, W	1181	2079

Table 10.6 Habitat Available to Threatened Species on the Offsite Offset Property

Scientific Name	Common Name	EPBC Act	TSC Act	Preferred Habitat	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)
Vespadelus troughtoni	Eastern Cave Bat	-	V	F, W	1181	2079
Plants						
Acacia pendula	Acacia pendula population in the Hunter catchment	V	E2	F, W, G	2079	2079
Eucalyptus camaldulensis	Eucalyptus camaldulensis population in the Hunter catchment	-	E2	New England Hwy frontage in Box-gum grassy woodlands, or in Rough-barked Apple - Blakely's Red Gum riparian grassy woodlands	45	45
Cymbidium canaliculatum	Cymbidium canaliculatum population in the Hunter Catchment	-	E2	F, W	1181	2079
Diuris tricolor	Diuris tricolor Fitzg., the Pine Donkey Orchid, in the Muswellbrook local government area	-	E2	F, W, G	2079	2079
Bothriochloa biloba	Lobed Blue-grass	V	-	F, W, G	2079	2079

Key: V = Vulnerable; E1 = Endangered; E2 = Endangered Population; CE = Critically Endangered; Mi = Migratory; Ma = Marine

10.6 Adequacy of the BOP in Addressing Project Impacts

The Project will result in the disturbance of 1928 ha of vegetation. The majority of vegetation to be cleared represents grassland (1539 ha), of which 107 ha comprises Box-Gum Woodland derived native grassland. A minority of the footprint, an estimated 389 ha of forest, woodland and shrubland, will be cleared by the Project progressively over 27 years.

The BOP will address the predicted loss of vegetation by provision of 1754 ha of Box-Gum Woodland, comprising 856 ha of woodland and 898 ha of derived native grassland; 1457 ha of other endangered forest and woodland communities; and 442 ha of non-threatened forest and woodland in the medium to long term. In total the offset provided will afford an offset of 3653 ha in size or a ratio of 1.9:1 for total vegetation to be cleared (see **Table 10.7**). However, the BOP will afford an immediate 1290 ha of existing forest and woodland to offset the progressive loss of 389 ha of forest and woodland. This will provide an immediate offset to impact ratio of 3.3:1 for forest and woodland generally.

The BOP will offset the loss of remnant (i.e. timbered) Box-Gum Woodland with an immediate 794 ha of existing remnant Box-Gum Woodland (at a ratio of 10.7:1). Similarly for the estimated clearance of 107 ha of listed Derived Native Grassland, the BOP will supply an overall 898 ha of EEC Derived Native Grassland (a ratio of 8.4:1), of which a subset comprises 343 ha of CEEC Derived Native Grassland (a ratio of 3.2:1). The total area of remnant and grassland Box-Gum Woodland that will be supplied by the BOP in the long term will offset the predicted impacts on remnant and grassland Box-Gum Woodland in the Study Area by approximately 9.7:1.

Impacts to 279 ha of other state-listed TECs will be offset at a ratio of 5.2:1.

The proposed offset areas are predicted to provide large areas of habitat for threatened woodland species including habitats for all of the threatened species known or considered likely to occur in the impact area. The proposed active management of the offset lands is predicted to substantially increase the values of the land for fauna and flora in the long term and will increase the areas of habitat available for many species.

The original vegetation within the Study Area and within offset lands was woodland and open forest. Thus the threatened species that can or are predicted to occur are dependent on these habitats, not grassland. Within the Study Area and proposed offset lands, the long term prediction is to restore and protect an area of forest and woodland habitat amounting to 3653 ha, compared with the 389 ha of currently existing forest and woodland to be cleared by the Project. As such the BOP will provide a substantial and appropriately targeted ecological offset for the Project.

The BOP will also have other ecological advantages as it will entail restoration of Saddlers Creek, which is currently in a highly degraded condition. This will have downstream benefits to the Hunter River itself by improving water quality emanating from Saddlers Creek and also by improving habitats within the creek itself. Other creeks in the property will also be of major benefit to wildlife by affording a water source and drought refuge that is currently somewhat degraded due to livestock grazing.

Table 10.7 Summary of Areas in the BOP Compared with the Offset Requirements of the Project

Vegetation Community	IMPACTS				BOP								
	Area of Vegetation within Study Area (ha)	[A] Area of Vegetation within Disturbance Footprint (ha)	Minimum Ratio	[B] Offsets Required (ha)	Saddlers Ck Restoration (ha)		Ridgeline (ha)	Onsite Rehabilitation (ha)		Offsite Offset (ha)	[C] Total Offset (ha)	Difference (ha) [C]-[B]	Offset Ratio [C] : [A]
					Existing Available Offsets	Restoration Offsets	Existing Available Offsets	Ratio	Available Offsets				
Box - gum grassy woodlands, Brigalow Belt South and Nandewar										67	67		
Hunter Floodplain Red Gum Woodland Complex	40	11	6:1	66	20	62					82		
River Oak riparian woodland, eastern NSW*										33	33		
Rough-barked Apple - Blakely's Red Gum riparian grassy woodlands, Brigalow Belt South and Nandewar										25	25		
Silvertop Stringybark grassy open forests, eastern Nandewar and New England Tablelands										253	253		
Upper Hunter White Box-Ironbark Grassy Woodland	94	63	6:1	378									
White Box grassy woodland, Brigalow Belt South and Nandewar										396	396		
Box-Gum Woodland (CEEC, EPBC Act; EEC, TSC Act)	**134**	**74**	**6:1**	**444**	**20**	**62**				**774**	**856**	**412**	**11.6**
Derived grasslands, Brigalow Belt South and Nandewar										343	343		
Derived Native Grassland-Hunter Floodplain Red Gum Woodland Complex	10	4	6:1	24									
Derived Native Grassland-Upper Hunter White Box-Ironbark Grassy Woodland	159	103	6:1	618									
Low Diversity Derived Native Grassland**										555	555		
Box-Gum Woodland Derived Native Grassland (CEEC, EPBC Act; EEC, TSC Act)	**169**	**107**	**6:1**	**642**						**898**	**898**	**256**	**8.4**
Central Hunter Box-Ironbark Woodland (EEC)	479	181	3:1	543	4		50	0.5:1	777		831		
Narrabeen Footslopes Slaty Gum Woodland (VEC)	100	98	3:1	294				0.5:1	626		626		
Other Threatened Woodland and Forest communities	**579**	**279**	**3:1**	**837**	**4**		**50**		**1403**		**1457**	**620**	**5.2**
Central Hunter Bulloak Forest Regeneration	26	25	3:1	75									
Cooba Scrub	65	9	3:1	27			35				35		
Hunter Valley River Oak Forest***	2	2	3:1	6									
Planted Vegetation	9		N/A	N/A	N/A	N/A	N/A		N/A	N/A		N/A	N/A
Silvertop Stringybark - gum open forest on basalts of the Liverpool Range, Brigalow Belt South and Nandewar										71	71		

Table 10.7 Summary of Areas in the BOP Compared with the Offset Requirements of the Project

	IMPACTS				BOP								
Vegetation Community	Area of Vegetation within Study Area (ha)	[A] Area of Vegetation within Disturbance Footprint (ha)	Minimum Ratio	[B] Offsets Required (ha)	Saddlers Ck Restoration (ha)		Ridgeline (ha)	Onsite Rehabilitation (ha)		Offsite Offset (ha)	[C] Total Offset (ha)	Difference (ha) [C]-[B]	Offset Ratio [C] : [A]
					Existing Available Offsets	Restoration Offsets	Existing Available Offsets	Ratio	Available Offsets				
White Box - stringybark shrubby woodlands, Brigalow Belt South and Nandewar										336	336		
Other non-listed Forest and Woodland communities	**102**	**36**	**3:1**	**108**			**35**			**407**	**442**	**334**	**12.3**
Other Grassland	3613	1432	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A		
Other Grassland	**3613**	**1432**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**		**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
TOTAL All Vegetation	**4597**	**1928**		**2031**	**24**	**62**	**85**		**1403**	**2079**	**3653**	**1622**	**1.9**
TOTAL Box-Gum Woodland	**303**	**181**		**1086**	**20**	**62**	**0**		**0**	**1672**	**1754**	**668**	**9.7**

*Co-dominated by *Eucalyptus melliodora* or *Eucalyptus blakelyi* x *Eucalyptus teretecornis*

**Only listed under the TSC Act

***Equivalent vegetation in the offsite offset property is *River Oak riparian woodland, eastern NSW*, which also conforms to Box Gum Woodland

10.7 MNES Addressed through Provision of the BOP

A summary of the habitat areas that will be made available for MNES through the conservation and management of both the Onsite and Offsite components of the BOP is provided in **Table 10.8** overpage. It demonstrates that the offsets can provide habitat for all the MNES known or likely to occur in the Study Area, as well as some MNES that are unlikely to occur in the Study Area but may be present in the locality. It also demonstrates that there will be a net gain in habitat for MNES in the long term. This is also discussed in **Appendix M**, which contains summary of assessment of MNES as required under the EPBC Act.

10.8 Compliancy of the BOP with NSW and Commonwealth Offsetting Policies

An evaluation of the Project's proposed BOP against both the OEH offsetting principles and the Commonwealth policy guidelines has been conducted and is presented in **Table 10.9** and **Table 10.10** respectively. It demonstrates that the BOP is consistent with the offsetting principles and is able to address the Project impacts on biodiversity and deliver a conservation gain.

Table 10.8 Habitat Provided by the Biodiversity Offset Package for MNES

Common Name	Preferred Habitat	Used For	Study Area		Offsite Offset Property		Onsite Offset Areas	
			Present or Likely to be Present	Area of Direct Impact (ha)	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)
Box-Gum Woodland	-	-	Y	181	774	1672	20	82
Weeping Myall Woodland	-	-	N	0	-	-	-	-
Regent Honeyeater	F, W	Infrequent Foraging; low numbers	Y (low)	389	1181	2079	109	1574
Swift Parrot	F, W	Infrequent Foraging; low numbers	Y (low)	389	1181	2079	109	1574
Spotted-tailed Quoll	F, W	Foraging; low density	Y (low)	389	1181	2079	109	1574
Koala	F, W	Foraging or movement	N	389	1181	2079	109	1574
Greater Long-eared Bat	F, W	Foraging and roosting	Y	389	1181	2079	109	1574
Green and Golden Bell Frog	Wetland	Foraging	N	0	-	-	24	86

Table 10.8 Habitat Provided by the Biodiversity Offset Package for MNES

Common Name	Preferred Habitat	Used For	Study Area		Offsite Offset Property		Onsite Offset Areas	
			Present or Likely to be Present	Area of Direct Impact (ha)	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)
		and breeding						
Lobed Blue-grass	F, W, G	-	Y	1928	2079	2079	171	1574
Finger Panic Grass	F, W, G on basalt	-	N	0	1181	2079	-	-
Leek-orchid	F, W, G	-	Y (low)	1928	2079	2079	171	1574
Illawarra Greenhood	F, W, G	-	N	0	2079	2079	171	1574
Austral Toadflax	F, W, G	-	Y (low)	0	2079	2079	171	1574

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
1. Impacts must be avoided first by using prevention and mitigation measures.	Offsets are then used to address remaining impacts. This may include modifying the proposal to avoid an area of biodiversity value or putting in place measures to prevent offsite impacts.	Avoiding ecological impacts has been considered where possible throughout the Project planning and design phases. Pre-feasibility studies informed mine plans and operational alternatives to best avoid and minimise environmental and social impacts related to the Project while still allowing the Project to be economically viable. The current mine plan 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 and thus avoid unnecessary additional impacts. Various measures have been developed to avoid and mitigate some of the predicted impacts of the Project, as discussed in **Chapters 7** and **8.** Residual impacts that can not otherwise be mitigated will be offset using both onsite and offsite components. A 'maintain or improve' approach to the proposed offsets will be implemented through the Biodiversity Offset Package (BOP) discussed in **Chapter 9**.
2. All regulatory requirements must be met.	Offsets cannot be used to satisfy approvals or assessments under other legislation, e.g. assessment requirements for Aboriginal heritage sites, pollution or other environmental impacts (unless specifically provided for by legislation or additional approvals).	All regulatory requirements for the BOP will be met.
3. Offsets must never	Offset schemes should not encourage landholders to	The offset areas will be managed in accordance with the BOP (and site-

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
reward ongoing poor performance.	deliberately degrade or mismanage offset areas in order to increase the value from the offset.	specific Biodiversity Offset Management Plans (BOMPs) to increase their ecological values over time and will not be deliberately degraded or mismanaged. The BOMP will be designed in accordance with the latest offset management guidelines made available by SEWPaC and contain a description and plan of land management and conservation measures (long and short term). It will include monitoring methodology, key performance indicators against which to measure progress and auditing arrangements.
4. Offsets will complement other government programs.	A range of tools is required to achieve the NSW Government's conservation objectives, including the establishment and management of new national parks, nature reserves, state conservation areas and regional parks and incentives for private landholders.	The BOP will complement other government programs for conservation in that it will address the goals of recovery plans for threatened ecological communities and species, including for Box-Gum Woodland and the Swift Parrot. The BOP will also adopt recommendations for management of weeds and feral animals. Offset lands will be permanently protected by an appropriate mechanism to be determined by Anglo American in consultation with OEH and other relevant agencies. Some options, including dedication of land to the National Parks reserve estates and conservation covenants are outlined in **Section 9.5**.
5. Offsets must be underpinned by sound ecological principles. They	- include the consideration of structure, function and compositional elements of biodiversity, including threatened species	The BOP will enhance, regenerate and protect forest, woodland and grassland communities that will be impacted by the Project, including Box-Gum Woodland and TEC's listed under the TSC Act, to ensure that

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
must:		ecological structure and function of representative communities in the locality will be maintained and improved. This includes replanting with appropriate local or endemic species in all strata, and protecting and enhancing habitat for a range of threatened flora and fauna species known or with potential to occur in the Study Area and offsite offsets.
	- enhance biodiversity at a range of scales	The BOP will enhance biodiversity values at landform (rehabilitation), local (protection of biodiversity) and regional scales (wildlife corridors and permanent conservation areas). The proposed Onsite Offset Areas (Saddlers Creek restoration, conservation of the primary ridgeline, rehabilitation and revegetation of the Project Disturbance Footprint) will form a large area supporting viable forest, woodland, riparian and grassland habitat for a wide variety of species. Under the BOP, understorey complexity and other habitat features such as logs, stags and tree hollows will be preserved and protected to encourage fauna and flora use of these habitats. The BOP will also link the proposed Onsite Offset Areas to existing conservation areas and to other habitat areas in the locality to enhance ecological function of habitats. A wildlife corridor will be created that links to other parts of the Saddlers Creek catchment that are already being managed and restored for conservation within land owned by Mt Arthur Coal and Drayton Mine and extending to the Hunter River. This will also improve creek line condition and function, which will have positive impacts on the Hunter River.
	- consider the conservation status of ecological	Offsets have been strategically chosen in anticipation of the predicted

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
	communities	loss of TECs, particularly Box-Gum Woodland. Minimum offset areas to compensate for the Project's impacts are discussed in Table 9.1. The BOP will maintain and improve occurrences of threatened ecological communities and regionally significant plant communities and includes targeted preservation of remaining and regenerated Box-Gum Woodland, Central Hunter Box-Ironbark Woodland, Narrabeen Footslopes Slaty Gum Woodland and other pre-existing, non-threatened communities.
	- ensure the long-term viability and functionality of biodiversity.	Offsets will be conserved in perpetuity and will be actively managed and monitored during the life of the Project to ensure the long-term viability of ecological values of the designated areas.
	- Biodiversity management actions, such as enhancement of existing habitat and securing and managing land of conservation value for biodiversity, can be suitable offsets. Reconstruction of ecological communities involves high risks and uncertainties for biodiversity outcomes and is generally less preferable than other management strategies, such as enhancing existing habitat.	The BOP has various components and biodiversity management actions to complement each other and ensure biodiversity values in the locality and region are maintained and enhanced. The BOP provides for the enhancement of existing habitat and wildlife corridors and will secure land for conservation in perpetuity via the Offsite Offset and restoration of Saddlers Creek and existing communities in the Study Area. Reconstruction of ecological communities, via rehabilitation and revegetation of the Project Disturbance Footprint, will be conducted in accordance with recognised land management principles and aims to recreate native vegetation that is self-sustaining in the long term and capable of supporting a diverse range of viable flora and fauna populations.

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
6. Offsets should aim to result in a net improvement in biodiversity over time.	Enhancement of biodiversity in offset areas should be equal to or greater than the loss in biodiversity from the impact site.	Minimum offset requirements have been adopted for the BOP in anticipation of the predicted loss of biodiversity, including threatened ecological communities and species as a result of the Project. Details of offset areas to compensate for the Project's impacts are discussed in **Table 9.1**; however a minimum of 3:1 ratio has been adopted for TSC Act-listed ecological communities and a minimum of 6:1 ratio adopted for communities that conform to the EPBC Act listing for Box-Gum Woodland and Derived Native Grassland. This will result in approximately 2031 ha required for offsetting purposes.
	Setting aside areas for biodiversity conservation without additional management or increased security is generally not sufficient to offset against the loss of biodiversity. Factors to consider include protection of existing biodiversity (removal of threats), time-lag effects, and the uncertainties and risks associated with actions such as revegetation.	The BOP will result in a net improvement in woodland and open forest communities over time, with commensurate benefits to threatened species. The BOP will protect areas of intact vegetation via an appropriate land zoning or other alternative means for the life of the impact. The BOP will also enhance and protect existing vegetation and fauna through management actions that include removal of grazing, weed and feral animal management, translocation of threatened species to protected areas, and reconstructing habitat corridors to link areas of habitat along Saddlers Creek and associated gullies. As areas are progressively mined, revegetation and rehabilitation works will be implemented concurrently over the life of the Project to minimise ecological impacts and significant loss of habitat at any one time. This will ensure that areas of mature, remnant woodland will be maintained at all times in the Disturbance Footprint. It also addresses the issue of time lag, which is the time it will take an offset to mature and yield a

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
		conservation gain that provides ecosystem functionality, which for rehabilitated areas may be an indeterminate point in the future.
	Offsets may include enhancing habitat, reconstructing habitat in strategic areas to link areas of conservation value, or increasing buffer zones around areas of conservation value and removal of threats by conservation agreements or reservation.	The BOP makes provisions for the regeneration and enhancement of ecological communities and habitat corridors. They are strategically located to add to the areas of existing habitat to be protected and enhanced, including linking to the Drayton Wildlife Refuge by extending a wildlife corridor along Saddlers Creek by restoring riparian vegetation and creek condition.
7. Offsets must be enduring - they must offset the impact of the development for the period that the impact occurs.	As impacts on biodiversity are likely to be permanent, the offset should also be permanent and secured by a conservation agreement or reservation and management for biodiversity. Where land is donated to a public authority or a private conservation organisation and managed as a biodiversity offset, it should be accompanied by resources for its management. Offsetting should only proceed if an appropriate legal mechanism or instrument is used to secure the required actions.	As discussed in **Section 9.5**, various options for the long-term conservation of offsets are being considered by Anglo American, including a variety of legal mechanisms. The BOP and BOMP will provide details of ongoing management of biodiversity.
8. Offsets should be agreed prior to the impact occurring.	Offsets should minimise ecological risks from time-lags. The feasibility and in-principle agreements to the necessary offset actions should be demonstrated prior	The nature and extent of the offsets will be agreed prior to commencement of the Project. As the disturbance will be staged over the life of the Project, the BOP will be progressively implemented over

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
	to the approval of the impact. Legal commitments to the offset actions should be entered into prior to the commencement of works under approval.	the life of the Project to ensure ecological impacts are minimised. Issues of time lag and legal commitments to long-term conservation of offsets are discussed in **Chapter 9**.
9. Offsets must be quantifiable - the impacts and benefits must be reliably estimated.	Offsets should be based on quantitative assessment of the loss in biodiversity from the clearing or other development and the gain in biodiversity from the offset. The methodology must be based on the best available science, be reliable and used for calculating both the loss from the development and the gain from the offset. The methodology should include:	The Project impacts and BOP have been assessed using Geographic Information Systems (GIS) and orthorectified aerial photography. The methodology uses ground truthed data, collected through field survey, to allow for accurate and reliable quantification of the biodiversity losses and gains for the Project
	- the area of impact - the types of ecological communities and habitat/species affected - connectivity with other areas of habitat/corridors - the condition of habitat - the conservation status and/or scarcity/rarity of ecological communities	The area of impact; types of communities and species to be impacted; extent of existing and future connectivity; condition of habitat and conservation status of ecological communities have been documented within **Chapters 5-9**.
	- management actions	The BOP makes provisions for the management of the offset areas to ensure that there will be a net benefit in biodiversity values.
	- level of security afforded to the offset site.	The Offset Areas will be conserved in perpetuity and will be actively managed during the life of the Project, ensuring that there is a net gain

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
		in biodiversity in the wider locality in the long term.
	The best available information/data should be used when assessing impacts of biodiversity loss and gains from offsets. Offsets will be of greater value where: - they protect land with high conservation significance	The proposed Offset Areas, both onsite and offsite, have high conservation significance as they occur in highly disturbed and modified environments and would otherwise not be protected in perpetuity. They also contain various threatened ecological communities that exist as both regeneration and mature remnants; habitat for threatened flora and fauna species; known occurrences of threatened species (as discussed in **Chapters 4, 5** and **10**) and significant riparian habitats and watercourses that act as locality and/or regional wildlife corridors.
	- management actions have greater benefits for biodiversity	The natural and assisted management actions that are proposed in the BOP, such as cessation or reduction of cattle grazing, revegetation, weed control and feral animal control have a high probability of providing a significant conservation benefit for the biodiversity of the offset areas.
	- the offset areas are not isolated or fragmented	The habitat within the locality is highly disturbed and largely fragmented in its current state. The BOP aims to reverse the effects of fragmentation through onsite rehabilitation and enhancement of forest and woodland that links to other vegetation in the locality. It also aims to recreate significant riparian and wildlife corridors that connect Saddlers Creek to the Hunter River and allow fauna movement across large distances. The Offsite Offset was strategically selected for its location and also effectively provides large areas of habitat. The Offsite Offset also provides connectivity within its locality by providing 'stepping stone' habitat to other National Parks and reserves in the region and

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
		riparian corridors along its two semi-permanent creeks and their tributaries.
	- the management for biodiversity is in perpetuity (e.g. secured through a conservation agreement).	The proposed offsets will be permanently protected and secured by an appropriate mechanism. The final method will be decided by Anglo American in consultation with OEH and other relevant agencies.
	Management actions must be deliverable and enforceable.	The BOP will specify key performance indicators, regular monitoring and audits to ensure the ongoing success of management of the offsets.
10. Offsets must be targeted.	They must offset impacts on the basis of like-for-like or better conservation outcome. Offsets should be targeted according to biodiversity priorities in the area, based on the conservation status of the ecological community, the presence of threatened species or their habitat, connectivity and the potential to enhance condition by management actions and the removal of threats. Only ecological communities that are equal or greater in conservation status to the type of ecological community lost can be used for offsets. One type of environmental benefit cannot be traded for another: for example, biodiversity offsets may also result in improvements in water quality or salinity but these benefits do not reduce the biodiversity offset requirements.	The offsets described in **Chapters 9** and **10** are targeted and will deliver a like-for-like or better conservation outcome for non-threatened and threatened ecological communities and species. Minimum offset ratios were adopted for each vegetation community to be impacted (**Tables 9.1** and **9.2**); these requirements informed the selection of offsets for inclusion in the BOP.

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
		Under the BOP, threatened ecological communities listed under the TSC and EPBC Acts will be targeted, with emphasis placed on offsetting and conserving Box Gum Woodland. Derived grassland will be offset by their woodland community types as woodland habitats have a higher conservation value. Various habitat types for threatened species identified within the Study Area have also been targeted, descriptions of which are provided in **Tables 10.5** and **10.6**.
11. Offsets must be located appropriately.	Wherever possible, offsets should be located in areas that have the same or similar ecological characteristics as the area affected by the development.	The proposed offsets are located appropriately within the landscape. The BOP includes Onsite Offset areas that are located within the Study Area, including the restoration of Saddlers Creek and extension of wildlife corridors to link with existing conservation areas managed by Drayton Mine and Mt Arthur Coal. Key considerations in assessing the suitability of the Offsite Offset to compensate for the impacts of the Project for inclusion in the BOP include: provision of extensive areas of moderate-high quality remnant and regenerating Box-Gum Woodland similar to that affected by the Project; provision of suitable habitat for threatened species that will potentially be affected by the Project; internal connectivity; important habitat features including waterways; and management and regenerative potential. The Offsite Offset is located further away, but shares the same general characteristics as the Study Area and supports a similar suite of threatened species.

Table 10.9 Evaluation of BOP against the OEH Offsetting Principles

OEH Principles for the use of Biodiversity Offsets in NSW		Evaluation
12. Offsets must be supplementary.	They must be beyond existing requirements and not already funded under another scheme. Areas that have received incentive funds cannot be used for offsets. Existing protected areas on private land cannot be used for offsets unless additional security or management actions are implemented. Areas already managed by the government, such as national parks, flora reserves and public open space cannot be used as offsets.	The proposed offsets are supplementary in that they are proposed exclusively for the Project and are not already funded or being managed for biodiversity value for another development proposal.
13. Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or a contract.	Offsets must be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes.	The Onsite and Offsite Offsets proposed in the BOP will be enforceable through development consent conditions. They will be monitored regularly to and auditable to ensure that actions have been carried out and key performance indicators are being met.

Table 10.10 Evaluation of the BOP against the Commonwealth Offsets Policy

EPBC Act Environmental Offsets Policy	Evaluation
1. deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action	The offsets will directly contribute to the long-term viability of MNES to be impacted by the Project; the proposed Offsite Offset contains extensive areas of the EPBC Act-listed critically endangered ecological community Box-Gum Woodland, of which a portion is to be cleared by the Project, which will be enhanced and conserved in perpetuity. The Offsite Offset also contains suitable known and potential habitat for threatened species listed under the EPBC Act. These species and their likelihood of occurrence based on habitat and locality records and are discussed further in **Tables 10.4** and **10.5**. The BOP will improve and protect biodiversity values that would otherwise not be conserved if the Project and offsetting do not take place.
2. be built around direct offsets but may include other compensatory measures	Direct offsets were chosen to meet the compensatory requirements of the Project and meet the minimum offset ratios outlined in **Tables 9.1** and **9.2**. These include Onsite and strategically located Offsite Offsets that provide for the long-term conservation of large areas of land and habitat for various flora and fauna. No indirect offsets are being offered as part of the BOP.
3. be in proportion to the level of statutory protection that applies to the protected matter	The updated EPBC Act Environmental Offsets Policy was published in October 2012. The Offsets Policy document and the accompanying Offset Assessment Guide pre-dates the current EA and were therefore not available during the development of biodiversity offsets for the Project. However, significant offsetting ratios are provided to offset Box-Gum Woodland and habitat for threatened species listed under the EPBC Act, as presented in **Table 10.7**.

Table 10.10 Evaluation of the BOP against the Commonwealth Offsets Policy

EPBC Act Environmental Offsets Policy	Evaluation
4. be of a size and scale proportionate to the residual impacts on the protected matter	Minimum offset requirements have been adopted for the BOP in anticipation of the predicted loss of biodiversity, including MNES, as a result of the Project. Details of offset areas to compensate for the Project's impacts are discussed in **Table 9.1**; however a minimum of 6:1 ratio has been adopted for the EPBC Act listing for CEEC Box-Gum Woodland and Derived Native Grassland. This results in approximately 1086 ha of Box-Gum Woodland that is required for offsetting purposes, which will be met with both Onsite and Offsite Offsets proposed in the BOP.
5. effectively account for and manage the risks of the offset not succeeding	The BOP outlines direct compensatory measures in the form of Onsite and Offsite Offsets. Direct offsets lower the risk of the offset not succeeding and are more likely to result in a conservation gain for MNES. As per the EPBC offset policy, the advanced delivery of offsets, as is the case with the Project, also reduces the risk by providing a conservation gain at an earlier point in time, prior to the commencement of the Project.
6. be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action, see section 7.6)	The offsets are proposed exclusively for the Project and are not already funded or being managed for biodiversity value for another development proposal. They have not been set aside in the conservation estate or are sites already unable to be built upon due to zoning laws as an offset for a separate proposed action.
7. be efficient, effective, timely, transparent, scientifically robust and reasonable	The proposed Offsite Offset was selected on its ecological merits and ability of Anglo American to efficiently and effectively maintain and improve the viability of MNES on the property, including Box-Gum Woodland and habitat forEPBC Act-listed flora and fauna.

Table 10.10 Evaluation of the BOP against the Commonwealth Offsets Policy

EPBC Act Environmental Offsets Policy	Evaluation
	The Offsets are timely, in that they will be implemented prior or concurrently to the proposed disturbance. The Offsite Offset was chosen as a result of both desktop analysis and multiple field surveys to assess the suitability of the property as an offset and is discussed further in **Chapter 10**.
8. have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.	A comprehensive BOP has been prepared that outlines arrangements for managing and monitoring the performance of the Offsite Offset and restoration and rehabilitation works undertaken for Osite Offsets within the Study Area. Management of the Onsite and Offsite Offsets will be enforceable through development consent conditions. They will be regularly monitored and auditable to ensure that the actions proposed in the have been carried out and key performance indicators are being met.

Chapter 11

Conclusion

The Drayton South Coal Project is a 27 year open cut coal mining development that has been proposed as a continuation of the existing Drayton Mine. A direct consequence of the Project is the clearance of 1928 ha of vegetation from the Study Area, including some forest and woodland, but largely comprising grassland as follows:

- 181 ha of state- and commonwealth-listed Box-Gum Woodland; comprising 74 ha of woodland and 107 ha of derived native grassland;
- 279 ha of other state-listed TECs;
- 36 ha of other native vegetation not listed under legislation; and
- 1432 ha of grassland not listed under legislation.

The Project will disturb a further 37 ha at Drayton Mine for minor additional mining areas adjoining existing pits. This disturbance will remove approximately 19 ha of vegetation that includes 0.4 ha of regrowth of the state-listed Hunter Lowland Redgum Forest but largely comprises grassland rehabilitation; low diversity derived native grasslands; and roadside plantings. It will also involve decommission of an existing industrial dam.

The Project will result in a direct disturbance to approximately 42% of the existing vegetation in the Study Area and less than 1% of the existing Hunter Lowland Redgum Forest under conservation at Drayton Mine. The vegetation is also much altered from its original condition and is currently quite fragmented. When considered in the local context and then in the wider regional context, the respective proportions of the native vegetation communities to be cleared are less than 5% of their larger distributions.

The Project is unlikely to have a significant impact on Hunter Lowland Redgum Forest in the locality as the small occurrence to be cleared is highly modified and has little opportunities for recovery. The clearance of the minor additional mining areas at Drayton Mine is also unlikely to have an impact on threatened species and populations as they currently retain little habitat value, do not support threatened species or important species habitats and are unlikely to do so in the future.

Notwithstanding the above, the vegetation to be cleared from the Study Area largely 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.

Furthermore, the native vegetation communities in the Study Area, whilst degraded by current land practices, is known to provide habitat for populations of five flora species and 21 fauna species as listed under the TSC Act and/or EPBC Act. The clearance of vegetation from the Study Area will remove habitat from the locality for a total of 26 threatened species and facilitate key threatening processes that are responsible for their continuing decline. At particular risk are sedentary species like flora species and small woodland birds. Hollow-dependent bats will lose important foraging and roosting habitat since tree hollows in mature woodlands are a limiting resource in the locality. Competition for remaining resources will place pressure on the remaining habitats in the locality if no ameliorative or compensatory actions are undertaken.

Due to the potential impacts to the EPBC Act listed 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 Project will address the above impacts through the development and implementation of an array of avoidance and mitigation measures; and residual impacts that cannot be addressed by these means will be compensated for by the provision of biodiversity offsets. That is, the Project will:

- **Avoid** – to the extent possible, to the project has been designed to avoid or minimize ecological impacts;
- **Mitigate** – where impacts are unavoidable, 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, have been compensated to offset what would otherwise be a net loss of habitat.

All mitigation measures during the construction and operation of the mine will be coordinated through the BAP. 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. Mitigation measures that will be implemented include:

- Measures to minimise the loss of vegetation and habitat, as far as practicable;
- Retention of key habitat attributes through re-distribution of logs, stags and felled trees to sites within the Study Area that will not be disturbed;
- Restoration and rehabilitation activities; and
- Ongoing monitoring.

To augment the above actions, a BOP has been developed to compensate for the residual impacts on threatened species and ecological communities that cannot be addressed through avoidance and mitigation measures. The BOP provides a significant conservation outcome for the Project by providing a suite of measures, that include both onsite and offsite offsets, to mitigate and compensate for the ecological impacts of the Project. The focus of the BOP is on the onsite restoration and rehabilitation of Saddlers Creek, which will be supplemented by the permanent conservation and ongoing management of offsite offset properties.

The original vegetation within the Project Boundary and within offset lands was woodland and open forest. Thus the threatened species that can or are predicted to occur are dependent on these habitats, not grassland. Within the Project Boundary and proposed offset lands, the long term prediction is for an area of forest and woodland habitat amounting to 3653 ha, compared with the 389 ha of currently existing forest and woodland to be cleared by the Project. As such the BOP will provide a substantial and appropriately targeted ecological offset for the project.

The BOP will also have other ecological advantages as it will entail restoration of Saddlers Creek, which is currently in a highly degraded condition. This will have downstream benefits to the Hunter River itself by improving water quality emanating from Saddlers Creek and also by improving habitats within the creek itself. Other creeks in the property will also be of major benefit to wildlife by affording a water source and drought refuge that is currently somewhat degraded due to livestock grazing.

The management of onsite and offsite offsets will be carried out in accordance with site-specific BOMPs. Each BOMP will be prepared as part of the BOP to prescribe ongoing management actions for the onsite and offsite offsets. This is a key component of the BOP to ensure that the biodiversity values of the offsets can be maintained and improved. The BOMP will explain the key management approaches and expected gains of the offsets and prescribe a suite of measures that will be implemented over the life of the Project.

The impact mitigation and compensation measures to be implemented over the life of the Project are likely to sufficiently ameliorate the potential impacts to threatened species and TECs. Moreover, they are expected to deliver a net benefit to flora and fauna within the locality by substantially increasing the proportion of native forest and woodland in conservation tenure. When the mitigation and compensation measures are considered, the Project will have a major ecological benefit in the medium to long term.

Bibliography

AGE (2012) Drayton South Coal Project – Groundwater Impact Assessment. Australasian Groundwater & Environmental Consultants Pty Ltd, Bowen Hills QLD.

Aitken, K. E. H. and Martin, K. (2007) "The importance of excavators in hole-nesting communities: availability and use of natural tree holes in old mixed forests of western Canada." Journal of Ornithology **148 (Suppl 2)**: S425-S434.

Aitken, K. E. H. and Martin, K. (2008) "Resource selection plasticity and community responses to experimental reduction of a critical resource." Ecology **89**: 971-980.

Alison Hunt & Associates Pty Ltd (2009) North South Liddell Gas Pipeline - Ecological Assessment Prepared for CDB Environment Pty Ltd.

Amarasekare, P. (2002) "Interference Competition and Species Coexistence." Proceedings: Biological Sciences **269**(1509): 2541-2550.

AMEC Americas Limited (2005) Mackenzie Gas Project: Effects of Noise on Wildlife. AMEC Americas Limited.

ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality - Chapter 3. Australian and New Zealand Environment Conservation Council (ANZECC), Canberra.

Anglo American Metallurgical Coal Pty Ltd (2011) AA RP 107: Biodiversity Performance Requirement. Anglo American Metallurgical Coal Pty Ltd.

Arthur Rylah Institute (2011) Re-snagging Revolution: River Habitat Rehabilitation Through Re-Snagging (poster). Department of Natural Resources and Environment, Victoria.

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003) The New Atlas of Australian Birds. Royal Australasian Ornithologists Union, Hawthorn East.

Bedrosian, T. A., Fonken, L., Walton, J. C. and Nelson, R. J. (2011) "Chronic exposure to dim light at night suppresses immune responses in Siberian hamsters." Biology Letters **7**(3): 468-471.

Beier, P. and Noss, R. F. (1998) "Do habitat corridors provide connectivity?" Conservation Biology **12**: 1241–1252.

Bennett, A. F. (1990) Habitat Corridors. Their Role in Wildlife Management and Conservation. A. F. Bennett.

Birds Australia. (2011) "Bird Data." Retrieved 2011, from http://www.birdata.com.au/homecontent.do.

Bishop, A. (2000) Field Guide to the Orchids of New South Wales and Victoria 2nd edition. UNSW Press, Sydney.

Blackmore, C. J., Peakall, R. and Heinsohn, R. (2011) "The absence of sex-biased dispersal in the cooperatively breeding Grey-crowned Babbler." Journal of Animal Ecology **80**: 69-78.

Blakers, M., Davies, S. J. J. and Reilly, P. N. (1984) The Atlas of Australian Birds. Royal Australasian Ornithologists Union, Melbourne University Press.

Boland, C. R. J. (2004a) "Breeding biology of rainbow bee-eaters (*Merops ornatus*): A migratory, colonial, cooperative bird " The Auk **121**(3): 811-823.

Boland, C. R. J. (2004b) "Introduced cane toads *Bufo marinus* are active nest predators and competitors of rainbow bee-eaters *Merops ornatus*: observational and experimental evidence." Biological Conservation **120**(1): 53-62.

Boland, D. J., Brooker, M. I. H., Chippendale, G. M., Hall, N., Hyland, B. P. M., Johnston, R. D., Kleinig, D. A. and Turner, J. D., Eds. (1984) Forest Trees of Australia. Thomas Nelson Australia & CSIRO, Melbourne.

Bookhout, T. A., Ed. (1996) Research and Management Techniques for Wildlife and Habitats. The Wildlife Society, Allan Press, Kansas.

Botanic Gardens Trust. (2011) "PlantNET." Retrieved 2011, from http://www.rbgsyd.nsw.gov.au/search_plant_net

Braun-Blanquet, J. (1927) Pflanzensoziologie Wien Springer.

Brierley, G., Miller, C., Brooks, A., Fryirs, K., Boulton, A., Ryder, D., Leishman, M., Keating, D. and Lander, J. (2005) "Making integrative, cross-disciplinary research happen: Initial lessons from the Upper Hunter River Rehabilitation Initiative." Proceedings of the 4th Australian Stream Management Conference: Linking Rivers to Landscapes. I. D. Rutherfurd, I. Wiszniewski, M. J. Askey-Doran and R. Glazik. Hobart, Department of Primary Industries, Water and Environment**:** 125-133.

Brooker, M. and Kleinig, D. (1990) Field guide to eucalypts of south eastern Australia, Volume 2. Inkata, Melbourne.

Brooks, A. P., Brierley, G. J. and Millar, R. G. (2003) "The long-term control of vegetation and woody debris on channel and flood-plain evolution: insights from a paired catchment study in southeastern Australia." Geomorphology **51**(1-3): 7-29.

Bryson, C. T. and Carter, R. (2004) "Biology of Pathways for Invasive Weeds." Weed Technology **18:** 1216-1220.

Bureau of Meteorology (BOM) (2011) Daily Weather Observations- Jerrys Plains NSW Commonwealth of Australia.

Bureau of Meteorology (BOM) (2012a) Daily Weather Observations- Jerrys Plains NSW Commonwealth of Australia.

Bureau of Meteorology (BOM) (2012b) Daily Weather Observations- Murrurundi Gap NSW Commonwealth of Australia.

Chan, A. A., Giraldo-Perez, P., Smith, S. and Blumstein, D. T. (2010) "Anthropogenic noise affects risk assessment and attention: the distracted prey hypothesis." Biology Letters.

Chen, J., Franklin, J. F. and Spies, T. A. (1990) "Microclimatic pattern and basic biological responses at the clearcut edges of old- growth Douglas fir stands." Northwest Environmental Journal **6**: 424–425.

Chessman, B. (2003) SIGNAL 2.iv A Scoring System for Macroinvertebrates ('water bugs') in Australian Rivers: User Manual. Department of Environment and Heritage, Canberra.

Chessman, B. C. (1995) "Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level indentification and a biotic index." Australian Journal of Ecology **20**: 122-129.

Chessman, B. C. and McEvoy, P. K. (1998) "Towards diagnostic biotic indices for river macroinvertebrates." Hydrobiologia **364**: 169-182.

Churchill, S. (2008) Australian Bats. Allen & Unwin, Crowes Nest, NSW.

Clarke, M. F. and Oldland, J. M. (2007) "Penetration of remnant edges by noisy miners (Manorina melanocephala) and implications for habitat restoration." Wildlife Research **34**(4): 253-261.

Cockle, K. L., Martin, K. and Drever, M. C. (2010) "Supply of tree-holes limits nest density of cavity-nesting birds in primary and logged subtropical Atlantic forest." Biological Conservation **143**: 2851-2859.

Commonwealth of Australia (1996) National Principles for the Provision of Water for Ecosystems. ARMCANZ and ANZECC Occasional Paper No. 2.

Commonwealth of Australia (2009) Matters of National Environmental Significance: Significant Impact Guidelines 1.1. Department of Environment, Water, Heritage and the Arts, Canberra.

Cooney, S. J. N. and Watson, D. M. (2005) "Diamond Firetails (*Stagonopleura guttata*) preferentially nest in mistletoe." Emu **105**: 317-322.

Cooper, C. B. and Walters, J. R. (2002) "Experimental evidence of disrupted dispersal causing decline of an Australian passerine in fragmented habitat." Conservation Biology **16**: 471–478.

Cooper, C. B., Walters, J. R. and Ford, H. (2002) "Effects of remnant size and connectivity on the response of Brown Treecreepers to habitat fragmentation." Emu **102**: 249-256.

Cooper, R. M. and McAllan, I. A. W. (1995) The Birds of Western New South Wales. Preliminary Atlas. NSW Bird Atlassers, Albury.

CRC for Freshwater Ecology (2000) Snags: A Valuable but Scarce Resource. Cooperative Research Centre for Freshwater Ecology, University of Canberra, Canberra.

Cumberland Ecology (2007) Drayton Mine Fauna Surveys. Cumberland Ecology, Carlingford Court, NSW.

Cumberland Ecology (2009) Mt Arthur Coal Consolidation Project. Ecological Assessment. Final Report. Prepared for Hansen Bailey. Carlingford Court, NSW.

Cumberland Ecology (2009a) Ecological Assessment of Section 75W Modification for Drayton Mine. Cumberland Ecology, Carlingford Court, NSW.

Cumberland Ecology (2010a) Bengalla Mine Development Consent Modification: Ecological Impact Assessment for a Section 75W Application for an Overburden Emplacement Area. Prepared for Hansen Bailey. Cumberland Ecology, Carlingford Court, NSW.

Cumberland Ecology (2010b) Drayton South Project: Pre-feasibility Study Ecological Assessment. Cumberland Ecology, Carlingford Court, NSW.

Cumberland Ecology Pty Ltd (2010c) Mount Pleasant Project Modification - Ecological Assessment. Prepared for Coal & Allied Operations Pty Limited. Cumberland Ecology, Carlingford Court, NSW.

Dale, V. H., Joyce, L. A., McNulty, S., Neilson, R. P., Ayres, M. P., Flannigan, M. D., Hanson, P. J., Irland, L. C., Lugo, A. E., Peterson, C. J., Simberloff, D., Swanson, F. J., Stocks, B. J. and Michael Wotton, B. (2001) "Climate Change and Forest Disturbances." BioScience **51**(9): 723-734.

Dames & Moore (2000a) Mount Arthur North Coal Project Flora and Fauna Report. Prepared for Coal Operations Australia Limited. Brisbane, QLD.

Dames & Moore (2000b) Mount Arthur North Coal Project Flora and Fauna Report. Prepared for Coal Operations Australia Limited. Brisbane, QLD.

Debus, S. J. S. (1984) "Biology of the Little Eagle on the Northern Tablelands of New South Wales." Emu **84**(2): 87 – 92.

Debus, S. J. S. (2006) "Breeding and population parameters of robins in a woodland remnant in northern New South Wales, Australia." Emu **106**: 147-156.

Debus, S. J. S. and Rose, A. B. (1994) "The Masked Owl *Tyto novaehollandiae* in New South Wales." Australian Birds **28**(Special Issue): 1-20.

DEC (2005) The Vertebrate Fauna of Northeastern Wollemi National Park, Unpublished report funded by the Central Branch Parks and Wildlife Division Biodiversity Survey Priorities Program by NSW Department of Environment and Conservation, Information and Assessment Unit, Metropolitan Branch, Environment Protection and Regulation Division.

DEC (NSW) (2004a) Investing in our catchments- Water quality and its role in river health.

DEC (NSW) (2004b) Threatened Biodiversity Survey and Assessment: Guidelines for Development and Activities. Working Draft. Department of Environment and Conservation (NSW), Sydney.

DEC (NSW) (2004c) Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (Working Draft) New South Wales Department of Environment and Conservation, Hurstville.

DEC (NSW) (2005a) Black-chinned Honeyeater - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005b) Brown Treecreeper (eastern subspecies) - Profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005c) Diamond Firetail - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005d) Draft Guidelines for Threatened Species Assessment. NSW Department of Environment and Conservation, Sydney.

DEC (NSW) (2005e) Eastern Freetail-bat - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005f) Gang-gang Cockatoo - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005g) Greater Broad-nosed Bat - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005h) Greater Long-eared Bat (south eastern form) - profile. H Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005i) Hooded robin (south eastern form) - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005j) Pine Donkey Orchid - species profile *Diuris tricolor*. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005k) Southern Myotis - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005l) Speckled Warbler - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005m) Spotted-tailed Quoll - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005n) Squirrel Glider - profile, Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005o) Swift Parrot - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005p) Turquoise Parrot - profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2005q) Yellow-bellied Sheathtail-bat - *Saccolaimus flaviventris* Threatened Species Profile. Department of Environment and Conservation (NSW), Hurstville.

DEC (NSW) (2006) Regent Honeyeater - profile. Department of Environment and Conservation (NSW), Hurstville.

DECC (NSW) (2005a) Threatened and pest animals of Greater Southern Syndey. Department of Environment and Climate Change, Sydney.

DECC (NSW) (2005b) Threatened Species Profile - *Melanodryas cucullata cucullata* Hooded Robin. Department of Environment and Climate Change, Sydney.

DECC (NSW) (2005c) Threatened Species Profile - *Miniopterus schreibersii oceanensis* Eastern Bentwing Bat. Department of Environment and Climate Change, Sydney.

DECC (NSW) (2005d) Threatened Species Profiles - *Chalinolobus dwyeri* Large-eared Pied Bat. Department of Environment and Climate Change, Sydney.

DECC (NSW) (2007a) Threatened and Pest Animals of Greater Southern Sydney. Department of Environment and Climate Change, Sydney.

DECC (NSW) (2007b) Threatened Species Assessment Guidelines: The Assessment of Significance. Department of Environment and Climate Change, Sydney.

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

DECC (NSW) 2008a. Protecting and Restoring Green and Golden Bell Frog Habitat. Department of Environment and Climate Change, Sydney.

DECCW (NSW) (2005) Finger Panic Grass - Profile. Department of Environment, Climate Change and Water, Hurstville.

DECCW (NSW) (2010a) Central Hunter Grey Box - Ironbark Woodland - Profile. Department of Environment, Climate Change and Water, Sydney.

DECCW (NSW) (2010b) Draft National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland. Department of Environment, Climate Change and Water, Sydney.

DECCW (NSW) (2010c) Scarlet robin - profile. Department of Environment, Climate Change and Water, Sydney.

DEH (2006) EPBC Act Policy Statements - White Box - Yellow Box - Blakely's Red Gum grassy woodland and derived grasslands. Department of Environment and Heritage, Canberra, ACT.

Department of Enviroment and Conservation NSW (2004) Regent Honeyeater (*Xanthomyza phrygia*) National and NSW Recovery Plan. Department of Environment and Conservation (NSW), Hurstville.

Department of Environment and Conservation NSW (2005) Draft Recovery Plan for the Green and Golden Bell Frog. Department of Environment and Conservation (NSW), Hurstville.

Department of Environment and Resource Management (2004) Soil Conservation Measures - Design Manual for Queensland. Department of Environment and Resource Management (QLD)

Department of Infrastructure; Planning and Natural Resources (2005) "Commencement of Part 3A (Major Projects) of the EP&A Act." DIPNR Circular **PS 05-006**.

Department of Planning (1995) State Environmental Planning Policy No. 44 - Koala Habitat Protection. Department of Planning, Sydney.

DEWHA (2009a) Fork-tailed Swift. Species Profile and Threats Database. Department of the Environment, Water, Heritage and the Arts, Canberra, ACT.

DEWHA (2009b) *Hirundapus caudacutus* White-throated Needletail in Species Profile and Threats Database. Department of the Environment, Water, Heritage and the Arts, Canberra, ACT.

DEWR (2007) Draft Policy Statement: Use of environmental offsets under the Environment Protection and Biodiversity Conservation Act 1999. Department of the Environment and Water Resources, Canberra.

Dickman, C. (1996) "Impact of exotic generalist predators on the native fauna of Australia." Wildlife Biology **2**: 185-195.

Dickman, C. R. (1991) "Mechanisms of Competition among Insectivorous Mammals." Oecologia **85**(4): 464-471.

DLWC (NSW) (2002) The NSW State Groundwater Dependent Ecosystems Policy. D. o. L. W. Conservation, NSW Government.

Doak, K. (2002) Ferals: Survey Analysis Report of Attitudes and Knowledge. Branding Information, and Demographics, Department of Natural Resources and Mines, Brisbane.

Doerr, V. A. J., Doerr, E. D. and Davies, M. J. (2011) "Dispersal behaviour of Brown Treecreepers predicts functional connectivity for several other woodland birds." Emu **111**: 71-83.

DPI Agriculture. (2011) "Noxious Weeds Declaration- Upper Hunter County Council." Retrieved 2011, from http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/noxweed

Driussi, C. and Jansz, J. (2006) "Pollution minimisation practices in the Australian mining and mineral processing industries." Journal of Cleaner Production **14**(8): 673-681.

Duncan, A. B., Baker, G. B. and Montgomery, N., Eds. (1999) The Action Plan for Australian Bats. Environment Australia, Canberra.

ECC (2001) Box-Ironbark Forests & Woodlands Investigation Final Report. Environment Conservation Council, East Melbourne VIC.

Eco Logical Australia Pty Ltd (2009) Proposed Bayswater B Power Station, Part 3A Flora and Fauna Assessment. Prepared for AECOM.

Ecotone (2000) Flora and Fauna and Threatened Species Assessment for the proposed coal mining area at Saddlers Creek. Ecotone Ecological Consultants Pty Ltd., Waratah, NSW.

Environmental Resources Management (ERM) Australia (2008) Hunter Valley Operations South Coal Project. Prepared for Coal & Allied Operations Pty Limited. Pyrmont, NSW.

Erskine, W. and Bell, F. C. (1982) "Rainfall, floods and river channel changes in the Upper Hunter." Australian Geographical Studies: 183-196.

Eyles, R. J. (1977) "Birchams Creek: the transition from a chain of ponds to a gully." Australian Geographical Studies **15**(2): 146-157.

Fahrig, L. (2003) "Effects of habitat fragmentation on biodiversity." Annual Review of Ecology Evolution and Systematics **34**: 487–515.

Farmer, A. M. (1993) "The Effect of Dust on Vegetation - A Review." Environmental Pollution **79**: 63-75.

Fischer, J. and Lindenmayer, D. B. (2002) "Small patches can be valuable for biodiversity conservation: two case studies on birds in southeastern Australia." Biological Conservation **106**: 129–136.

Fischer, J. and Lindenmayer, D. B. (2007) "Landscape modification and habitat fragmentation: a synthesis." Global Ecology and Biogeography **16**(3): 265-280.

Fitzgerald, G. and Wilkinson, R. (2009) Assessing the Social Impact of Invasive Animals in Australia Invasive Animals Cooperative Research Centre, Canberra.

Fletcher, J. and Busnel, R. G. (1978) Effects of Noise on Wildlife. Academic Press, Inc.

Ford, H. A. (2011) "The causes of decline of woodland birds of eucalypt woodlands: advances in our knowledge over the last 10 years." Emu **111**: 1-9.

Franklin, D. C., Menkhorst, P. W. and Robinson, J. L. (1989) "Ecology of the Regent Honeyeater *Xanthomyza phrygia*." EMU: 141-154.

Franklin, J. F. (1993) "Preserving Biodiversity: Species, Ecosystems, or Landscapes." Ecological Applications **3**(2): 202-205.

Fryirs, K., Spink, A. and Brierley, G. (2009) "Post-European settlement response gradients of river sensitivity and recovery across the upper Hunter catchment, Australia." Earth Surface Processes and Landforms **34**(7): 897-918.

Gardner, J. L. (2004) "Winter flocking behaviour of Speckled Warblers and the Allee effect." Biological Conservation **118**: 195-204.

Garkaklis, M. J., Calver, M. C., Wilson, B. A. and Hardy, G. E. S. (2004) "Habitat Alteration caused by introduced plant disease: a significant threat to the conservation of Australian forest fauna." Conservation of Australia's forest fauna. D. Lunney. Mosman, Royal Zoological Society of New South Wales.

Garnett, S. T. and Crowley, G. M. (2000) The Action Plan for Australian Birds. Environment Australia, Canberra.

Gehrke, P. C. and Harris, J. H. (1996) Fish and Fisheries of the Hawkesbury-Nepean River System: Final Report to the Sydney Water Corporation-Part One.

Geoimage Pty Ltd (2010) Satellite Imagery. Geoimage Pty Ltd., Taringa, QLD.

Gibbons, P. and Boak, M. (2002) "The value of paddock trees for regional conservation in an agricultural landscape." Ecological Management and Restoration **3**: 205-210.

Gibbons, P. and Lindenmayer, D. B. (2002) Tree Hollows and Wildlife Conservation in Australia. CSIRO Publishing, Melbourne.

Gibbons, P., Lindenmayer, D. B., Barry, S. C. and Tanton, M. T. (2000) "Hollow formation in eucalypts from temperate forests in southeastern Australia." Pacific Conservation Biology **6**: 218-228.

Gibbons, P., Lindenmayer, D. B., Barry, S. C. and Tanton, M. T. (2002) "Hollow selection by vertebrate fauna in forests of southeastern Australia and implications for forest management." Biological Conservation **103**: 1-12.

Gibbons, P., Lindenmayer, D. B., Fischer, J., Manning, A. D., Weinberg, A., Seddon, J., Ryan, P. and Barrett, G. W. (2008) "The Future of Scattered Trees in Agricultural Landscapes." Conservation Biology **22**: 1309-1319.

Gong, W., Sinden, J., Braysher, M. and Jones, R. (2009) The Economic Impacts of Vertebrate Pests in Australia. Canberra.

Hall, L. S. (1981) The Biogeography of Australian Bats. Ecological Biogeography of Australia. **3:** 1557-1583.

Hanquet, D., Legalle, M., Garbage, S., eacute and ghino, R. (2004) "Ontogenetic microhabitat shifts in stream invertebrates with different biological traits." Hydrobiology **160**(3): 329-346.

Hansen Bailey (2007) Drayton Mine Extension Flora and Fauna Impact Assessment. Prepared for Anglo Coal (Drayton Management) Pty Limited. Hansen Bailey, Brisbane, QLD.

Hansen Bailey (2009) Drayton Mine Project Approval Modification Environmental Assessment. Prepared for Anglo Coal (Drayton Management) Pty Limited. Hansen Bailey, Singleton, NSW.

Harden, G. J. (1993) Flora of New South Wales Volume 4. New South Wales. University Press, Kensington.

Harden, G. (2002) Flora of NSW. Vol 2. Revised Edition. University Press, Kensington.

Harden, G. J. (1990-1993) Flora of NSW Volumes 1-4. University Press, Kensington.

Harper, M. J., McCarthy, M. A., van der Ree, R. and Fox, J. C. (2004) "Overcoming bias in ground-based surveys of hollow-bearing trees using double-sampling." Forest Ecology and Management **190**(291-300).

Harpstead, M. I., Sauer, T. J. and Bennett, W. F. (2001) Soil Science Simplified. Ames, IO, Iowa State University Press.

Harris, J. H. and Gehrke, P. C., Eds. (1997) Fish and Rivers in Stress: The NSW Rivers Survey. NSW Fisheries and the CRC for Freshwater Ecology.

Hatton, T. and Evans, R. (1998) Dependence of Ecosystems on Groundwater and its Significance to Australia. Canberra Land and Water Resources Research and Development Corporation

Hawking J H, Ed. (1994) A Preliminary Guide to Keys and Zoological Information to Identify Invertebrates from Australian Freshwaters. Identification Guide No 2., Co-operative Research Centre for Freshwater Ecology.

Hawking, J. H. and Smith, F. J., Eds. (1997) Colour Guide to Invertebrates of Australian Inland Waters. Albury, Co-operative Research Centre for Freshwater Ecology.

Healthy Rivers Commission (2003) Healthy Rivers for Tomorrow, Final Report.

Heinsohn, R., Murphy, S. and Legge, S. (2003) "Overlap and competition for nest holes among eclectus parrots, palm cockatoos and sulphur-crested cockatoos." Australian Journal of Zoology **51**: 81-94.

Higgins, P. J. (1999) Handbook of Australian, New Zealand and Antarctic Birds Volume 4. Oxford University Press, Melbourne.

Higgins, P. J. and Peter, J. M. (2002) Handbook of Australian, New Zealand and Antarctic Birds Volume 6. Oxford University Press, Melbourne.

Higgins, P. J., Peter, J. M. and Cowling, S. J., Eds. (2006) Handbook of Australian, New Zealand and Antarctic Birds. Oxford University Press, Melbourne.

Howell, T. and Creese, B. (2010) Freshwater Fish Communities of the Hunter, Manning, Karuah and Macquarie-Tuggerah Catchments: a 2004 Status Report. Industry & Investment NSW, Cronulla.

Hoye, G. A. and Dwyer, P. D. (1995) Large-eared Pied Bat. The Mammals of Australia. R. Strahan. NSW, Reed Books.

Hunter-Central Rivers Catchment Management Authority (2010) "Hunter-Central Rivers Catchment Management Authority", from http://www.hcr.cma.nsw.gov.au/.

International Council on Mining and Metals (2006) Good Practice Guidance for Mining and Biodiversity. ICMM.

Keitt, T. H., Urbah, D. L. and Milne, B. T. (1997) "Detecting critical scales in fragmented landscapes." Conservation Ecology [online] **1**(1)

Kennedy, S. and Overs, A. (2001) "Foraging ecology and habitat use of the Swift Parrot on the south-western slopes of New South Wales." Corella **25**: 68-74.

Kennedy, S. and Tzaros, C. (2005) "Foraging ecology of the swift parrot Lathamus discolor in the Box-Ironbark forests and woodlands of Victoria." Pacific Conservation Biology **11**: 158-173.

Koch, A. J. (2008) "Errors associated with two methods of assessing tree hollow occurrence and abundance in *Eucalyptus obliqua* forest, Tasmania." Forest Ecology and Management **255**(674-685)

Lawlor, L. R. (1980) "Overlap, Similarity, and Competition Coefficients." Ecology **61**(2): 245-251.

Lindenmayer, D., Bennett, A. and Hobbs, R. (2010) Temperate Woodland Conservation and Management. CSIRO Publishing, Collingwood.

Lindenmayer, D., Crane, M. and Michael, D. (2005) Woodlands: A disappearing landscape, CSIRO Publishing, Collingwood.

Lindenmayer, D. B. and Cunningham, R. B. (2011) "Longitudinal patterns in bird reporting rates in a threatened ecosystem: Is change regionally consistent?" Biological Conservation **144**: 430-440.

Lindenmayer, D. B., Cunningham, R. B. and Pope, M. L. (1999) "A large-scale "experiment" to examine the effects of landscape context and habitat fragmentation on mammals." Biological Conservation **88**(3): 387-403.

Lindenmayer, D. B., Cunningham, R. B., Tanton, M. T., Smith, A. P. and Nix, H. A. (1990) "Habitat Requirements of the Mountain Brushtail Possum and the Greater Glider in the Montane Ash-type Eucalypt Forests of the Central Highlands of Victoria." Aust. Wildl. Res. **17**: 467-478.

Lindenmayer, D. B. and Fischer, J. (2006) Habitat fragmentation and landscape change. Island Press, Washington D.C.

Lindenmayer, D. B., Norton, T. W. and Tanton, M. T. (1990) "Differences between wildfire and clearfelling on the structure of montane ash forests of Victoria and their implications for fauna dependent on tree hollows." Australian Forestry **53**(2): 61-68.

Llewellyn, L. C. (1983) "The Distribution of Fish in New South Wales." Australian Society for Limnology, Special Publication **7**(23)

Longcore, T. and Rich, C. (2004) "Ecological Light Pollution." Frontiers in Ecology and Environment **2**(4): 191-198.

Longcore, T. and Rich, C. (2010) Light Pollution and Ecosystems. ActionBioscience.org original article.

Lunney, D., Curtin, A. L., Ayers, D., Cogger, H. G., Dickman, C. R., Maitz, W., Law, B. and Fisher, D. (2000) The threatened and non-threatened native vertebrate fauna of New South Wales: status and ecological attributes. NSW National Parks and Wildlife Service, Hurstville.

Mackowski (1984) Wildlife Hollows and Timber Production in Blackbutt Forest (Appendix One)

Maher, W. A. and Norris, R. H. (1990) "Water Quality Assessment Programs in Australia. Deciding What to Measure, and How and Where to use Bioindicators." Environmental Monitoring and Assessment **14**(2-3): 115-130.

Manning, A. D., Fischer, J. and Lindenmayer, D. B. (2006) "Scattered trees are keystone structures — implications for conservation." Biological Conservation **132**: 311–321.

Manu, S., Peach, W. and Cresswell, W. (2007) "The effects of edge, fragment size and degree of isolation on avian species richness in highly fragmented forest in West Africa." Ibis **149**(2): 287-297.

Marchant, S. and Higgins, P. J. (1993) Handbook of Australian, New Zealand and Antarctic Birds Volume 2. Oxford University Press, Melbourne.

Marine Pollution Research Pty Ltd (2009) Bowmans Creek Diversion: Appendix 9 Riparian & Aquatic Ecology Assessment. Prepared for Ashton Coal Operations Limited.

Maron, M., Main, A., Bowen, M., Howes, A., Kath, J., Pillette, C. and McAlpine, C. A. (2011) "Relative influence of habitat modification and interspecific competition on woodland bird assemblages in eastern Australia." Emu **111**: 40-51.

Marshall, J. C., Sheldon, F., Thoms, M. and Choy, S. (2006) "The macroinvertebrate fauna of an Australian dryland river: spatial and temporal patterns and environmental relationships." Marine and Freshwater Research **57**(1): 61-74.

McIntyre, S., McIvor, J. G. and Heard, K. M. (2002) Managing and Conserving Grassy Woodlands. CSIRO Publishing, Collingwood.

Menkhorst, P. and Knight, F. (2001) A Field Guide to the Mammals of Australia. Oxford University Press, South Melbourne.

Menkhorst, P. and Knight, F. (2004) A field guide to the mammals of Australia. S Oxford University Press, South Melbourne.

Ministry for the Environment (NZ) (2001) Good practice guide for assessing and managing the environmental effects of dust emissions. Wellington, New Zealand.

Morris, A. K., McGill, A. R. and Holmes, G., Eds. (1981) Handlist of Birds in New South Wales. NSW Field Ornithologists Club, Sydney.

Murcia, C. (1995) "Edge effects in fragmented forests: implications for conservation." Trends in Ecology and Evolution **10**(2): 58-62.

Murphy, S. A. and Legge, S. M. (2007) "The gradual loss and episodic creation of Palm Cockatoo (*Probosciger aterrimus*) nest-trees in a fire- and cyclone-prone habitat." Emu **107**: 1-6.

Nelson, G. H., Smith, F. E. and Slobodkin, L. B. (1960) "Community Structure, Population Control, and Competition." The American Naturalist **94**(879): 421-425.

Newton, I. (1994) "The role of nest sites in limiting the numbers of hole-nesting birds: a review." Biological Conservation **70**: 265-276.

Nichols, O. G. (2005) Development of Rehabilitation Completion Criteria for Native Ecosystem Establishment on Coal Mines in the Hunter Valley. Final Report. Australian Coal Association Research Program, Brisbane.

Nichols, O. G., Grant, C. and Bell, L. C. (2005) Developing ecological completion criteria to measure the success of forest and woodland establishment on rehabilitated mines in Australia.

NSW DECCW (2005) Illawarra Greenhood - profile. Department of Environment, Climate Change and Water, Hurstville.

NSW Department of Planning (2005) Coal Mining Potential in the Upper Hunter Valley - Strategic Assessment.

NSW National Parks and Wildlife Service (2002) *Pterostylis gibbosa* (R.Br.) Illawarra Greenhood Orchid Recovery Plan. Department of Sustainability, Environment, Water, Population and Communities, Canberra.

NSW NPWS (1999a) Threatened Species Information: Glossy Black-cockatoo. NSW National Parks and Wildlife Service, Hurstville.

NSW NPWS (1999b) Threatened Species Information: Spotted-tailed Quoll. NSW National Parks and Wildlife Service, Hurstville.

NSW NPWS (1999c) Threatened Species Information: Turquoise Parrot. NSW National Parks and Wildlife Service, Hurstville.

NSW NPWS (2003a) Recovery Plan for the Yellow-bellied Glider (*Petaurus australis*). NSW National Parks and Wildlife Service, Hurstville.

NSW NPWS (2003b) Threatened Species Information: Barking Owl. NSW National Parks and Wildlife Service, Hurstville.

NSW NPWS (2004a) Eastern Freetail-bat (*Mormopterus norfolkensis*). NSW National Parks and Wildlife Service Northern Directorate, Coffs Harbour.

NSW NPWS (2004b) Greater Broad-nosed Bat *Scoteanax rueppellii*. NSW National Parks and Wildlife Service Northern Directorate, Coffs Harbour.

NSW NPWS (2004c) Large-eared Pied Bat (*Chalinolobus dwyeri*) NSW National Parks and Wildlife Service Northern Directorate, Coffs Harbour.

NSW Scientific Committee (2004a) Barking Owl - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004b) Black-chinned Honeyeater (eastern subspecies) - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004c) Bothriochloa biloba (a grass) - removal of vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004d) Diamond Firetail - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004e) Eastern cave bat - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004f) Eastern freetail-bat - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004g) Glossy black-cockatoo - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004h) Greater broad-nosed bat - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004i) Grey-crowned babbler (eastern subspecies) - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004j) Grey-headed Flying-fox - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004k) Hooded robin (south-eastern form) - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004l) Infection of native plants by *Phytophthora cinnamomi* - key threatening process declaration. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004m) Large-footed myotis - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004n) Masked Owl - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004o) Powerful Owl - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004p) Regent honeyeater - endangered species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004q) Speckled Warbler - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004r) Squirrel glider - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004s) Swift parrot - endangered species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004t) Turquoise parrot - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004u) White box yellow box Blakely's red gum woodland - endangered ecological community listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004v) Yellow-bellied glider - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2004w) Yellow-bellied sheathtail bat - vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee. (2004x) *Bothriochloa biloba* (a grass) - removal of vulnerable species listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2005a) *Eucalyptus camaldulensis* (a tree) Hunter catchment population - Endangered population determination - final. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2005b) Gang-gang cockatoo - vulnerable species listing. NSW National Parks and Wildlife Service, Hurstville.

NSW Scientific Committee (2006) Diuris tricolor, the Pine Donkey Orchid - proposed endangered population listing. Department of Environment and Conservation (NSW), Hurstville.

NSW Scientific Committee (2009a) Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion - proposed vulnerable ecological community listing. Department of Environment and Climate Change, Hurstville.

NSW Scientific Committee (2009b) Little Lorikeet - vulnerable species listing. Department of Environment and Climate Change, Hurstville.

NSW Scientific Committee (2010a) Central Hunter Grey Box - Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions - endangered ecological community listing. Department of Environment and Climate Change, Hurstville.

NSW Scientific Committee (2010b) Little Eagle - vulnerable species listing. Department of Environment, Climate Change and Water, Hurstville.

NSW Scientific Committee (2010c) Scarlet robin - vulnerable species listing. Department of Environment, Climate Change and Water, Hurstville.

NSW Scientific Committee (2010d) Spotted Harrier *Circus assimilis* Jardine and Selby 1828 - vulnerable species listing. Department of Environment, Climate Change and Water, Hurstville.

NSW Scientific Committee (2010e) Varied Sittella - vulnerable species listing. Department of Environment, Climate Change and Water, Hurstville.

NSW Scientific Committee (2011) *Cymbidium canaliculatum* R. Br. - endangered population listing. Office of Environment and Heritage, Hurstville.

NSW Scientific Committee (2011a) Hunter Lowland Redgum Forest in the Sydney Basin and NSW North Coast Bioregions. Office of Environment and Heritage, Hurstville.

OEH. (2011) "Atlas of NSW Wildlife." Retrieved 2011, from http://wildlifeatlas.nationalparks.nsw.gov.au/wildlifeatlas/watlas.jsp.

OEH (2011a) Principles for the use of biodiversity offsets in NSW. Office of Environment and Heritage (NSW), Sydney

OEH (NSW) (2011) Sydney Basin Bioregion. Office of Environment and Heritage, Sydney.

OEH (2012) Green and Golden Bell Frog (Litoria aurea) - Threatened Species Profile. Office of Environment and Heritage, Hurstville.

Oldroyd, B. P., Thexton, E. G., Lawler, S. H. and Crozier, R. H. (1997) "Population Demography of Australian Feral Bees (Apis mellifera)" Oecologia **111**(3): 381-387.

Oliver D. L. (1998) "Short Communication: Roosting of Non-breeding Regent Honeyeaters *Xanthomyza phrygia*." Emu **98**: 65-69.

Oliver D. L. (2000) "Foraging behaviour and resource selection of the Regent Honeyeater Xanthomyza phrygia in Northern New South Wales." Emu **100**: 12-30.

Olsen, J., Judge, D., Fuentes, E., Rose, A. B. and Debus, S. J. S. (2010) "Diets of Wedge-tailed Eagles (Aquila audax) and Little Eagles (Hieraaetus morphinoides) breeding near Canberra, Australia." Journal of Raptor Research **44**: 50-61.

Owings, D. H. and Morton, E. S. (1998) Animal vocal communications: A new approach, Cambridge University Press, New York.

Parsons Brinckerhoff Australia Pty Ltd (2008) Gas Supply Pipeline East West Route - Biological Impacts. Prepared for Macquarie Generation. Newcastle, NSW.

Peake, T. (2005) *The Vegetation of the Central Hunter Valley*. Draft Report. Paterson, Hunter-Central Rivers Catchment Management Authority.

Peake, T. C. (2006) The Vegetation of the Central Hunter Valley, New South Wales. A Report on the Findings of the Hunter Remnant Vegetation Project. Paterson, Hunter-Central Rivers Catchment Management Authority.

Phillips, S., Callaghan, J. and Thompson, V. (2000) "The tree species preferences of koalas (*Phascolarctos cinereus*) inhabiting forest and woodland communities on Quaternary deposits in the Port Stephens area, New South Wales." Wildlife Research **27**: 1-10.

Pimentel, D. and Kounang, N. (1998) "Ecology of Soil Erosion in Ecosystems." Ecosystems **1**(5): 416-426.

Pitney Bowes Software Inc. (2010) MapInfo. Pitney Bowes Inc.

Pizzey, G. and Knight, F. (2003) The Field Guide to the Birds of Australia. HarperCollins Publishers Pty Ltd., Australia.

Primack, R. B. (1993) Essentials of Conservation Biology. Sinauer Associates Inc., Sunderland.

Quinn, F. C., J. B. Williams, C. L. Gross, and J. J. Bruhl. (1995) Report on Rare and Threatened Plants of North East New South Wales.

Rabin, L. A., McCowan, B., Hooper, S. L. and Owings, D. H. (2003) "Anthropogenic Noise and its Effects on Animals Communication: An Interface Between Comparative Psychology and Conservation Biology." International Journal of Comparative Psychology **16**(2).

Rappole, J. H. and McDonald, M. V. (1994) "Cause and Effect in Population Declines of Migratory Birds." The Auk **111**(3): 652-660.

Rawlings, K., Freudenberger, D. and Carr, D. (2010) A Guide to Managing Box Gum Grassy Woodlands. Caring for our Country Environmental Stewardship. Department of the Environment, Water, Heritage and the Arts, Canberra.

Rayner, L., Ellis, M. and Taylor, J. E. (2010) "Double sampling to assess the accureace of ground-based surveys of tree hollows in eucalypt woodlands." Austral Ecology **36** (252-260).

Reid, J. R. W. (1999) Threatened and declining birds in the New South Wales sheep-wheat belt: I Diagnosis, characteristics and management. CSIRO Wildlife and Ecology, Canberra.

Remm, J., Hmus, A. and Rosenvald, R. (2008) "Density and diversity of hole-nesting passerines: dependence on the characteristics of cavities." Acta Ornithologica **43**(1): 83-91.

Resource Planning Pty Limited (1993) Bayswater No. 3 Coal Coal Mine Project Environmental Impact Statement. Report prepared for Bayswater Colliery Company Pty Limited.

Richardson, F. J., Richardson, R. G. and Shepherd, R. C. H., Eds. (2006) Weeds of the South-east: An identification guide for Australia. R.G. and F.J. Richardson, Victoria.

Robson, B., Hogan, M. and Forrester, T. (2005) "Hierarchical patterns of invertebrates assemblage structure in stony upland streams change with time and flow permanence." Freshwater Biology **50**: 944-953.

Rosenberg, D., Resh, V. H. and King, R. S. (2008) "Use of Aquatic Insects in Biomonitoring." An Introduction to the Aquatic Insects of North America. R. W. Merritt, K. W. Cummins and M. B. Berg, Kendall/Hunt, IA.

Rutherfurd, I. D., Jerie, K. and Marsh, N. (2000) A Rehabilitation Manual for Australian Streams. Land and Water Resources Research and Development Corporation & Cooperative Research Centre for Catchment Hydrology, Canberra.

Saleh, T. (2007) "Effects of Artificial Lighting on Wildlife." The Road-RIPorter (Summer Solstice Issue) **12**(2).

Saunders, T (2006) Bird Surveys of the Proposed Drayton Mine Extension, Merops Services Pty Ltd, Laggan.

Saunders, D. L. and Heinsohn, R. (2008) "Winter habitat use by the endangered, migratory Swift Parrot (*Lathamus discolor*) in New South Wales, Australia." Emu **108**: 81-89.

Schodde, R. and Tidemann, S. (1986) Reader's Digest Complete Book of Australian Birds. Readers Digest Services Pty Ltd., Sydney.

SEWPaC (2009) Water resources - Overview - New South Wales. Surface Water Management Area: Hunter River - Regulated. Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

SEWPaC (2010a) *Ardea modesta* - Eastern Great Egret in Species Profile and Threats Database. Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

SEWPaC (2010b) Invasive Species Fact Sheet. European Red Fox (*Vulpes vulpes*) Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

SEWPaC (2011a) Chalinolobus dwyeri in Species Profile and Threats Database. Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

SEWPaC (2011b) EPBC Protected Matters Search Tool. Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

SEWPaC (2011c) *Haliaeetus leucogaster* in Species Profile and Threats Database. Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

SEWPaC (2011d) *Merops ornatus* Rainbow Bee-eater in Species Profile and Threats Database. Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

SEWPaC (2011e) *Nyctophilus corben*i in Species Profile and Threats Database. Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

SEWPaC (2011f) *Prasophyllum sp. Wybong* (C.Phelps ORG 5269) in Species Profile and Threats Database. Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

SEWPaC (2011g) Weeping Myall Woodlands in Community and Species Profile and Threats Database. Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

SEWPaC (2011h) *Prasophyllum sp. Wybong* (C.Phelps ORG 5269) in Species Profile and Threats Database. Department of Sustainability, Environment, Water, Population and Communities, Canberra.

SEWPaC (2012). Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy. October 2012. Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Sharpe, A. K. and Downes, B. J. (2006) "The effects of potential larval supply, settlement and post-settlement processes on the distribution of two species of filter-feeding caddisflies." Freshwater Biology **51**(4): 717-729.

Sheldon, F. and Thoms, M. C. (2006) "Relationships between flow variability and macroinvertebrate assemblage composition: data from four Australian dryland rivers." River Research and Applications **22**(2): 219-238.

Soderquist, T. and Gibbons, D. (2007) "Home-range of the Powerful Owl (Ninox strenua) in dry sclerophyll forest." Emu **107**: 177-184.

Southern New England Landcare Ltd (2008) Methods to Manage Mistletoe, A Landholder's Guide. Southern New England Landcare Ltd., Armidale, NSW.

Spellerberg, I. F. (1998) "Ecological Effects of Roads and Traffic: A Literature Review." Global Ecology and Biogeography Letters **7**(5): 317-333.

Spencer, S. and Tinnin, R. (1997) "Effects of coal dust on plant growth and species composition in an arid environment." Journal of Arid Environments **37**(3): 475-485.

Stojanovic, D. (2011) Drayton South Bird Survey Report. Prepared for Cumberland Ecology.

Sunnucks, P. (2011) "Towards modelling persistence in woodland birds: the role of genetics." Emu **111**: 19-39.

Tame, T. (1992) Acacias of southeast Australia, Kangaroo Press Pty Ltd, Kenthurst.

Tas. DPIPWE (2003) Threatened Species Notesheet - *Thesium australe.* Tasmanian Department of Primary Industries, Parks, Water and Environment.

Taylor, B. D. and Goldingay, R. L. (2010) "Roads and wildlife: impacts, mitigation and implications for wildlife management in Australia." Wildlife Research **37**(4): 320-331.

Taylor, P. D., Fahrig, L., Henein, K. and Merriam, G. (1993) "Connectivity is a vital element of landscape structure." Oikos **68**(3): 571-573.

The Ecology Lab Pty Ltd (2000) Saddlers Creek Environmental Feasibility Study: Assessment of Fish Habitats, The Ecology Lab Pty Ltd, Brookvale, NSW.

Threatened Species Scientific Committee (2008) Weeping Myall Woodlands Listing Advice. Department of Environment, Heritage and the Arts, Canberra.

Threatened Species Scientific Committee. (2008a) Approved Conservation Advice for *Digitaria porrecta* (Finger Panic Grass) Department of the Environment, Water, Heritage and the Arts, Canberra.

Threatened Species Scientific Committee. (2008b) Commonwealth Conservation Advice on *Bothriochloa biloba* (Lobed Blue-grass) Department of Environment, Water, Heritage and the Arts, Canberra.

Threatened Species Scientific Committee (2009) Commonwealth Conservation Advice on *Prasophyllum* sp. Wybong (C. Phelps ORG 5269) (a leek orchid) Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Tidemann, C. and Nelson, J. (2004) Long-distance movements of the grey-headed flying-fox (*Pteropus poliocephalus*)

Turak, E. and Waddell, N. (2001a) Development of AUSRIVAS models for New South Wales. NSW EPA, Sydney.

Turak, E. and Waddell, N. (2001b) New South Wales (NSW) Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual. NSW EPA, Sydney.

Turak, E., Waddell, N. and Johnstone, G., Eds. (2004) New South Wales (NSW) Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual. Department of Environment and Conservation (NSW), Sydney.

Turner , R. J. (1991) "Mistletoe in eucalypt forest - a resource for birds" Australian Forestry **54**: 226 - 235.

Tzaros, C. (1996) "Nesting and Ecology of the Speckled Warbler." Australian Birdwatcher **16**: 221-225.

Umwelt (Australia) Pty Limited (2000) Antiene Joint User Rail Facility Environmental Impact Assessment. Prepared for Coal Operations Australia Limited and Drayton Coal Pty Ltd. Toronto, NSW.

Umwelt (Australia) Pty Limited (2006a) Mt Arthur Coal Ecological Assessment for Downcast Ventilation Shaft Facility Prepared for Mt Arthur Coal Pty Limited. Toronto, NSW.

Umwelt (Australia) Pty Limited (2006b) Mt Arthur Coal Ecological Assessment Proposed South Pit Extension Project. Toronto, NSW.

Umwelt (Australia) Pty Limited (2007) Ecological Assessment Proposed Mt Arthur Underground Project. Prepared for Mt Arthur Coal. Toronto, NSW.

Umwelt (Australia) Pty Limited (2009) Narama Extended Project Environmental Assessment. Prepared for Ravensworth Operations Pty Limited. Toronto, NSW.

Umwelt (Australia) Pty Limited (2010) Ravensworth Operations Project Environmental Assessment. Prepared for Ravensworth Operations Pty Limited. Toronto, NSW.

Umwelt (Australia) Pty Limited (2010b) Ecological Assessment - Proposed Relocation of 500 kV Electricity Transmission Line, Mangoola Coal. Prepared for Xstrata Mangoola Pty Limited and TransGrid. Toronto, NSW.

Umwelt (Australia) Pty Ltd (2008) Ecological Assessment - Proposed Modification for Mangoola Coal Pipeline. Prepared for Xstrata Mangoola Pty Ltd. Toronto, NSW.

Umwelt (Australia) Pty Ltd (2007) 2006 Ecological Monitoring Report - Mt Arthur Coal. Toronto, NSW.

Umwelt (Australia) Pty Ltd (2008) Plan of Management for the Painted Diuris (*Diuris tricolor*) at A171. Toronto, NSW.

Utz, R. M., Hilderbrand, R. H. and Boward, D. M. (2009) "Identifying regional difference in threshold responses of aquatic invertebrates to land cover gradients." Ecological Indicators **9**: 556-567.

Van Dyck, S. and Strahan, R., Eds. (2008) The Mammals of Australia, 3rd edition Reed New Holland, Sydney.

von der Ohe, P. C. and Liess, M. (2004) "Relative sensitivity distribution of aquatic invertebrates to organic and metal compounds." Environmental Toxicology and Chemistry **23**: 150–156.

Wasson, R. J., Mazari, R. K., Starr, B. and Clifton, G. (1998) "The recent history of erosion and sedimentation on the Southern Tablelands of southeastern Australia: sediment flux dominated by channel incision." Geomorphology **24**(4): 291-308.

West, P. and Saunders, G. (2007) Pest Animal Survey: A Review of the Distribution, Impacts and Control of Invasive Animals Throughout NSW and the ACT. Vertebrate Pest Research Unit, NSW Department of Primary Industries, Orange.

WRM (2012) Drayton South Coal Project – Surface Water Impact Assessment. WRM Water and Environment, Paddington QLD.

Yahner, R. H. (1988) "Changes in wildlife communities near edges." Conservation Biology **2**: 333-339.

Appendix A

Minister's Requirements for Assessment under the EPBC Act

Appendix A

Director-General's Requirements for the Assessment of a Controlled Action under section 75 of the *Environmental Protection and Biodiversity Conservation Act 1999*

The Minister for Sustainability, Environment, Water, Population and Communities has declared the Drayton South Coal Project to be a controlled action under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The controlled action is likely to have a direct and indirect impact on matters of national environment significance, in particular, threatened species and/or threatened ecological communities listed under sections 18 and 18A, and migratory species listed under sections 20 and 20A of the EPBC Act.

In accordance with the one-off accredited assessment process for this project, the environmental assessment of the impacts of the controlled action is to be assessed under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The assessment should include enough information about the controlled action and its relevant impacts to allow the Minister for Sustainability, Environment, Water, Population and Communities to make an informed decision whether or not to approve the controlled action under the EPBC Act.

The following assessment requirements are to be integrated into the assessment required for Part 3A of the EP&A Act. The following matters in the EPBC Act and schedule 4 of the *Environment Protection and Biodiversity Conservation Regulations 2000* should be considered.

General information

1. The background of the action, including:

    a. the title of the action;
    b. the full name and postal address of the designated proponent;
    c. a clear outline of the objective of the action;
    d. the location of the action;
    e. the background to the development of the action;
    f. how the action relates to any other actions (of which the proponent should reasonably be aware) that have been, or are being, taken or that have been approved in the region affected by the action;
    g. the current status of the action; and
    h. the consequences of not proceeding with the action.

Description of the controlled action

2. A description of the action, including:

    a. all the components of the action;
    b. the precise location of any works to be undertaken, structures to be built or elements of the action that may have relevant impacts;
    c. how the works are to be undertaken and design parameters for those aspects of the structures or elements of the action that may have relevant impacts;
    d. to the extent reasonably practicable, a description of any feasible alternatives to the controlled action that have been identified through the assessment, and their likely impact, including:

        i. if relevant, the alternative of taking no action;
        ii. a comparative description of the impacts of each alternative on the matters protected by the controlling provisions for the action;
        iii. sufficient detail to clarify why any alternative is preferred to another.

A description of the relevant impacts of the controlled action

3. An assessment of all relevant impacts[1] with reference to the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines Matters of National Environmental Significance (2009)* that the controlled action has, will have or is likely to have on:

    a. relevant threatened species and/or threatened ecological communities listed under sections 18 and 18A of the EPBC Act, including but not limited to:
        - White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland;
        - Weeping Myall Woodlands;
        - Regent Honeyeater *(Anthochaera phrygia)*;
        - Swift Parrot *(Lathamus discolor)*;
        - Spotted-tail Quoll (*Dasyurus maculatus maculatus)*
        - Greater Long-eared Bat (*Nyctophilus timorensis*)
        - Green and Golden Bell Frog (*Litoria aurea)*
        - Lobed Blue Grass (*Bothriochloa biloba)*
        - Finger Panic Grass (*Digitaria porrecta)*
        - Leek-orchid (*Prasophyllum sp. Wybong)* (C.Phelps ORG 5269)
        - Illawarra Greenhood (*Pterostylis gibbosa)*
        - Austral Toadflax (*Thesium australe)*

    b. relevant migratory species listed under sections 20 and 20A of the EPBC Act, including but not limited to:
        - Regent Honeyeater (*Xanthomyza Phrygia*) (Also a listed threatened species)

4. Information must include:

    a. a description of the relevant impacts of the action on matters of national environmental significance;
    b. a detailed assessment of the nature and extent of the likely short term and long term relevant impacts;
    c. a statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible;
    d. analysis of the significance of the relevant impacts;
    e. any technical data and other information used or needed to make a detailed assessment of the relevant impacts.

5. The description of the impacts should include an analysis of the vegetation condition on the site, as well as the methods by which this was determined. It should also include direct, indirect, cumulative and facilitative impacts on the following EPBC-listed communities: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland and Weeping Myall Woodlands. For each community, it should include a description of:

    a. extent, including connectivity with other areas of the ecological community;
    b. quality or integrity (including, but not limited to, assisting invasive species, that are harmful to the ecological communities, to become established; or causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the communities which kill or inhibit the growth of species in the ecological community);
    c. EPBC Act listed species in, or in any way dependent upon, the ecological community;
    d. composition;
    e. habitat present on site critical to the survival of the ecological community[2]; and

[1] The term "relevant impact" is defined in section 82 of the EPBC Act.

[2] "habitat critical to the survival of a species or ecological community" refers to areas that are necessary:
- for activities such as foraging, breeding, roosting, or dispersal;

f. abiotic (non-living) factors (such as water, nutrients or soil) necessary for the ecological community's survival, for example increasing groundwater levels or making the site wetter, soil disturbance or substantial alteration of surface water drainage patterns.

These impacts should be described for the construction and operational phases of the controlled action.

6. Where there is a potential habitat for EPBC Act listed species, surveys must be undertaken. These surveys must be timed appropriately and undertaken for a suitable period of time by a qualified person[3]. A subsequent description of the relevant impacts on such EPBC Act listed species should include, inter alia, direct, indirect, cumulative and facilitative impacts on the:

   a. population of the species at the site;
   b. area of occupancy of the species;
   c. habitat critical to the survival of the species;
   d. breeding cycle of the population; and
   e. availability or quality of habitat for the species.

Proposed safeguards and mitigation measures

7. A description of feasible mitigation measures, changes to the controlled action or procedures, which have been proposed by the proponent or suggested in public submissions, and which are intended to prevent or minimise relevant impacts. Information must include:

   a. a description, and an assessment of the expected or predicted effectiveness of, the mitigation measures;
   b. any statutory or policy basis for the mitigation measures;
   c. the cost of the mitigation measures;
   d. an outline of an environmental management plan that sets out the framework for continuing management, mitigation and monitoring programs for the relevant impacts of the action, including any provisions for independent environmental auditing;
   e. the name of the agency responsible for endorsing or approving each mitigation measure or monitoring program;
   f. a consolidated list of mitigation measures proposed to be undertaken to prevent, minimise or compensate for the relevant impacts of the action.

Offsets

8. Should any residual impact exist that cannot be mitigated it may be necessary for offset measures to be considered in order to ensure the protection of matters of national environmental significance in perpetuity.

Other approvals and conditions

9. Any other requirements for approval or conditions that apply, or that the proponent reasonably believes are likely to apply, to the proposed action. Information must include:

   a. details of any local or State government planning scheme, or plan or policy under any local or State government planning system that deals with the proposed action, including:

- for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators);
- to maintain genetic diversity and long term evolutionary development; or
- for the reintroduction of population or recovery of the species or ecological community.

Such habitat may be, but is not limited to: habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the register of Critical Habitat maintained by the Minister under the EPBC Act.

[3] Where available, species-specific survey guidelines can be obtained on the department's *Species Profile and Threats Database*: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

i. what environmental assessment of the proposed action has been, or is being, carried out under the scheme, plan or policy; and
ii. how the scheme provides for the prevention, minimisation and management of any relevant impacts;

b. a description of any approval that has been obtained from a State, Territory or Commonwealth agency or authority (other than an approval under the Act), including any conditions that apply to the action;
c. a statement identifying any additional approval that is required;
d. a description of the monitoring, enforcement and review procedures that apply, or are proposed to apply, to the action.

Economic and social matters

10. A description of the short-term and long-term social and economic implications and/or impacts of the project.

Environmental record of person proposing to take the action

11. Details of any proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against:

a. the proponent; and
b. for an action for which a person has applied for a permit, the person making the application.

12. Details of the proponent's environmental policy and planning framework.

Information sources

13. For information given in an environment assessment, the draft must state:

a. the source of the information;
b. how recent the information is;
c. how the reliability of the information was tested; and
d. what uncertainties (if any) are in the information.

Consultation

14. Any consultation about the action, including:

a. any consultation that has already taken place;
b. proposed consultation about relevant impacts of the action;
c. if there has been consultation about the proposed action — any documented response to, or result of, the consultation.

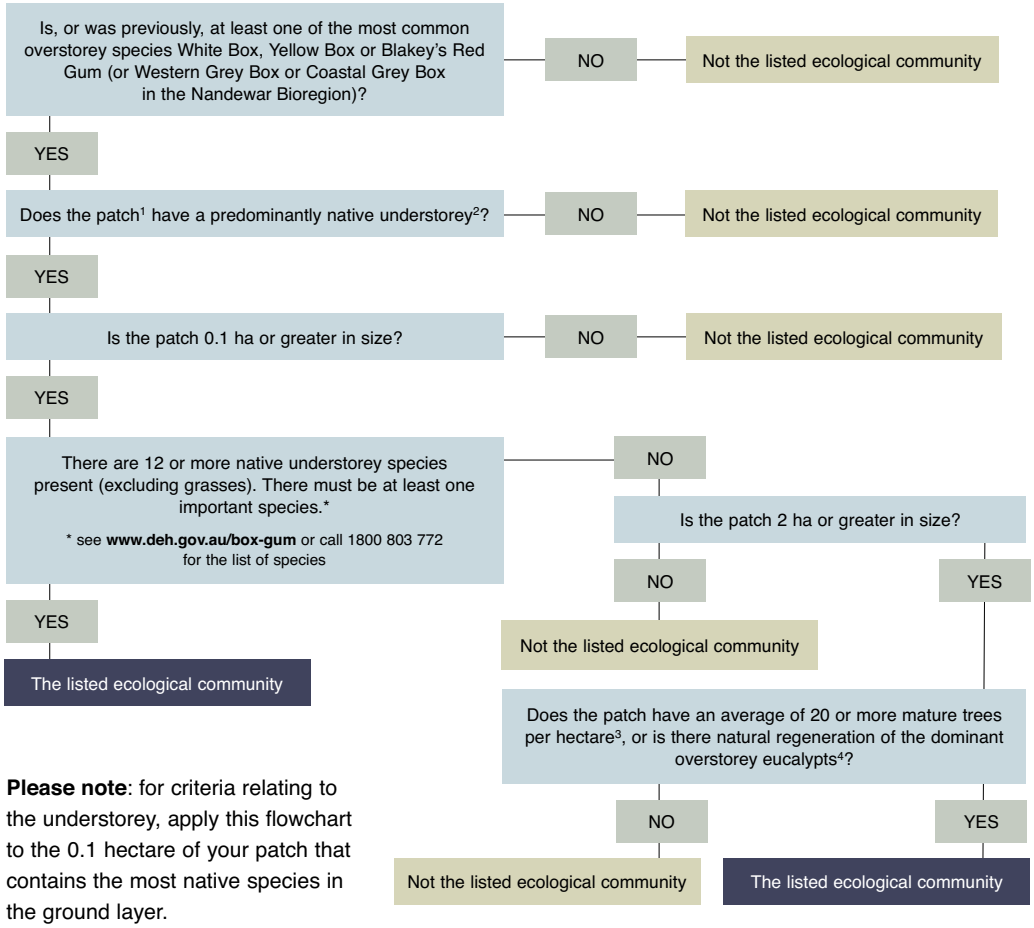
15. Identification of affected parties, including a statement mentioning any communities that may be affected and describing their views.

Appendix B

Identification Guideline (Flowchart) and Advice (Threatened Species Scientific Committee) for Box-Gum Woodland

The flowchart below represents the lowest condition at which patches are included in the listed ecological community. This is not the ideal state of the ecological community. Large patches, those that link remnants in the landscape, those that occur in highly cleared areas, those that contain rare, declining or threatened species, and those that represent the entire range of the ecological community, are important for the long-term future of the ecological community.

Determining if your land has an area of the listed ecological community



Please note: for criteria relating to the understorey, apply this flowchart to the 0.1 hectare of your patch that contains the most native species in the ground layer.

---

[1] Patch – a patch is a continuous area containing the ecological community (areas of other ecological communities such as woodlands dominated by other species are not included in a patch). In determining patch size it is important to know what is, and is not, included within any individual patch. The patch is the larger of:

- an area that contains five or more trees in which no tree is greater than 75 m from another tree, or
- the area over which the understorey is predominantly native.

Patches must be assessed at a scale of 0.1 ha (1000m^2) or greater.

[2] A predominantly native ground layer is one where at least 50 per cent of the perennial vegetation cover in the ground layer is made up of native species. The best time of the year to determine this is late autumn when the annual species have died back and have not yet started to regrow. (At other times of the year, you can determine whether something is perennial or not is if it is difficult to pull out of the soil. Annual species pull out very easily.)

[3] Mature trees are trees with a circumference of at least 125 cm at 130 cm above the ground.

[4] Natural regeneration of the dominant overstorey eucalypts when there are mature trees plus regenerating trees of at least 15 cm circumference at 130 cm above the ground.

THREATENED SPECIES SCIENTIFIC COMMITTEE

The Hon Tony Burke MP
Minister for Sustainability, Environment, Water, Population and Communities
Parliament House
CANBERRA ACT 2600

Dear Minister

Re: Advice on the presence of hybrids in listed ecological communities.

You have sought advice on whether or not the existence of hybrids in a native vegetation patch that is part of a listed ecological community renders that part of the ecological community ineligible for protection.

Hybridisation among eucalypt species (i.e. members of the two closely-related genera *Eucalyptus* and *Corymbia*) was controversial a century ago. However, its occurrence is now widely accepted as part of the natural evolutionary process. In addition to eucalypt species, hybridisation is well documented in a wide range of other plants and animals.

The full extent of hybridisation among eucalypt species is still not fully understood but it is clear that related co-occurring species do often hybridise. In addition, eucalypts cultivated outside their natural range have been found to hybridise with local native species. These discoveries have made genetic and hybridisation studies an integral part of the progressive improvement in the group's taxonomy, as well as commercial eucalypt breeding.

Recent eucalypt research has three foci namely scientific curiosity about the issue, selective tree breeding and more recently the risks posed by plantation species to local native species by non-natural interbreeding. Since 1991 there has been approximately 6,200 papers published on, and around these topics for eucalypt species.

The TSSC was always aware of hybrids in communities as accepted science so in some early listing advices the Committee did not see it as an issue and did not make it explicit that the existence of natural hybrids, of any taxa, was an acceptable part of the definition of the ecological communities. In recent times all relevant listing advices contain such a statement.

Threatened Species Scientific Committee Secretariat
C/- Species Listing Section, Department of the Environment, Water, Heritage and the Arts
GPO Box 787, CANBERRA ACT 2601✦ ph 02 6274 1639

The opinion of the TSSC is that the presence of natural hybrids of any taxa within any ecological community currently listed under the EPBC Act does not render the areas of the ecological community in which hybrids occur ineligible for protection.

The Committee further suggests that, rather than modifying individual listing advices to clarify this issue, a more expedient approach would be to publish the general principles presented in this letter on the Department's website. The most appropriate place would be in conjunction with the EPBC list of threatened ecological communities and/or with relevant listing advice on the Department's Species Profile and Threats Database.

Yours sincerely

Associate Professor Robert J.S. Beeton AM FEIANZ
Chair
Threatened Species Scientific Committee

20 December 2010

Appendix C

TSC Act Final Determination: Box-Gum Woodland

White box yellow box Blakely's red gum woodland - endangered ecological community listing

NSW Scientific Committee - final determination

The Scientific Committee, established by the Threatened Species Conservation Act, has made a Final Determination to list the White Box Yellow Box Blakely's Red Gum Woodland as an ENDANGERED ECOLOGICAL COMMUNITY on Part 3 of Schedule 1 of the Act. The listing of Endangered Ecological Communities is provided for by Part 2 of the Act.

The Scientific Committee previously made a Preliminary Determination to support the proposal to list the White Box-Yellow Box Woodland. The Scientific Committee considers that the White Box Yellow Box Blakely's Red Gum Woodland is a more appropriate name for this Community.

The Scientific Committee has found that:

1. 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. White Box Yellow Box Blakely's Red Gum Woodland is found on relatively fertile soils on the tablelands and western slopes of NSW and generally occurs between the 400 and 800 mm isohyets extending from the western slopes, at an altitude of c. 170m to c. 1200 m, on the northern tablelands (Beadle 1981). The community occurs within the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands and NSW South Western Slopes Bioregions.

2. 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). Grass and herbaceous species generally characterise the ground layer. 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. Shrubs are generally sparse or absent, though they may be locally common.

3. White Box Yellow Box Blakely's Red Gum Woodland is characterised by the following assemblage of species.

- Acacia buxifolia
- Acacia implexa
- Acacia paradoxa
- Allocasuarina verticillata
- Alectryon oleifolius
- Aristida behriana
- Aristida ramosa
- Asperula conferta
- Atalaya hemiglauca
- Austrodanthonia auriculata
- Austrodanthonia bipartita
- Austrodanthonia racemosa
- Austrodanthonia richardsonii
- Austrostipa aristiglumis

- Austrostipa blackii
- Austrostipa nodosa
- Austrostipa scabra
- Bothriochla macra
- Brachychiton populneus
- Brachyloma daphnoides
- Bracteantha viscosa
- Brunoniella australis
- Bulbine bulbosa
- Bursaria spinosa
- Callitris endlicheri
- Callitris glaucophylla
- Capparis mitchellii
- Cassinia longifolia
- Cassinia quinquefaria
- Cheilanthes sieberi
- Chloris trucata
- Chloris ventricosa
- Chrysocephalum apiculatum
- Cymbopogon refractus
- Dianella longifolia
- Dianella revoluta
- Dichanthium sericeum
- Dichelachne micrantha
- Dichelacne sciurea
- Diuris dendrobioides
- Dodonaea viscosa
- Echinopogon caespitosus
- Ehretia membranifolia
- Elymus scaber
- Eremophila mitchellii
- Eucalyptus blakelyi
- Eucalyptus albens
- Eucalyptus bridgesiana
- Eucalyptus conica
- Eucalyptus goniocalyx
- Eucalyptus melliodora
- Eucalyptus microcarpa
- Eucalyptus nortonii
- Eulalia aurea
- Exocarpos cupressiformis
- Geijera parviflora
- Geranium solanderi
- Glycine clandestina
- Glycine tabacina
- Glycine tomentella
- Gonocarpus elatus
- Goodenia pinnatifida
- Hibbertia linearis
- Hibbertia obtusifolia
- Hypericum gramineum
- Jacksonia scoparia
- Jasminum lineare
- Jasminum suavissimum
- Leptorhynchos squamatus
- Lissanthe strigosa
- Lomandra filiformis
- Melichrus urceolatus

- Microseris lanceolata
- Notelaea microcarpa
- Olearia elliptica
- Olearia viscidula
- Oxalis perennans
- Pandorea pandorana
- Panicum queenslandicum
- Parsonsia eucalyptophylla
- Pimelea curviflora
- Plantago debilis
- Plantago gaudichaudii
- Poa labillardieri
- Poa sieberiana
- Rostellularia adscendens
- Rumex brownii
- Sida corrugata
- Sorghum leiocladum
- Stackhousia monogyna
- Stackhousia viminea
- Swainsona galegifolia
- Templetonia stenophylla
- Themeda australis
- Wahlenbergia communis

The total flora and fauna species list for the community is considerably larger than that given above, with many species present in only some sites or in very small quantity. In any particular site not all of the assemblage listed above may be present. At any one time, seeds of some species may only be present in the soil seed bank with no above-ground individuals present. The species composition of the site will be influenced by the size of the site, recent rainfall or drought conditions, its disturbance history and geographic and topographic location. The community is an important habitat for a diverse fauna (vertebrates and invertebrates), but detailed records are not available from most stands and the invertebrate fauna is poorly known.

4. Woodlands with Eucalyptus albens are most common on the undulating country of the slopes region while Eucalyptus blakelyi and Eucalyptus melliodora predominate in grassy woodlands on the tablelands. Drier woodland areas dominated by Eucalyptus albens often form mosaics with areas dominated by Eucalyptus blakelyi and Eucalyptus melliodora occurring in more moist situations, while areas subject to waterlogging may be treeless. E microcarpa is often found in association with E. melliodora and E. albens on the south western slopes. Woodlands including Eucalyptus crebra, Eucalyptus dawsonii and Eucalyptus moluccana (and intergrades with Eucalyptus albens), for example in the Merriwa plateau, Goulburn River National Park and western Wollemi National Park, are also included. Intergrades between Eucalyptus blakelyi and Eucalyptus tereticornis may also occur here.

5. Latitudinal and climatic gradients in the patterns of species present are found across the range of the community (eg. see Prober 1996 for variation in White Box). This is reflected in a gradual change in herb and grass species from northern to southern NSW (eg. Prober 1996). Within White Box Yellow Box Blakely's Red Gum Woodland, species such as Rostellularia adscendens, Chloris ventricosa, Austrodanthonia racemosa, Brunoniella australis, Cymbopogon refractus, Swainsona galegifolia, Notelaea microcarpa, Stackhousia viminea, Olearia elliptica, Jasminum suavissimum, Plantago gaudichaudii, Dichanthium sericeum, Plantago debilis and Wahlenbergia communis are generally more restricted to more northern areas (eg. Prober 1996). Some other species in White Box Yellow Box Blakely's Red Gum Woodland were generally restricted to southern areas. These include Gonocarpus elatus, Austrostipa blackii, Aristida behriana, Bracteantha viscosa, Austrodanthonia auriculata and Austrostipa nodosa (Prober 1996).

6. White Box Yellow Box Blakely's Red Gum Woodland includes vegetation described as Eucalyptus albens alliance and E. melliodora / E. blakelyi alliance in Beadle (1981), the Eucalyptus albens alliance in Moore (1953a,b), the grassy white box woodlands of Prober and Thiele (1993,1995) and Prober (1996) and the Grassy white box woodland of the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999. In the southern tablelands and parts of the southwest slopes, White Box Yellow Box Blakely's Red Gum Woodland are described in Thomas et al. (2000).

7. Related communities are the Eucalyptus microcarpa, Eucalyptus pilligaensis Grey Box/ Eucalyptus populnea Poplar Box communities of the western slopes and plains and the Eucalyptus moluccana, Grey Box, communities of the Clarence, lower Hunter Valley and Western Sydney. These are not covered by this Determination. Similarly the natural temperate grasslands and the Eucalyptus pauciflora grassy woodlands of the cooler parts of the southern tablelands are not covered by this Determination.

8. White Box Yellow Box Blakely's Red Gum Woodland has been drastically reduced in area and

highly fragmented because of clearance for cropping and pasture improvement. Austin et al. (2000) found the community had been reduced to less than 1% of its pre-European extent in the Central Lachlan region. Comparable degrees of reduction have been documented for NSW south western slopes and southern Tablelands (estimated <4% remaining, Thomas et. al. 2000), and for the Holbrook area (estimated <7% remaining, Gibbons and Boak (2000). Gibbons and Boak (2000) found remnants of woodlands dominated by Eucalyptus albens, E. melliodora and E. blakelyi were severely fragmented. Further remnants of the community are degraded as a consequence of their disturbance history. Some remnants of these communities survive with the trees partly of wholly removed by post European activities, and conversely, often remnants of these communities survive with these tree species largely intact but with the shrub or ground layers degraded to v

arying degrees through grazing or pasture modification. Remnants are subject to varying degrees of threat that jeopardise their viability. These threats include: further clearing (for cropping, pasture improvement or other development); deterioration of remnant condition (caused by firewood cutting, increased livestock grazing, weed invasion, inappropriate fire regimes, soil disturbance and increased nutrient loads); degradation of the landscape in which remnants occur (including soil acidification, salinity, and loss of connectivity between remnants).

9. The understorey may be highly modified by grazing history and disturbance. A number of native species appear not to tolerate grazing by domestic stock and are confined to the least disturbed remnants (Dianella revoluta, Diuris dendrobioides, Microseris lanceolata, Pimelea curviflora, Templetonia stenophylla (Prober & Thiele 1995). Dominant pasture species typically change from Themeda australis, Austrostipa aristiglumis and Poa spp. to Austrostipa falcata, Austrodanthonia spp. and Bothriochla macra as grazing intensity increases (Moore 1953a). This may reflect differences in palatability of these species and their ability to tolerate grazing pressure. Light grazing and burning may also be a problem and lead to Aristida ramosa dominance (Lodge & Whalley 1989).

10. The condition of remnants ranges from relatively good to highly degraded, such as paddock remnants with weedy understories and only a few hardy natives left. A number of less degraded remnants have survived in Travelling Stock Routes, cemeteries and reserves, although because of past and present management practices understorey species composition may differ between the two land uses. Some remnants of the community may consist of only an intact overstorey or an intact understorey, but may still have high conservation value due to the flora and fauna they support. Other sites may be important faunal habitat, have significant occurrences of particular species, form part of corridors or have the potential for recovery. The conservation value of remnants may be independent of remnant size.

11. 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.

12. The community is poorly represented in conservation reserves. There are small occurrences of White Box Yellow Box Blakely's Red Gum Woodland in Border Ranges National Park, Goobang National Park, Goulburn River National Park, Manobalai Nature Reserve, Mt Kaputar National Park, Oxley Wild Rivers National Park, Queanbeyan Nature Reserve, Towari National Park, Warrumbungle National Park, Wingen Maid Nature Reserve and Wollemi National Park. The community also occurs in the following State Conservation Areas, Copeton State Conservation Area, Lake Glenbawn State Conservation Area and Lake Keepit State Conservation Area.

13. Fauna species of conservation significance found in some stands of White Box Yellow Box Blakely's Red Gum Woodland include,

- Aprasia parapulchella - Pink-tailed Legless Lizard
- Burhinus grallarius - Bush Stone-curlew
- Cacatua leadbeateri - Major Mitchell's Cockatoo
- Climacteris picumnus victoriae - Brown Treecreeper
- Dasyurus maculatus - Spotted-tailed Quoll
- Delma impar - Striped Legless Lizard
- Grantiella picta - Painted Honeyeater
- Hoplocephalus bitorquatus - Pale-headed Snake
- Lathamus discolor - Swift Parrot
- Lophoictinia isura - Square-tailed Kite
- Melanodryas cucullata cucullata - Hooded Robin
- Melithreptus gularis gularis - Black-chinned Honeyeater
- Neophema pulchella - Turquoise Parrot
- Ninox connivens - Barking Owl
- Petaurus norfolcensis - Squirrel Glider
- Phascolarctos cinereus - Koala
- Polytelis swainsonii - Superb Parrot
- Pomatostomus temporalis temporalis - Grey-crowned Babbler
- Pyrrholaemus sagittata - Speckled Warbler
-

Saccolaimus flaviventris - Yellow-bellied Sheathtail-bat

- Stagonopleura guttata - Diamond Firetail
- Synemon plana - Golden Sun Moth
- Tyto novaehollandiae - Masked Owl
- Varanus rosenbergi - Rosenberg's Goanna
- Xanthomyza phrygia - Regent Honeyeater

A number of plant species of conservation significance are likely to occur in White Box Yellow Box Blakely's Red Gum Woodland

- Ammobium craspedioides
- Bothriochloa biloba
- Dichanthium setosum
- Discaria pubescens
- Diuris spp.
- Prasophyllum petilum
- Pterostylis spp.
- Rutidosis leptorhynchoides
- Swainsona spp.

A number of key threatening processes also occur in White Box Yellow Box Blakely's Red Gum Woodland. These include: Clearing of native vegetation, Predation by the European Red Fox Vulpes vulpes, Predation by the Feral Cat, Felis catus.

14. In view of the small size of existing remnants, and the threat of further clearing, disturbance and degradation, the Scientific Committee is of the opinion that White Box Yellow Box Blakely's Red Gum Woodland is likely to become extinct in nature in New South Wales unless the circumstances and factors threatening its survival or evolutionary development cease to operate and that listing as an endangered ecological community is warranted.

Proposed Gazettal date: 15/03/02

Exhibition period: 15/03/02 - 19/04/02

References

Austin, M.P., Cawsey, E.M., Baker, B.L., Yialeloglou, M.M., Grice, D.J. & Briggs, S.V. (2000) Predicted vegetation cover in the Central Lachlan Region. CSIRO Wildlife & Ecology Final Report for Natural Heritage Trust Project AA 1368.97.

Beadle, N.C.W. (1981) The Vegetation of Australia. Cambridge University Press, Cambridge.

Gibbons, P. & Boak, M. (2000) The importance of paddock trees for regional conservation in agricultural landscapes. A discussion paper for consideration by Riverina Highlands Regional Vegetation Committee. NSW National Parks and Wildlife Service, Southern Directorate unpublished report.

Lodge,G.M. & Whalley, R.D.B. (1989) Native and natural pastures on the northern slopes and tablelands of New South Wales: a review and annotated bibliography. Technical Bulletin 35, NSW Agriculture.

Moore, C.W.E. (1953a) The vegetation of the south-eastern Riverina, New South Wales. I. The climax communities. Australian Journal of Botany 1, 489-547.

Moore, C.W.E. (1953b) The vegetation of the south-eastern Riverina, New South Wales. II. The disclimax communities. Australian Journal of Botany 1, 548-567.

Prober, S.M. (1996) Conservation of the grassy white box woodlands: rangewide floristic variation and implications for reserve design. Australian Journal of Botany 44, 57-77.

Prober, S.M. & Thiele, K.R. (1993) The ecology and genetics of remnant grassy white box woodlands in relation to their conservation. Victorian Naturalist 110, 30-36.

Prober, S.M. & Thiele, K.R. (1995) Conservation of grassy white box woodlands: relative contributions of size and disturbance to floristic composition and diversity of remnants. Australian Journal of Botany 43, 349-366.

Thomas, V., Gellie, N. & Harrison, T. (2000) Forest ecosystem classification and mapping for the Southern CRA region, Volume II Appendices. NSW National Parks & Wildlife Service, Southern Directorate. A report undertaken for the NSW CRA/RFA Steering Committee.

About the NSW Scientific Committee

Appendix D

Flora Species Recorded in the Study Area

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Trees								
Anacardiaceae	*	*Schinus areira*	Pepper Tree			X	X	X
Casuarinaceae		*Allocasuarina littoralis*	Black She-oak				X	X
Casuarinaceae		*Allocasuarina luehmannii*	Buloak			X	X	X
Casuarinaceae		*Casuarina cunninghamiana*	River Oak			X	X	X
Casuarinaceae		*Casuarina glauca*	Swamp Oak					X
Fabaceae - Mimosoideae		*Acacia implexa*	Hickory Wattle			X	X	
Fabaceae - Mimosoideae		*Acacia salicina*	Cooba					X
Flacourtiaceae	*	*Dovyalis caffra*	Kei-Apple			X		
Loranthaceae		*Amyema miquelii*				X	X	
Loranthaceae		*Amyema sp.*						X
Loranthaceae		*Lysiana exocarpi subsp. tenuis*				X		
Loranthaceae		*Muellerina celastroides*				X		
Myrtaceae		*Angophora floribunda*	Rough-barked Apple			X	X	X
Myrtaceae		*Eucalyptus albens*	White Box			X		
Myrtaceae		*Eucalyptus albens x moluccana*	White Box - Grey Box intergrade			X	X	X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Myrtaceae		*Eucalyptus blakelyi*	Blakely's Red Gum					X
Myrtaceae		*Eucalyptus camaldulensis*	River Red Gum					X
Myrtaceae		*Eucalyptus conica*	Fuzzy Box				X	X
Myrtaceae		*Eucalyptus crebra*	Narrow-leaved Ironbark			X	X	
Myrtaceae		*Eucalyptus dawsonii*	Slaty Gum			X	X	X
Myrtaceae		*Eucalyptus melliodora*	Yellow Box			X	X	X
Myrtaceae		*Eucalyptus moluccana*	Grey Box			X	X	X
Myrtaceae		*Eucalyptus moluccana x albens*	White Box - Grey Box intergrade					X
Myrtaceae		*Eucalyptus nicholii*	Narrow-leaved Peppermint (planted)		V			X
Myrtaceae		*Eucalyptus tereticornis*	Forest Red Gum			X		
Myrtaceae		*Eucalyptus tereticornis x blakelyi*	Forest Red Gum - Blakely's Red Gum intergrade				X	X
Proteaceae	*	*Grevillea robusta*	Silky Oak			X		
Sterculiaceae		*Brachychiton populneus*	Kurrajong					X
Sterculiaceae		*Brachychiton populneus subsp. populneus*	Kurrajong			X	X	
Shrubs								
Apocynaceae	*	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush			X	X	X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Asteraceae		*Cassinia compacta*				X		
Asteraceae		*Cassinia quinquefaria*	Cough Bush			X	X	X
Asteraceae		*Cassinia uncata*	Sticky Cassinia			X		
Asteraceae		*Ozothamnus diosmifolius*	White Dogwood				X	X
Cactaceae	*	*Opuntia stricta*	Prickly Pear					X
Casuarinaceae		*Allocasuarina littoralis (imm)*	Black She-oak					X
Casuarinaceae		*Allocasuarina luehmannii (imm)*	Buloak					X
Chenopodiaceae		*Atriplex semibaccata*	Creeping Saltbush			X	X	X
Chenopodiaceae		*Maireana microphylla*	Small-leaved Bluebush			X	X	X
Chenopodiaceae		*Sclerolaena birchii*				X		
Chloanthaceae		*Spartothamnella juncea*	Bead Bush			X	X	X
Euphorbiaceae		*Breynia oblongifolia*	Coffee Bush			X		
Fabaceae - Caesalpinoideae		*Senna odorata*				X		
Fabaceae - Faboideae		*Daviesia ulicifolia*	Gorse Bitter Pea			X		
Fabaceae - Faboideae		*Hardenbergia violacea*	False Sarsparilla					X
Fabaceae - Faboideae		*Indigofera australis*	Australian Indigo			X		
Fabaceae - Faboideae		*Templetonia stenophylla*	Leafy Templetonia			X	X	X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Fabaceae - Mimosoideae		*Acacia cultriformis*	Knife-leaf Wattle			X		
Fabaceae - Mimosoideae		*Acacia decora*	Western Silver Wattle			X		
Fabaceae - Mimosoideae		*Acacia falcata*				X		
Fabaceae - Mimosoideae		*Acacia paradoxa*	Kangaroo Thorn			X	X	X
Fabaceae - Mimosoideae		*Acacia pendula*	Weeping Myall		E2		X	
Fabaceae - Mimosoideae		*Acacia salicina*	Cooba			X	X	X
Fabaceae - Mimosoideae		*Pultenaea sp.*						X
Myoporaceae		*Myoporum montanum*	Western Boobialla			X		
Myrtaceae		*Angophora floribunda (imm)*	Rough-barked Apple					X
Myrtaceae		*Eucalyptus dawsonii (imm)*	Slaty Gum					X
Myrtaceae		*Eucalyptus moluccana x albens*	White Box - Grey Box intergrade					X
Oleaceae		*Notelaea ?longifolia f. intermedia*				X		
Oleaceae		*Notelaea longifolia*	Large Mock-olive				X	X
Oleaceae		*Notelaea microcarpa*	Native Olive					X
Oleaceae		*Notelaea microcarpa var. microcarpa*				X	X	
Oleaceae		*Notelaea ovata*					X	X
Pittosporaceae		*Bursaria spinosa*	Blackthorn			X	X	X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Pittosporaceae		*Bursaria spinosa subsp. spinosa*	Blackthorn					
Pittosporaceae		*Cryptandra amara*	Bitter Cryptandra			X	X	X
Rubiaceae		*Psydrax odorata (syn. Canthium odoratum)*	Lamboto			X		
Rubiaceae		*Psydrax odorata f. buxifolia (syn. Canthium buxifolium)*				X		
Rubiaceae		*Psydrax sp. (syn. Canthium sp.)*					X	X
Rutaceae		*Geijera parviflora*	Wilga Wilga				X	X
Santalaceae		*Exocarpos cuppressiformis*	Cherry Ballart				X	
Sapindaceae		*Dodonaea viscosa subsp. cuneata*	Wedge-leaf Hop-bush			X		
Solanaceae	*	*Lycium ferocissimum*	African Boxthorn				X	X
Solanaceae		*Solanum brownii*	Violet Nightshade			X	X	X
Solanaceae		*Solanum cinereum*	Narrawa Burr			X	X	X
Solanaceae	*	*Solanum nigrum*	Black-berry Nightshade			X	X	X
Solanaceae	*	*Solanum pseudocapsicum*	Jerusalem Cherry					X
Solanaceae		*Solanum sp.*						X
Sterculiaceae		*Brachychiton populneus (imm)*	Kurrajong					X
Thymelaceae		*Pimelea curviflora*					X	X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Thymelaceae		*Pimelea curviflora var. divergens*				X		
Thymelaceae		*Pimelea linifolia*	Slender Rice Flower				X	X
Thymelaceae		*Pimelea linifolia subsp. linifolia*				X		
Thymelaceae		*Pimelea sp.*						X
Herbs - Dicots								
Acanthaceae		*Brunoniella australis*	Blue Trumpet				X	X
Acanthaceae		*Brunoniella pumilio*	Dwarf Brunoniella			X		
Acanthaceae		*Rostellularia adscendens*						X
Acanthaceae		*Rostellularia adscendens var. adscendens*				X	X	
Aizoaceae	*	*Galenia pubescens*	Galenia				X	X
Amaranthaceae		*Alternanthera sp. A*				X		
Amaranthaceae	*	*Gomphrena celosioides*	Gomphrena Weed			X		
Amaranthaceae		*Ptilotus indivisus*	Tangled Silver-tails				X	
Amaranthaceae		*Ptilotus semilanatus*				X	X	X
Apiaceae	*	*Cyclospermum leptophyllum*	Slender Celery			X		X
Apiaceae		*Daucus glochidiatus*	Native Carrot				X	X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Apiaceae	*	*Torilis nodosa*	Knotted Hedge-parsley			X		
Asteraceae	*	*Aster subulatus*	Wild Aster			X		X
Asteraceae	*	*Bidens pilosa*	Cobbler's Pegs			X	X	X
Asteraceae		*Calocephalus citreus*	Lemon Beauty-heads			X		
Asteraceae		*Calotis cuneifolia*	Purple Burr-daisy			X	X	X
Asteraceae		*Calotis hispidula*	Bogan Flea			X		
Asteraceae		*Calotis lappulacea*	Yellow Burr-daisy			X	X	X
Asteraceae	*	*Carthamus lanatus*	Saffron Thistle			X	X	X
Asteraceae		*Chrysocephalum apiculatum*	Common Everlasting			X	X	X
Asteraceae		*Chrysocephalum semipapposum*	Clustered Everlasting					X
Asteraceae		*Chrysocephalum sp?*						X
Asteraceae	*	*Cirsium vulgare*	Spear Thistle			X	X	X
Asteraceae	*	*Conyza bonariensis*	Fleabane				X	X
Asteraceae	*	*Conyza spp.*				X		
Asteraceae		*Cymbonotus lawsonianus*	Bears-ear				X	X
Asteraceae		*Euchiton involucratus (syn. Gnaphalium involucratum)*	Star Cudweed			X		

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Asteraceae		*Euchiton sp.*						X
Asteraceae	*	*Facelis retusa*						X
Asteraceae		*Gamochaeta sp.*						X
Asteraceae		*Glossocardia bidens (syn. Glossogyne tannensis)*	Cobblers Tack			X	X	X
Asteraceae		*Gnaphalium sp.*	a cudweed					X
Asteraceae	*	*Hedypnois rhagadioloides*	Cretan Weed				X	
Asteraceae	*	*Hypochaeris radicata*	Catsear			X		X
Asteraceae		*Lagenophora stipitata*						X
Asteraceae		*Leiocarpa websteri*					X	X
Asteraceae		*Minuria leptophylla*				X	X	X
Asteraceae	*	*Onopordum acanthium*	Scotch Thistle				X	X
Asteraceae		*Podolepis jaceoides*	Showy Copper-wire Daisy				X	X
Asteraceae	*	*Senecio madagascariensis*	Fireweed			X	X	X
Asteraceae		*Senecio pinnatifolius*	Variable Groundsel					X
Asteraceae		*Senecio quadridentatus*	Cotton Fireweed					X
Asteraceae		*Senecio spp.*				X		X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Asteraceae		*Sigesbeckia orientalis*				X		
Asteraceae	*	*Silybum marianum*	Variegated Thistle					X
Asteraceae		*Solenogyne? sp.*						X
Asteraceae	*	*Solvia sessilis (syn. Solvia pterosperma)*	Bindyi				X	X
Asteraceae	*	*Sonchus oleraceus*	Common Sowthistle			X	X	X
Asteraceae	*	*Tagetes minuta*	Stinking Roger			X		
Asteraceae	*	*Taraxacum officionale*	Dandelion				X	X
Asteraceae	*	*Tolpis barbata*	Yellow Hawkeweed				X	
Asteraceae		*Vernonia cinerea*					X	X
Asteraceae		*Vittadinia cuneata*	Fuzzweed				X	X
Asteraceae		*Vittadinia cuneata var cuneata forma cuneata*				X		
Boragniaceae		*Cynoglossum australe*				X		
Brassicaceae	*	*Capsella bursa-pastoris*	Shepherd's Purse					X
Brassicaceae	*	*Lepidium bonariense*				X		X
Brassicaceae		*Lepidium pseudohyssopifolium*	Peppercress				X	X
Brassicaceae	*	*Lepidium sp.*						X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Brassicaceae	*	*Rapistrum rugosum*	Giant Mustard				X	
Brassicaceae		*Rorippa laciniata*				X		
Cactaceae	*	*Opuntia stricta*	Common Prickly Pear					X
Cactaceae	*	*Opuntia stricta var. stricta*	Common Prickly Pear			X	X	
Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell			X	X	X
Campanulaceae		*Wahlenbergia gracilis*	Sprawling Bluebell				X	X
Campanulaceae		*Wahlenbergia stricta*	Austral Bluebell				X	X
Caryophyllaceae	*	*Cerastium glomeratum*	Mouse-ear Chickweed				X	X
Caryophyllaceae	*	*Petroghagia ssp.*					X	X
Caryophyllaceae	*	*Petrorhagia nanteuilii*				X		
Caryophyllaceae	*	*Polycarpon tetraphyllum*	Four-leaved Allseed			X		
Caryophyllaceae	*	*Silene gallica var. gallica*					X	X
Caryophyllaceae	*	*Spergula arvensis*	Corn Spurry			X		
Caryophyllaceae	*	*Spergularia rubra*	Sandspurry			X		
Chenopodiaceae		*Einadia hastata*	Berry Saltbush					X
Chenopodiaceae		*Einadia nutans*					X	X
Chenopodiaceae		*Einadia nutans ssp linifolia*				X		

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Chenopodiaceae		*Einadia polygonoides*				X	X	X
Chenopodiaceae		*Einadia trigonos*	Fishweed					X
Chenopodiaceae		*Einadia trigonos subsp. leiocarpa*	Fishweed			X		
Chenopodiaceae		*Enchylaena tomentosa*	Ruby Saltbush			X	X	X
Chenopodiaceae		*Maireana enchylaenoides*	Wingless Bluebush			X		
Chenopodiaceae	*	*Sclerolaena birchii*	Galvanised Burr					X
Clusiaceae		*Hypericum gramineum*	Small St. John's Wort			X	X	X
Clusiaceae	*	*Hypericum perforatum*	St. Johns Wort			X		X
Convolvulaceae		*Dichondra repens*	Kidney Weed			X	X	X
Crassulaceae		*Crassula sieberiana*	Australian Stonecrop			X		X
Crassulaceae		*Crassula sp.*					X	X
Euphorbiaceae		*Chamaesyce drummondii*	Caustic Weed				X	X
Euphorbiaceae		*Poranthera microphylla*				X		
Fabaceae - Faboideae		*Cullen tenax*	Emu Grass				X	X
Fabaceae - Faboideae		*Desmodium brachypodum*	Large Tick-trefol			X	X	X
Fabaceae - Faboideae		*Desmodium varians*	Slender Tick-trefoil			X	X	X
Fabaceae - Faboideae	*	*Medicago sp.*	a Burr Medic				X	X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Fabaceae - Faboideae		*Templetonia stenophylla*	Leafy Templetonia					X
Fabaceae - Faboideae	*	*Trifolium arvense*					X	X
Fabaceae - Faboideae	*	*Trifolium dubium*	Yellow Suckling Clover				X	X
Fabaceae - Faboideae	*	*Trifolium sp.*					X	X
Fabaceae - Faboideae		*Zornia dyctiocarp*	Zornia					X
Gentianaceae	*	*Schenkia spicata (syn. Centaurium spicatum)*	Spike Centaury			X		
Geraniaceae		*Erodium cicutarium*	Common Storksbill				X	
Geraniaceae		*Erodium crinitum*	Blue Storksbill					X
Geraniaceae		*Geranium solanderi*	Native Geranium				X	X
Goodeniaceae		*Goodenia hederacea*	Forest Goodenia				X	X
Goodeniaceae		*Goodenia spp.*				X		
Goodeniaceae		*Scaevola aemula*	Fairy Fan-flower				X	
Goodeniaceae		*Scaevola albida var. albida*					X	
Goodeniaceae		*Scaevola sp.*						X
Goodeniaceae		*Velleia paradoxa*	Spur Velleia			X	X	X
Haloragaceae		*Gonocarpus sp.*						X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Lamiaceae	*	*Marrubium vulgare*	White Horehound				X	X
Lamiaceae		*Mentha satureioides*	Creeping Mint			X		X
Lamiaceae		*Plectranthus spp.*				X		
Lamiaceae		*Salvia verbenaca*	Vervain			X		
Linaceae		*Linum marginale*	Native Flax				X	
Malvaceae		*Abutilon oxycarpum*	Flannel Weed			X		
Malvaceae		*Sida corrugata*					X	X
Malvaceae		*Sida cunninghamii*					X	X
Malvaceae	*	*Sida rhombifolia*	Paddy's Lucerne			X	X	X
Myoporaceae		*Eremophila debilis*	Winter Apple			X	X	X
Myrsinaceae	*	*Anagallis arvensis*	Scarlet/Blue Pimpernel			X	X	X
Myrtaceae		*Angphora floribunda (seedling)*	Rough-barked Apple					X
Myrtaceae		*Eucalyptus molucanna (seedling)*	Grey Box					X
Nyctaginaceae		*Boerhavia dominii*	Tarvine					X
Oxalidaceae		*Oxalis chnoodes*				X		
Oxalidaceae		*Oxalis exilis*					X	X
Oxalidaceae		*Oxalis perennans*						X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Phyllanthaceae		*Phyllanthus virgatus*				X		X
Plantaginaceae		*Plantago debilis*					X	X
Plantaginaceae		*Plantago gaudichaudii*	Narrow-leaved Plantain				X	X
Plantaginaceae	*	*Plantago lanceolata*	Lamb's Tongues				X	X
Plantaginaceae		*Plantago spp.*				X		
Plantaginaceae		*Veronica plebeia*	Creeping Speedwell			X	X	X
Polygonaceae		*Polygonum plebeium*	Small Knotweed			X		
Polygonaceae		*Rumex brownii*	Swamp Dock			X	X	X
Rubiaceae		*Asperula conferta*	Common Woodruff			X	X	X
Rubiaceae		*Galium binifolium*				X		
Rubiaceae		*Galium gaudichaudii*	Rough Bedstraw			X		
Rubiaceae	*	*Galium propinquum*	Maori Bedstraw				X	X
Rubiaceae		*Opercularia diphylla*				X		
Rubiaceae	*	*Richardia stellaris*				X		
Stackhousiaceae		*Stackhousia monogyna*	Creamy Candles				X	X
Stackhousiaceae		*Stackhousia viminea*	Slender Stackhousia			X		
Verbenaceae	*	*Verbena officinalis*	Common Verbena			X		

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Verbenaceae	*	*Verbena sp.*					X	X
Herbs - Monocots								
Anthericaceae		*Arthropodium milleflorum*	Pale Vanilla-lily				X	X
Anthericaceae		*Caesia parviflora*	Pale Grass-lily			X		
Anthericaceae		*Caesia sp.*					X	X
Anthericaceae		*Dichopogon fimbriatus*	Nodding Chocolate Lily				X	X
Anthericaceae		*Laxmannia gracilis*	Slender Wire Lily				X	X
Commelinaceae		*Commelina cyanea*	Native Wandering Jew			X	X	X
Commelinaceae		*Murdannia graminea*				X		
Cyperaceae		*Carex inversa*					X	X
Cyperaceae		*Cyperus gracilis*	Slender Flat-sedge			X	X	X
Cyperaceae		*Eleocharis plana*	Flat Spike-sedge			X		
Cyperaceae		*Fimbristylis dichotoma*	Common Fringe-sedge			X		
Cyperaceae		*Scleria sp.*						X
Hydrocharitaceae		*Ottelia ovalifolia*	Swamp Lily			X		
Iridaceae	*	*Romulea rosea*	Onion Grass				X	X
Juncaceae	*	*Juncus acutus*	Sharp Rush					X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Juncaceae		*Juncus sp.*						X
Juncaceae		*Juncus usitatus*				X	X	X
Lomandraceae		*Lomandra confertifolia subsp. pallida*				X		
Lomandraceae		*Lomandra filiformis*	Wattle Mat-rush					X
Lomandraceae		*Lomandra filiformis subsp. filiformis*	Wattle Mat-rush				X	
Lomandraceae		*Lomandra longifolia*	Spiny-headed Mat-rush			X		
Lomandraceae		*Lomandra multiflora*	Many-flowered Mat-rush					X
Lomandraceae		*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush			X	X	
Luzuriagaceae		*Eustrephus latifolius*	Wombat Berry			X		
Luzuriagaceae		*Geitonoplesium cymosum*	Scrambling Lily			X		
Orchidaceae		*Cymbidium canaliculatum*	Tiger Orchid		E2		X	
Orchidaceae		*Diuris tricolor*	Painted Diuris, Pine Donkey Orchid		V, E2		X	X
Phormiaceae		*Dianella caerulea var. cinerascens*				X		
Phormiaceae		*Dianella longifolia*	Blue Flax-Lily				X	X
Phormiaceae		*Dianella revoluta*	Blue Flax-Lily			X	X	X
Typhaceae		*Typha orientalis*	Broad-leaved Cumbungi					X
Herbs - Grasses								

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Poaceae		*Aristida jerichoensis*	Jericho Wiregrass					X
Poaceae		*Aristida personata (syn. Aristida ramosa var speciosa)*	Purple Wire-grass			X		
Poaceae		*Aristida ramosa*	Purple Wiregrass				X	X
Poaceae		*Aristida vagans*	Threeawn Speargrass				X	X
Poaceae		*Austrodanthonia bipartita (syn. Danthonia linkii var. linkii)*	Wallaby Grass			X		
Poaceae		*Austrodanthonia fulva*					X	X
Poaceae		*Austrodanthonia racemosa*					X	X
Poaceae		*Austrodanthonia sp*					X	X
Poaceae		*Austrostipa scabra*	Speargrass				X	X
Poaceae		*Austrostipa verticillata (syn. Stipa verticillata)*	Slender Bamboo Grass			X	X	X
Poaceae		*Bothriochloa biloba*	Lobed Blue-grass	V			X	X
Poaceae		*Bothriochloa decipiens*	Redleg Grass					X
Poaceae		*Bothriochloa macra*	Red-leg Grass			X	X	X
Poaceae		*Bothriochloa spp.*				X		
Poaceae	*	*Briza minor*	Shivery Grass				X	X

CUMBERLAND ECOLOGY
Hansen Bailey

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Poaceae	*	*Bromus catharticus*	Prairie Grass			X		
Poaceae	*	*Bromus molliformis*	Soft Brome				X	X
Poaceae		*Chloris divaricata var. divaricata*	Slender Chloris			X		X
Poaceae		*Chloris truncata*	Windmill Grass			X	X	X
Poaceae		*Chloris ventricosa*	Plump Windmill Grass				X	X
Poaceae		*Cymbopogon refractus*	Barbwire Grass			X	X	X
Poaceae	*	*Cynodon dactylon*	Couch			X		X
Poaceae		*Dactyloctenium radulans*	Button Grass			X		
Poaceae		*Dichanthium sericeum*	Queensland Bluegrass				X	X
Poaceae		*Dichelachne micrantha*	Shorthair Plumegrass			X		
Poaceae		*Digitaria sp.*					X	X
Poaceae	*	*Echinochloa crus-galli*	Barnyard Grass					X
Poaceae		*Elymus scaber*	Common Wheatgrass					X
Poaceae		*Elymus scaber var. scaber*	Common Wheatgrass			X	X	
Poaceae		*Eragrostis brownii*	Brown's Lovegrass				X	X
Poaceae	*	*Eragrostis curvula*	African Lovegrass					
Poaceae		*Eragrostis leptostachya*	Paddock Lovegrass			X	X	X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Poaceae		*Eriochloa pseudoacrotricha*	Early Spring Grass			X		
Poaceae		*Eulalia fulva*	Silky Browntop				X	
Poaceae		*Lachnagrostis filiformis (syn. Agrostis avenacea)*					X	X
Poaceae	*	*Lolium perenne*	Perennial Ryegrass				X	X
Poaceae		*Microlaena stipoides*	Weeping Meadow Grass			X	X	X
Poaceae		*Notodanthonia longifolia (syn. Danthonia longifolia)*	Long-leaved Wallaby Grass			X		
Poaceae		*Panicum effusum*	Hairy Panic				X	X
Poaceae		*Paspalidium distans*					X	X
Poaceae		*Paspalidium gracile*	Slender Panic					
Poaceae	*	*Paspalum dilatatum*	Paspalum			X	X	X
Poaceae		*Paspalum distichum*	Water Couch			X		
Poaceae	*	*Pennisetum clandestinum*	Kikuyu Grass					X
Poaceae		*Phragmites australis*	Common Reed					X
Poaceae		*Poa sieberiana*					X	X
Poaceae	*	*Setaria parviflora*	Pigeon Grass					X
Poaceae		*Sporobolus creber*	Slender Rat's Tail Grass			X	X	X

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Poaceae		*Themeda australis*	Kangaroo Grass			X	X	X
Poaceae	*	*Vulpia bromoides*	Squirrel Tail Fescue				X	X
Vines/Climbers								
Apocynaceae		*Marsdenia ?viridiflora*	Native Pear			X		
Bignoniaceae		*Pandorea pandorana*	Wonga Wonga Vine			X		
Convolvulaceae		*Convolvulus erubescens*	Blushing Bindweed			X	X	X
Fabaceae - Faboideae		*Glycine canescens*	Silky Glycine			X		
Fabaceae - Faboideae		*Glycine clandestina*				X	X	X
Fabaceae - Faboideae		*Glycine microphylla*	Small-leaf glycine			X	X	X
Fabaceae - Faboideae		*Glycine tabacina*				X	X	X
Fabaceae - Faboideae		*Hardenbergia violacea*	False Sarsparilla			X		
Fabaceae - Faboideae		*Rhynchosia minima*				X		
Luzuriagaceae		*Geitonoplesium cymosum*	Scrambling Lily					X
Ranunculaceae		*Clematis glycinoides*	Headache Vine			X	X	X
Vitaceae		*Clematicissus opaca (syn. Cissus opaca)*	Pepper Vine			X		
Herbs - Ferns								

Table D.1 Flora Species Recorded in the Study Area

Family		Species	Common Name	Legal Status		Ecological Study		
				EPBC Act	TSC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Adiantaceae		*Adiantum aethiopicum*	Common Maidenhair			X		
Adiantaceae		*Cheilanthes austrotenuifolia*	Rock Fern				X	X
Adiantaceae		*Cheilanthes distans*	Bristly Cloak Fern					X
Adiantaceae		*Cheilanthes lasiophylla*	Woolly Cloak-fern			X		
Adiantaceae		*Cheilanthes sieberi*	Poison Rock Fern				X	X
Adiantaceae		*Cheilanthes sieberi subsp. sieberi*	Mulga Fern			X		

** denotes an introduced species*

Appendix E

Flora Quadrat Dataset

Table E.1 Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area

Family		Species	Common Name	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23
Trees																										
Casuarinaceae		*Allocasuarina littoralis*	Black She-oak		+																					
Casuarinaceae		*Allocasuarina luehmanii*	Bulloak		2	4	4		1														1			
Casuarinaceae		*Casuarina cunninghamiana*	River Oak													1										
Fabaceae - Mimosoideae		*Acacia salicina*	Cooba						+	+					1	+										
Loranthaceae		*Amyema sp.*	a mistletoe		+		+			+					+											
Myrtaceae		*Angophora floribunda*	Rough-barked Apple						+						2											
Myrtaceae		*Eucalyptus conica*	Fuzzy Box						1																	
Myrtaceae		*Eucalyptus dawsonii*	Slaty Gum			2															2	2				
Myrtaceae		*Eucalyptus melliodora*	Yellow Box						3																	
Myrtaceae		*Eucalyptus moluccana*	Grey Box	3	3		2		1												2	3	2			
Myrtaceae		*Eucalyptus moluccana x albens*	White Box - Grey Box intergrade					4		2	2				2											
Myrtaceae		*Euclayptus tereticornis x blakelyi*	Forest Red Gum - Blakely's Red Gum intergrade		x			2							1											
Sterculiaceae		*Brachychiton populneus*	Kurrajong	2	1						x										+					
Shrubs																										
Apocynaceae	*	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	+	+					+					+		+	+	+		+		+	+		
Asteraceae		*Cassinia quinquefaria*	Cough Bush		+																					
Asteraceae		*Ozothamnus diosmifolius*	White Dogwood		+																					
Cactaceae		*Opuntia stricta*	Prickly Pear																		+					
Casuarinaceae		*Allocasuarina littoralis (imm)*	Black She-oak		1																					
Casuarinaceae		*Allocasuarina luehmanii (imm)*	Buloak		1	2			+								+									
Chenopodiaceae		*Atriplex semibaccata*	Creeping Saltbush				+	+			+															
Chenopodiaceae		*Maireana microphylla*	Small-leaved Bluebush		+		+			+										+						+
Chloanthaceae		*Spartothamnella juncea*	Bead Bush		+																					
Fabaceae - Faboideae		*Hardenbergia violacea*	False Sarsparilla												+											
Fabaceae - Faboideae		*Templetonia stenophylla*	Leafy Templetonia					+																		
Fabaceae - Mimosoideae		*Acacia paradoxa*	Kangaroo Thorn		+													+								
Fabaceae - Mimosoideae		*Acacia salicina*	Cooba			+	+	+		+	1				+		+			+	+		1	+		
Fabaceae - Mimosoideae		*Pultenaea sp.*															+									
Myrtaceae		*Angophora floribunda (imm)*	Rough-barked Apple												+											
Myrtaceae		*Eucalyptus dawsonii (imm)*	Slaty Gum			+																				
Myrtaceae		*Eucalyptus moluccana x albens*	White Box - Grey Box intergrade								1											1				
Oleaceae		*Notelaea longifolia*	Large Mock-olive	1																						
Oleaceae		*Notelaea microcarpa*						+			+															
Oleaceae		*Notelaea ovata*			+																					
Pittosporaceae		*Bursaria spinosa*	Blackthorn			+					+				+								+			
Pittosporaceae		*Cryptandra amara*	Bitter Cryptandra			+																				
Rubiaceae		*Psydrax sp. (syn. Canthium sp.)*						+																		
Rutaceae		*Geijera parviflora*	Wilga Wilga	1																						
Solanaceae	*	*Lycium ferocissimum*	African Boxthorn				+																			
Solanaceae		*Solanum brownii*	Violet Nightshade		+					+																
Solanaceae		*Solanum cinereum*	Narrawa Burr	+										+				+								
Solanaceae	*	*Solanum nigrum*	Black-berry Nightshade	+					+																	
Solanaceae	*	*Solanum pseudocapsicum*																			+					
Solanaceae		*Solanum sp.*																								
Sterculiaceae		*Brachychiton populneus (imm)*	Kurrajong	+						+					+						+		+			
Thymelaceae		*Pimelea curviflora*						+																		
Thymelaceae		*Pimelea linifolia*	Slender Rice Flower			2											+									
Thymelaceae		*Pimelea sp.*																+								

Table E.1 Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area

Family		Species	Common Name	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23
Herbs - Dicots																										
Acanthaceae		*Brunoniella australis*	Blue Trumpet			+				+											+	+	+	+		
Acanthaceae		*Rostellularia adscendens*				+					+			+	+								+			
Aizoaceae	*	*Galenia pubescens*	Galenia		+					+		1				+										
Amaranthaceae		*Ptilotus semilanatus*																				+				
Apiaceae	*	*Cyclospermum leptophyllum*																								+
Apiaceae		*Daucus glochidiatus*	Native Carrot	+		+				+					+											
Asteraceae	*	*Aster subulatus*	Wild Aster																							
Asteraceae	*	*Bidens pilosa*	Cobbler's Pegs	+																						
Asteraceae		*Calotis cuneifolia*	Purple Burr-daisy		+																		+			
Asteraceae		*Calotis lappulacea*	Yellow Burr-daisy	+	+	+			+	+	2		+	+	+				+			+	+			+
Asteraceae	*	*Cathamnus lanatus*	Saffron Thistle	+						+		2	1	+			+			+				+		
Asteraceae		*Chrysocephalum apiculatum*	Common Everlasting	+	+	+			1		+						+		+				+	+	1	
Asteraceae		*Chrysocephalum semipapposum*											+	+	+			+								
Asteraceae		*Chrysocephalum sp?*																		+						
Asteraceae	*	*Cirsium vulgare*	Spear Thistle	+	+					+	+		+				+		+	+			+		+	+
Asteraceae	*	*Conyza bonariensis*	Fleabane	+	+								1	+	+					+		+			+	
Asteraceae		*Cymbonotus lawsonianus*	Bears-ear			+															+	+	+	+		+
Asteraceae		*Euchiton* sp.													+								+			
Asteraceae	*	*Facelis retusa*															+									+
Asteraceae		*Gamochaeta sp.*																				+				
Asteraceae		*Glossocardia bidens (syn. Glossogyne tannensis)*	Cobblers Tack				+				+															
Asteraceae		*Gnaphalium sp.*																		1					1	+
Asteraceae	*	*Hypochaeris radicata*	Catsear															+		+						
Asteraceae		*Lagenophora stipitata*	Blue Bottle-daisy																					+		
Asteraceae		*Leiocarpa websteri*						+	+				+	+												
Asteraceae		*Minuria leptophylla*				+	+	+						+												
Asteraceae	*	*Onopordum acanthium*	Scotch Thistle	+																						
Asteraceae		*Podolepis jaceoides*	Showy Copper-wire Daisy			+																				
Asteraceae	*	*Senecio madagascariensis*	Fireweed	+	+	+	+	+		+	+	+		+	+		+	+	+	1			+	+	+	+
Asteraceae		*Senecio pinnatifolius*	Variable Groundsel										+													
Asteraceae		*Senecio quadridentatus*																								
Asteraceae		*Senecio sp.*																			+					
Asteraceae		*Solenogyne? sp.*															+									
Asteraceae	*	*Solvia sessilis (syn. Solvia pterosperma)*	Bindyi			+																				
Asteraceae	*	*Sonchus oleraceus*	Common Sowthistle	+		+	+			+	+						+				+		+			
Asteraceae	*	*Silybum marianum*																	+							
Asteraceae	*	*Taraxacum officionale*	Dandelion	+																						
Asteraceae		*Vernonia cinerea*									+															
Asteraceae		*Vittadinia cuneata*	Fuzzweed	+	+		+			+	+						+				+		+			+
Brassicaceae	*	*Capsella bursa-pastoris*	Shepherd's Purse																							
Brassicaceae	*	*Lepidium bonariense*																								
Brassicaceae		*Lepidium pseudohyssopifolium*	Peppercress			+	+			+			+		+						+					
Brassicaceae	*	*Lepidium sp.*																								
Cactaceae	*	*Opuntia stricta*	Prickly Pear	+	+	+	+	+			+	+				+						+				
Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell					+	+	+																
Campanulaceae		*Wahlenbergia gracilis*	Sprawling Bluebell		+				+		+		+	+	+		+									+
Campanulaceae		*Wahlenbergia stricta*	Austral Bluebell	+																						
Caryophyllaceae	*	*Cerastium glomeratum*	Mouse-ear Chickweed	+																						
Caryophyllaceae	*	*Petroghagia sp.*				+						+	+	+												
Caryophyllaceae	*	*Silene gallica var. gallica*		+																						

Table E.1 Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area

Family		Species	Common Name	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23
Chenopodiaceae		*Einadia hastata*																								
Chenopodiaceae		*Einadia nutans*									+		+	+		+					+	+				
Chenopodiaceae		*Einadia polygonoides*					1	1	+												+					
Chenopodiaceae		*Einadia trigonos*											+													
Chenopodiaceae		*Enchylaena tomentosa*	Ruby Saltbush	+			+	+		+	1				+	+										
Chenopodiaceae	*	*Sclerolaena birchii*	Galvanised Burr																							
Clusiaceae		*Hypericum gramineum*	Small St. John's Wort						+												+					
Clusiaceae		*Hypericum perforatum*	St. John's Wort															+						+	+	
Convolvulaceae		*Dichondra repens*	Kidney Weed	+	+	+	+	+	+	1	+				+		+	+	+		+	+	+	+	+	+
Crassulaceae		*Crassula sieberiana*	Australian Stonecrop																							
Crassulaceae		*Crassula sp.*				+																				
Euphorbiaceae		*Chamaesyce drummondii*	Caustic Weed			+																	+			
Fabaceae - Faboideae		*Cullen tenax*	Emu Grass										+	+												
Fabaceae - Faboideae		*Desmodium brachypodum*	Large Tick-trefoil	x							+				+											
Fabaceae - Faboideae		*Desmodium varians*	Slender Tick-trefoil	+						+																
Fabaceae - Faboideae	*	*Medicago sp.*	a Burr Medic	1																						
Fabaceae - Faboideae		*Templetonia stenophylla*	Leafy Templetonia			+																				
Fabaceae - Faboideae	*	*Trifolium arvense*					+																			
Fabaceae - Faboideae	*	*Trifolium dubium*	Yellow Suckling Clover			+																				
Fabaceae - Faboideae	*	*Trifolium sp.*															+						+			+
Fabaceae - Faboideae		*Zornia dictiocarpa*	Zornia																							
Gentianaceae	*	*Centaurium sp.*															+							+		
Gentianaceae		*Erodium crinitum*	Blue Storksbill																							
Geraniaceae		*Geranium solanderi*	Native Geranium	x																				+	+	
Goodeniaceae		*Goodenia hederacea*	Forest Goodenia					+		+						+										
Goodeniaceae		*Goodenia sp.*																								+
Goodeniaceae		*Scaevola* sp.	Fan Flower																							
Goodeniaceae		*Velleia paradoxa*	Spur Velleia			+	+																			
Haloragaceae		*Gonocarpus sp.*								+																
Lamiaceae	*	*Marrubium vulgare*	White Horehound							+							+									
Lamiaceae		*Mentha satureioides*	Creeping Mint											+						+	+			+	+	
Lamiaceae		*Scutellaria humilis*																					+			
Malvaceae		*Modiola caroliniana*																								
Malvaceae		*Sida corrugata*				+	+	+		+			+	+	+						+			+		
Malvaceae		*Sida cunninghamii*			+								+	+	+						+		+			
Malvaceae	*	*Sida rhombifolia*	Paddy's Lucerne						+	+	+	+	+	+	+		+		+	1	+					
Myoporaceae		*Eremophila debilis*	Winter Apple		+					+	+				+						+	+				
Myrsinaceae	*	*Anagallis arvensis*	Scarlet/Blue Pimpernel	+		+			+	+	+								+							
Myrtaceae		*Angphora floribunda (seedling)*	Rough-barked Apple												+											
Myrtaceae		*Eucalyptus molucanna (seedling)*	Grey Box		+																					
Nyctaginaceae		*Boerhavia dominii*	Tarvine										+													
Oxalidaceae		*Oxalis exilis*									+		+		+		+	+	+		+					
Oxalidaceae		*Oxalis perennans*																								
Oxalidaceae		*Oxalis sp.*																			+					
Phyllanthaceae		*Phyllanthus virgatus*									+			+							+	+		+		
Plantaginaceae		*Plantago debilis*						+			+						+				1		+	+	+	+
Plantaginaceae		*Plantago gaudichaudii*	Narrow-leaved Plantain			+																		+		
Plantaginaceae	*	*Plantago lanceolata*	Lamb's Tongues			+				+		+					+			+			+	+		
Plantaginaceae		*Veronica plebeia*	Creeping Speedwell	+	+						+															
Polygonaceae		*Asetosella sp.*																					+			
Polygonaceae		*Rumex brownii*	Swamp Dock	+																						
Rosacaea		*Acaena novae-zealandiae*	Biddy Biddy																							+
Rubiaceae		*Asperula conferta*	Common Woodruff		+	+		+		+											1	+	+	+		+

Table E.1 Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area

Family		Species	Common Name	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23
Rubiaceae	*	*Galium propinquum*	Maori Bedstraw	+						+																
Rubiaceae		*Galium sp.*																			+					
Rubiaceae	*	*Richardia stellaris*																				+				
Stackhousiaceae		*Stackhousia monogyna*	Creamy Candles			+																				
Stackhousiaceae		*Stackhousia viminea*	Slender Stackhousia																				+			
Verbenaceae	*	*Verbena sp.*		+							+															
Herbs - Monocots																										
Anthericaceae		*Arthropodium milleflorum*	Pale Vanilla-lily	+	+			+			+			+	+											
Anthericaceae		*Arthropodium sp.*																			+		+			
Anthericaceae		*Dichopogon fimbriatus*	Nodding Chocolate Lily	+	+																					
Anthericaceae		*Laxmannia gracilis*	Slender Wire Lily				+	+																		
Anthericaceae		*Caesia sp.*							+	+																
Commelinaceae		*Commelina cyanea*	Native Wandering Jew											+												
Cyperaceae		*Cyperus gracilis*	Slender Flat-sedge			+	+														+	+				
Cyperaceae		*Carex inversa*							+																	
Cyperaceae		*Scleria sp.*																								
Iridaceae	*	*Romulea rosea*	Onion Grass			+											+	+		1				+		
Juncaceae		*Juncus acutus**																								
Juncaceae		*Juncus (sp. Long)*				+																				
Juncaceae		*Juncus usitatus*			+																					
Lomandraceae		*Lomandra filiformis*	Wattle Mat-rush		1	+	+	+	+		+											+	+	+		
Lomandraceae		*Lomandra glauca*																				+	+	+	+	
Lomandraceae		*Lomandra multiflora*	Many-flowered Mat-rush		+	+		+	+		+						+									
Lomandraceae		*Lomandra longifolia*	Spiny-headed Matt-rush																							
Orchidaceae		*Diuris tricolor*	Painted Diuris						+																	
Phormiaceae		*Dianella longifolia*	Blue Flax-Lily			+				+																
Phormiaceae		*Dianella revoluta*	Blue Flax-Lily		+			+	1																	
Herbs - Grasses																										
Poaceae		*Aristida jerichoensis*	Jericho Wiregrass											3			1		3	1		+		+		1
Poaceae		*Aristida ramosa*	Purple Wiregrass	+	1	2		+	2	2	1	2		2	1			1		2		2	2	3	1	
Poaceae		*Aristida vagans*	Threeawn Speargrass	3	1	2	2		2		+		2													
Poaceae		*Austrodanthonia racemosa*					+																			
Poaceae		*Austrodanthonia fulva*									+					+										
Poaceae		*Austrodanthonia sp.*			+	+	+	+			+												+			
Poaceae		*Austrostipa scabra*	Speargrass					1		+	4					+									2	
Poaceae		*Austrostipa verticillata*	Slender Bamboo Grass	4	1	1			1	2	2	2	3	1	+				+		4		+	+		
Poaceae		*Bothriochloa biloba*	Lobed Blue-grass						+																	
Poaceae		*Bothriochloa decipiens*	Red-leg Grass												1			1	3	1			+		2	
Poaceae		*Bothriochloa macra*	Red-leg Grass	+	+	+	1	+																		
Poaceae	*	*Briza minor*	Shivery Grass			+																				
Poaceae	*	*Bromus molliformis*	Soft Brome							+																
Poaceae		*Chloris divaricata*														+										
Poaceae		*Chloris truncata*	Windmill Grass		+		+	+																		
Poaceae		*Chloris ventricosa*	Plump Windmill Grass	+	+	+	+	+		+	+	+		+	+	+	1	1	1	2	1	+	+		1	1
Poaceae		*Cymbopogon refractus*	Barbwire Grass	+	2			+	1		+	+		+	+			2		1		+	+		2	1
Poaceae		*Cynodon dactylon*	Couch Grass										1				1							1		
Poaceae		*Dichanthium sericeum*	Queensland Bluegrass	x							+						+	1							1	1
Poaceae		*Digitaria sp.*				+															+	+				
Poaceae	*	*Echinochloa crus-galli*	Barnyard Grass									1														
Poaceae		*Elymus scaber*	Common Wheatgrass	+		+		+		+					1		1									1
Poaceae		*Eragrostis brownii*	Brown's Lovegrass				+								1			+	+			+				

Table E.1 Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area

Family		Species	Common Name	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23
Poaceae		*Eragrostis leptostachya*	Paddock Lovegrass		+				+				+	+	+								+			
Poaceae		*Lachnagrostis filiformis (syn. Agrostis avenacea)*				+										+										
Poaceae	*	*Lolium perenne*	Perennial Ryegrass							+																
Poaceae		*Microlaena stipoides*	Weeping Meadow Grass		1	+			+	+												+			1	
Poaceae		*Panicum effusum*	Hairy Panic		+	4	+	+	+	+		+	+	1		+	1		+			+	+		1	
Poaceae		*Paspalidium distans*					+														1					
Poaceae	*	*Paspalum dilatatum*	Paspalum			+													+	3						+
Poaceae		*Paspalum sp.*																1								
Poaceae	*	*Pennisetum clandestinum*	Kikuyu Grass																							
Poaceae		*Poa sieberiana*				+																				
Poaceae	*	*Setaria parviflora*	Pigeon Grass									+														
Poaceae		*Sporobolus creber*	Slender Rat's Tail Grass		+	+						1	+	+	1		3	1	+	2		+				1
Poaceae		*Themeda australis*	Kangaroo Grass					+	1						+				2				+	+		
Poaceae	*	*Vulpia bromoides*	Squirrel Tail Fescue			+																				
Vines/Climbers																										
Nyctaginaceae		Boerhavia dominii																				+				
Commelinaceae		Commelina cyanea	Native Wandering Jew																		+					
Convolvulaceae		*Convolvulus erubescens*	Blushing Bindweed			+	+			+	+				+											
Fabaceae - Faboideae		*Glycine microphylla*	Small-leaf glycine	+																						
Fabaceae - Faboideae		*Glycine tabacina*		+	+	+	+	+	+	+	+		+	+	+				+		+		+		1	+
Fabaceae - Faboideae		*Glycine clandestina*				+	+		+													+				
Luzuriagaceae		*Geitonoplesium cymosum*	Scrambling Lily												+											
Ranunculaceae		*Clematis glycinoides*	Headache Vine												+								+			
Ranunculaceae		*Clematis ? Sp.*																					+			
Herbs - Ferns																										
Adiantaceae		*Cheilanthes distans*	Bristly Cloak Fern																+							
Adiantaceae		*Cheilanthes sieberi*	Poison Rock Fern		+	+						+	+	+	+			+	+				1	+	+	+
Adiantaceae		*Cheilanthes austrotenuifolia*	Rock Fern					+	+																	

Class	Cover-abundance
R	Rare (less than 0.1% cover)
+	Few Individuals (less than 1% cover)
1	Many Individuals (less than 5% cover)
2	5 - less than 25% cover
3	25 - less than 50% cover
4	50 - less than 75% cover
5	75 - 100% cover
x	incidental (adjacent but not within plot
(*)	exotic species; not native to study area

Table E.1 Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area

Family		Species	Common Name	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	RA1	RA2	RA3	RA4	RA5	RA6	RA7
Trees																						
Casuarinaceae		*Allocasuarina littoralis*	Black She-oak																			
Casuarinaceae		*Allocasuarina luehmanii*	Bulloak									3		2								
Casuarinaceae		*Casuarina cunninghamiana*	River Oak								2											
Fabaceae - Mimosoideae		*Acacia salicina*	Cooba																			
Loranthaceae		*Amyema sp.*	a mistletoe																			
Myrtaceae		*Angophora floribunda*	Rough-barked Apple																			
Myrtaceae		*Eucalyptus conica*	Fuzzy Box																			
Myrtaceae		*Eucalyptus dawsonii*	Slaty Gum									2			2							
Myrtaceae		*Eucalyptus melliodora*	Yellow Box																			
Myrtaceae		*Eucalyptus moluccana*	Grey Box																			
Myrtaceae		*Eucalyptus moluccana x albens*	White Box - Grey Box intergrade																			
Myrtaceae		*Euclayptus tereticornis x blakelyi*	Forest Red Gum - Blakely's Red Gum intergrade																			
Sterculiaceae		*Brachychiton populneus*	Kurrajong																			
Shrubs																						
Apocynaceae	*	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush										+									
Asteraceae		*Cassinia quinquefaria*	Cough Bush																			
Asteraceae		*Ozothamnus diosmifolius*	White Dogwood																			
Cactaceae		*Opuntia stricta*	Prickly Pear																			
Casuarinaceae		*Allocasuarina littoralis (imm)*	Black She-oak																			
Casuarinaceae		*Allocasuarina luehmanii (imm)*	Buloak			+								2	1							
Chenopodiaceae		*Atriplex semibaccata*	Creeping Saltbush																			
Chenopodiaceae		*Maireana microphylla*	Small-leaved Bluebush	+	+	+								+	+							
Chloanthaceae		*Spartothamnella juncea*	Bead Bush																			
Fabaceae - Faboideae		*Hardenbergia violacea*	False Sarsparilla																			
Fabaceae - Faboideae		*Templetonia stenophylla*	Leafy Templetonia														X					
Fabaceae - Mimosoideae		*Acacia paradoxa*	Kangaroo Thorn																			
Fabaceae - Mimosoideae		*Acacia salicina*	Cooba											+	+							
Fabaceae - Mimosoideae		*Pultenaea sp.*																				
Myrtaceae		*Angophora floribunda (imm)*	Rough-barked Apple																			
Myrtaceae		*Eucalyptus dawsonii (imm)*	Slaty Gum																			
Myrtaceae		*Eucalyptus moluccana x albens*	White Box - Grey Box intergrade																			
Oleaceae		*Notelaea longifolia*	Large Mock-olive												+							
Oleaceae		*Notelaea microcarpa*																				
Oleaceae		*Notelaea ovata*																				
Pittosporaceae		*Bursaria spinosa*	Blackthorn																			
Pittosporaceae		*Cryptandra amara*	Bitter Cryptandra																			
Rubiaceae		*Psydrax sp. (syn. Canthium sp.)*																				
Rutaceae		*Geijera parviflora*	Wilga Wilga																			
Solanaceae	*	*Lycium ferocissimum*	African Boxthorn											+	+							
Solanaceae		*Solanum brownii*	Violet Nightshade												+	X		X				
Solanaceae		*Solanum cinereum*	Narrawa Burr																			
Solanaceae	*	*Solanum nigrum*	Black-berry Nightshade												+							
Solanaceae	*	*Solanum pseudocapsicum*																				
Solanaceae		*Solanum sp.*							+						+							
Sterculiaceae		*Brachychiton populneus (imm)*	Kurrajong																			
Thymelaceae		*Pimelea curviflora*																				
Thymelaceae		*Pimelea linifolia*	Slender Rice Flower																	X	X	
Thymelaceae		*Pimelea sp.*																				

Table E.1 Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area

Family		Species	Common Name	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	RA1	RA2	RA3	RA4	RA5	RA6	RA7
Herbs - Dicots																						
Acanthaceae		*Brunoniella australis*	Blue Trumpet																			
Acanthaceae		*Rostellularia adscendens*																				
Aizoaceae	*	*Galenia pubescens*	Galenia		+		+	+	+	+		1		2	3							
Amaranthaceae		*Ptilotus semilanatus*																				
Apiaceae	*	*Cyclospermum leptophyllum*					+				+											
Apiaceae		*Daucus glochidiatus*	Native Carrot																			
Asteraceae	*	*Aster subulatus*	Wild Aster	+																		
Asteraceae	*	*Bidens pilosa*	Cobbler's Pegs																			
Asteraceae		*Calotis cuneifolia*	Purple Burr-daisy																			
Asteraceae		*Calotis lappulacea*	Yellow Burr-daisy													X	X					
Asteraceae	*	*Cathamnus lanatus*	Saffron Thistle		+	+	+	+	+	1	+		+									
Asteraceae		*Chrysocephalum apiculatum*	Common Everlasting	+		+				+				+	+	X	X		X			
Asteraceae		*Chrysocephalum semipapposum*																				
Asteraceae		*Chrysocephalum sp?*																				
Asteraceae	*	*Cirsium vulgare*	Spear Thistle	+			+				+			+	+							
Asteraceae	*	*Conyza bonariensis*	Fleabane	+			+		+		+		+	+	1							
Asteraceae		*Cymbonotus lawsonianus*	Bears-ear			+	+							+								
Asteraceae		*Euchiton* sp.																				
Asteraceae	*	*Facelis retusa*				+																
Asteraceae		*Gamochaeta sp.*																				
Asteraceae		*Glossocardia bidens (syn. Glossogyne tannensis)*	Cobblers Tack																			
Asteraceae		*Gnaphalium sp.*		+		+			+	+		+										
Asteraceae	*	*Hypochaeris radicata*	Catsear			+																
Asteraceae		*Lagenophora stipitata*	Blue Bottle-daisy																			
Asteraceae		*Leiocarpa websteri*			+																	
Asteraceae		*Minuria leptophylla*																				
Asteraceae	*	*Onopordum acanthium*	Scotch Thistle	+																		
Asteraceae		*Podolepis jaceoides*	Showy Copper-wire Daisy																			
Asteraceae	*	*Senecio madagascariensis*	Fireweed	+	+	+	+	+	+	+	+		+	+	2							
Asteraceae		*Senecio pinnatifolius*	Variable Groundsel																			
Asteraceae		*Senecio quadridentatus*		+																		
Asteraceae		*Senecio sp.*																				
Asteraceae		*Solenogyne? sp.*																				
Asteraceae	*	*Solvia sessilis (syn. Solvia pterosperma)*	Bindyi						+					+	+							
Asteraceae	*	*Sonchus oleraceus*	Common Sowthistle				+	+	+	+				+	+							
Asteraceae	*	*Silybum marianum*																				
Asteraceae	*	*Taraxacum officionale*	Dandelion							+	+		+	+								
Asteraceae		*Vernonia cinerea*																				
Asteraceae		*Vittadinia cuneata*	Fuzzweed		+	+					+					X	X	X			X	
Brassicaceae	*	*Capsella bursa-pastoris*	Shepherd's Purse												+							
Brassicaceae	*	*Lepidium bonariense*					+					+										
Brassicaceae		*Lepidium pseudohyssopifolium*	Peppercress																			
Brassicaceae	*	*Lepidium sp.*													+							
Cactaceae	*	*Opuntia stricta*	Prickly Pear											+	+							
Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell														X					
Campanulaceae		*Wahlenbergia gracilis*	Sprawling Bluebell																		X	X
Campanulaceae		*Wahlenbergia stricta*	Austral Bluebell																	X	X	
Caryophyllaceae	*	*Cerastium glomeratum*	Mouse-ear Chickweed																			
Caryophyllaceae	*	*Petroghagia sp.*																				
Caryophyllaceae	*	*Silene gallica var. gallica*																				

Table E.1 Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area

Family		Species	Common Name	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	RA1	RA2	RA3	RA4	RA5	RA6	RA7
Chenopodiaceae		*Einadia hastata*																X				X
Chenopodiaceae		*Einadia nutans*									+	+			+	X						
Chenopodiaceae		*Einadia polygonoides*			+										+			X				
Chenopodiaceae		*Einadia trigonos*																				
Chenopodiaceae		*Enchylaena tomentosa*	Ruby Saltbush								+	1		1	1			X				
Chenopodiaceae	*	*Sclerolaena birchii*	Galvanised Burr															X				
Clusiaceae		*Hypericum gramineum*	Small St. John's Wort																			
Clusiaceae		*Hypericum perforatum*	St. John's Wort																			
Convolvulaceae		*Dichondra repens*	Kidney Weed	+	+	+		+						+		X	X	X				
Crassulaceae		*Crassula sieberiana*	Australian Stonecrop															X	X			
Crassulaceae		*Crassula sp.*												+	+						X	
Euphorbiaceae		*Chamaesyce drummondii*	Caustic Weed																			
Fabaceae - Faboideae		*Cullen tenax*	Emu Grass																			
Fabaceae - Faboideae		*Desmodium brachypodum*	Large Tick-trefoil														X				X	
Fabaceae - Faboideae		*Desmodium varians*	Slender Tick-trefoil											+		X	X					X
Fabaceae - Faboideae	*	*Medicago sp.*	a Burr Medic																			
Fabaceae - Faboideae		*Templetonia stenophylla*	Leafy Templetonia																			
Fabaceae - Faboideae	*	*Trifolium arvense*																				
Fabaceae - Faboideae	*	*Trifolium dubium*	Yellow Suckling Clover																			
Fabaceae - Faboideae	*	*Trifolium sp.*			+	+	+	1	1	1	1		+	+									
Fabaceae - Faboideae		*Zornia dictiocarpa*	Zornia								+											
Gentianaceae	*	*Centaurium sp.*							+	+												
Gentianaceae		*Erodium crinitum*	Blue Storksbill											+	+							
Geraniaceae		*Geranium solanderi*	Native Geranium	+			+		+				+	+				X	X			X
Goodeniaceae		*Goodenia hederacea*	Forest Goodenia	+																		
Goodeniaceae		*Goodenia sp.*																				
Goodeniaceae		*Scaevola* sp.	Fan Flower														X					
Goodeniaceae		*Velleia paradoxa*	Spur Velleia																			
Haloragaceae		*Gonocarpus sp.*																				
Lamiaceae	*	*Marrubium vulgare*	White Horehound		1		+															
Lamiaceae		*Mentha satureioides*	Creeping Mint	+	+																	
Lamiaceae		*Scutellaria humilis*																				
Malvaceae		*Modiola caroliniana*					+															
Malvaceae		*Sida corrugata*		+		+					+					X			X			
Malvaceae		*Sida cunninghamii*																				
Malvaceae	*	*Sida rhombifolia*	Paddy's Lucerne			+		+	+	+	+				+							
Myoporaceae		*Eremophila debilis*	Winter Apple													X	X	X				
Myrsinaceae	*	*Anagallis arvensis*	Scarlet/Blue Pimpernel					+						+	+							
Myrtaceae		*Angphora floribunda (seedling)*	Rough-barked Apple																			
Myrtaceae		*Eucalyptus molucanna (seedling)*	Grey Box																			
Nyctaginaceae		*Boerhavia dominii*	Tarvine																			
Oxalidaceae		*Oxalis exilis*			+							+										
Oxalidaceae		*Oxalis perennans*												+		X	X	X	X			
Oxalidaceae		*Oxalis sp.*		+		+	+	+		+			+									
Phyllanthaceae		*Phyllanthus virgatus*														X						
Plantaginaceae		*Plantago debilis*				1											X				X	X
Plantaginaceae		*Plantago gaudichaudii*	Narrow-leaved Plantain				+															
Plantaginaceae	*	*Plantago lanceolata*	Lamb's Tongues				+	2	1	1	1		1	1	1							
Plantaginaceae		*Veronica plebeia*	Creeping Speedwell																			
Polygonaceae		*Asetosella sp.*																				
Polygonaceae		*Rumex brownii*	Swamp Dock								+			+				X				
Rosacaea		*Acaena novae-zealandiae*	Biddy Biddy																			
Rubiaceae		*Asperula conferta*	Common Woodruff		+	+	+							+		X					X	

Table E.1 Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area

Family		Species	Common Name	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	RA1	RA2	RA3	RA4	RA5	RA6	RA7
Rubiaceae	*	*Galium propinquum*	Maori Bedstraw																			
Rubiaceae		*Galium sp.*																				
Rubiaceae	*	*Richardia stellaris*												+								
Stackhousiaceae		*Stackhousia monogyna*	Creamy Candles																			
Stackhousiaceae		*Stackhousia viminea*	Slender Stackhousia			+										X	X		X			
Verbenaceae	*	*Verbena sp.*					+							+								
Herbs - Monocots																						
Anthericaceae		*Arthropodium milleflorum*	Pale Vanilla-lily																		X	
Anthericaceae		*Arthropodium sp.*																				
Anthericaceae		*Dichopogon fimbriatus*	Nodding Chocolate Lily																			
Anthericaceae		*Laxmannia gracilis*	Slender Wire Lily																			
Anthericaceae		*Caesia sp.*																				
Commelinaceae		*Commelina cyanea*	Native Wandering Jew																			
Cyperaceae		*Cyperus gracilis*	Slender Flat-sedge																			X
Cyperaceae		*Carex inversa*																X				
Cyperaceae		*Scleria sp.*															X					
Iridaceae	*	*Romulea rosea*	Onion Grass	+			1	+		+			+	2	1							
Juncaceae		*Juncus acutus**									3											
Juncaceae		*Juncus (sp. Long)*																				
Juncaceae		*Juncus usitatus*																				
Lomandraceae		*Lomandra filiformis*	Wattle Mat-rush	+										+		X		X	X			
Lomandraceae		*Lomandra glauca*																				
Lomandraceae		*Lomandra multiflora*	Many-flowered Mat-rush											+								
Lomandraceae		*Lomandra longifolia*	Spiny-headed Matt-rush										1									
Orchidaceae		*Diuris tricolor*	Painted Diuris																			
Phormiaceae		*Dianella longifolia*	Blue Flax-Lily											+		X						
Phormiaceae		*Dianella revoluta*	Blue Flax-Lily																			
Herbs - Grasses																						
Poaceae		*Aristida jerichoensis*	Jericho Wiregrass	2		1	2						2									
Poaceae		*Aristida ramosa*	Purple Wiregrass		+	1	1		1		1			1	1						X	
Poaceae		*Aristida vagans*	Threeawn Speargrass																			
Poaceae		*Austrodanthonia racemosa*																				
Poaceae		*Austrodanthonia fulva*		+	+	1																
Poaceae		*Austrodanthonia sp.*													+							
Poaceae		*Austrostipa scabra*	Speargrass									1		3	2							
Poaceae		*Austrostipa verticillata*	Slender Bamboo Grass	2							+			3	2						X	X
Poaceae		*Bothriochloa biloba*	Lobed Blue-grass																			
Poaceae		*Bothriochloa decipiens*	Red-leg Grass			1	1	2	2	2				+	+							
Poaceae		*Bothriochloa macra*	Red-leg Grass																			
Poaceae	*	*Briza minor*	Shivery Grass																			
Poaceae	*	*Bromus molliformis*	Soft Brome												+							
Poaceae		*Chloris divaricata*																				
Poaceae		*Chloris truncata*	Windmill Grass	+	+																	
Poaceae		*Chloris ventricosa*	Plump Windmill Grass				+								+							
Poaceae		*Cymbopogon refractus*	Barbwire Grass																			
Poaceae		*Cynodon dactylon*	Couch Grass						2	1	4	1	2									
Poaceae		*Dichanthium sericeum*	Queensland Bluegrass		+	1																
Poaceae		*Digitaria sp.*										1										
Poaceae	*	*Echinochloa crus-galli*	Barnyard Grass																			
Poaceae		*Elymus scaber*	Common Wheatgrass				1	4	1	2		2										
Poaceae		*Eragrostis brownii*	Brown's Lovegrass									1										

Table E.1 Dataset for Flora Quadrats and Rapid Assessment Plots collected from the Study Area

Family		Species	Common Name	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	RA1	RA2	RA3	RA4	RA5	RA6	RA7
Poaceae		*Eragrostis leptostachya*	Paddock Lovegrass																			
Poaceae		*Lachnagrostis filiformis (syn. Agrostis avenacea)*																				
Poaceae	*	*Lolium perenne*	Perennial Ryegrass												2							X
Poaceae		*Microlaena stipoides*	Weeping Meadow Grass							+				+								
Poaceae		*Panicum effusum*	Hairy Panic			+		+														
Poaceae		*Paspalidium distans*																				
Poaceae	*	*Paspalum dilatatum*	Paspalum					+														
Poaceae		*Paspalum sp.*				1																
Poaceae	*	*Pennisetum clandestinum*	Kikuyu Grass											2								
Poaceae		*Poa sieberiana*																				
Poaceae	*	*Setaria parviflora*	Pigeon Grass																			
Poaceae		*Sporobolus creber*	Slender Rat's Tail Grass				+	+	1		1	2		+	+						X	
Poaceae		*Themeda australis*	Kangaroo Grass																			
Poaceae	*	*Vulpia bromoides*	Squirrel Tail Fescue																			
Vines/Climbers																						
Nyctaginaceae		Boerhavia dominii																				
Commelinaceae		Commelina cyanea	Native Wandering Jew																			
Convolvulaceae		*Convolvulus erubescens*	Blushing Bindweed																			
Fabaceae - Faboideae		*Glycine microphylla*	Small-leaf glycine																			
Fabaceae - Faboideae		*Glycine tabacina*				+										X	X					
Fabaceae - Faboideae		*Glycine clandestina*												+		X	X					
Luzuriagaceae		*Geitonoplesium cymosum*	Scrambling Lily																			
Ranunculaceae		*Clematis glycinoides*	Headache Vine																			
Ranunculaceae		*Clematis ? Sp.*																				
Herbs - Ferns																						
Adiantaceae		*Cheilanthes distans*	Bristly Cloak Fern	+																		
Adiantaceae		*Cheilanthes sieberi*	Poison Rock Fern	+		+			1	+		+		+	+				X	X	X	X
Adiantaceae		*Cheilanthes austrotenuifolia*	Rock Fern																			

Class	Cover-abundance
R	Rare (less than 0.1% cover)
+	Few Individuals (less than 1% cover)
1	Many Individuals (less than 5% cover)
2	5 - less than 25% cover
3	25 - less than 50% cover
4	50 - less than 75% cover
5	75 - 100% cover
x	incidental (adjacent but not within plot
(*)	exotic species; not native to study area

Appendix F

Fauna Species Recorded in the Study Area

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Amphibia							
Hylidae	*Litoria caerulea*	Green Tree Frog			X		
Hylidae	*Litoria fallax*	Eastern Dwarf Tree Frog			X		
Hylidae	*Litoria latopalmata*	Broad-palmed Frog			X		
Hylidae	*Litoria peronii*	Peron's Tree Frog			X		
Myobatrachidae	*Crinia signifera*	Common Eastern Froglet				X	X
Myobatrachidae	*Limnodynastes ornatus*	Ornate Burrowing Frog			X		
Myobatrachidae	*Limnodynastes tasmaniensis*	Spotted Grass Frog			X		
Myobatrachidae	*Uperoleia tyleri*	Tyler's Toadlet			X		
Aves							
Acanthizidae	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill			X	X	X
Acanthizidae	*Acanthiza lineata*	Striated Thornbill					X
Acanthizidae	*Acanthiza nana*	Yellow Thornbill			X	X	X
Acanthizidae	*Acanthiza reguloides*	Buff-rumped Thornbill			X	X	X
Acanthizidae	*Gerygone fusca*	Western Gerygone			X	X	
Acanthizidae	*Gerygone mouki*	Brown Gerygone					X

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Acanthizidae	*Gerygone olivacea*	White-throated Gerygone				X	
Acanthizidae	*Pyrrholaemus saggitatus*	Speckled Warbler	V		X	X	X
Acanthizidae	*Smicrornis brevirostris*	Weebill			X	X	X
Accipitridae	*Accipiter fasciatus*	Brown Goshawk			X	X	X
Accipitridae	*Aquila audax*	Wedge-tailed Eagle			X	X	X
Accipitridae	*Circus assimilis*	Spotted Harrier	V			X	
Accipitridae	*Elanus axillaris*	Black-shouldered Kite			X	X	
Accipitridae	*Hieraaetus morphinoides*	Little Eagle	V				X
Accipitridae	*Milvus sphenurus*	Whistling Kite				X	
Aegothelidae	*Aegotheles cristatus*	Australian Owlet-nightjar			X		X
Alcedinidae	*Dacelo novaeguineae*	Laughing Kookaburra			X	X	X
Alcedinidae	*Todiramphus sanctus*	Sacred Kingfisher			X	X	
Anatidae	*Anas gracilis*	Grey Teal			X	X	
Anatidae	*Anas superciliosa*	Pacific Black Duck			X		X
Anatidae	*Aythya australis*	Hardhead				X	
Anatidae	*Chenonetta jubata*	Australian Wood Duck			X		X
Anatidae	*Cygnus atratus*	Black Swan					X

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Anatidae	*Dendrocygna eytoni*	Plumed Whistling-Duck			X		
Apodidae	*Hirundapus caudacutus*	White-throated Needletail		Mi	X		
Ardeidae	*Egretta novaehollandiae*	White-faced Heron			X		
Artamidae	*Artamus cyanopterus*	Dusky Woodswallow			X	X	
Artamidae	*Artamus personatus*	Masked Woodswallow				X	
Artamidae	*Artamus superciliosus*	White-browed Woodswallow				X	
Artamidae	*Cracticus nigrogularis*	Pied Butcherbird			X	X	X
Artamidae	*Cracticus torquatus*	Grey Butcherbird			X		X
Artamidae	*Gymnorhina tibicen*	Australian Magpie			X	X	X
Artamidae	*Strepera graculina*	Pied Currawong			X	X	X
Cacatuidae	*Cacatua galerita*	Sulphur-crested Cockatoo			X	X	X
Cacatuidae	*Eolophus roseicapillus*	Galah			X	X	X
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike			X	X	X
Charadriidae	*Vanellus miles*	Masked Lapwing				X	X
Cisticolidae	*Cisticola exilis*	Golden-headed Cisticola				X	
Climacteridae	*Cormobates leucophaea*	White-throated Treecreeper				X	
Climacteridae	*Climacteris picumnus victoriae*	Brown Treecreeper	V		X		X

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Columbidae	*Ocyphaps lophotes*	Crested Pigeon			X	X	X
Columbidae	*Phaps chalcoptera*	Common Bronzewing			X		X
Coraciidae	*Eurystomus orientalis*	Dollarbird				X	
Corcoracidae	*Corcorax melanorhamphos*	White-winged Chough			X	X	X
Corvidae	*Corvus coronoides*	Australian Raven			X	X	X
Corvidae	*Corvus mellori*	Little Raven				X	
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed Cuckoo			X	X	
Cuculidae	*Chalcites basalis*	Horsfield's Bronze-Cuckoo			X	X	
Cuculidae	*Chalcites lucidus*	Shining Bronze-Cuckoo				X	
Cuculidae	*Chalcites osculans*	Black-eared Cuckoo			X		
Cuculidae	*Cuculus pallidus*	Pallid Cuckoo				X	
Cuculidae	*Eudynamys orientalis*	Pacific Koel				X	
Dicaeidae	*Dicaeum hirundinaceum*	Mistletoebird			X		X
Dicruridae	*Grallina cyanoleuca*	Magpie-lark			X	X	X
Dicruridae	*Myiagra inquieta*	Restless Flycatcher			X		
Dicruridae	*Rhipidura albiscapa*	Grey Fantail			X	X	X
Dicruridae	*Rhipidura leucophrys*	Willie Wagtail			X	X	X

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Dicruridae	*Rhipidura rufifrons*	Rufous Fantail			X		
Estrildidae	*Neochmia temporalis*	Red-browed Finch			X		X
Estrildidae	*Stagonopleura guttata*	Diamond Firetail	V		X		X
Estrildidae	*Taeniopygia bichenovii*	Double-barred Finch			X	X	X
Estrildidae	*Taeniopygia guttata*	Zebra Finch			X		
Falconidae	*Falco berigora*	Brown Falcon			X	X	X
Falconidae	*Falco cenchroides*	Nankeen Kestrel			X	X	X
Falconidae	*Falco longipennis*	Australian Hobby			X		X
Falconidae	*Falco subniger*	Black Falcon			X		
Hirundinidae	*Hirundo neoxena*	Welcome Swallow				X	X
Hirundinidae	*Hirundo nigricans*	Tree Martin					X
Hirundinidae	*Petrochelidon ariel*	Fairy Martin			X	X	
Maluridae	*Malurus cyaneus*	Superb Fairy-wren			X	X	X
Maluridae	*Malurus lamberti*	Variegated Fairy-wren			X		
Meliphagidae	*Anthochaera carunculata*	Red Wattlebird				X	
Meliphagidae	*Lichenostomus chrysops*	Yellow-faced Honeyeater				X	X
Meliphagidae	*Lichenostomus penicillatus*	White-plumed Honeyeater			X		X

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Meliphagidae	*Lichenostomus virescens*	Singing Honeyeater					
Meliphagidae	*Manorina melanocephala*	Noisy Miner			X	X	X
Meliphagidae	*Melithreptus brevirostris*	Brown-headed Honeyeater					X
Meliphagidae	*Melithreptus gularis gularis*	Black-chinned Honeyeater	V		X		
Meliphagidae	*Myzomela sanguinolenta*	Scarlet Honeyeater					X
Meliphagidae	*Philemon citreogularis*	Little Friarbird			X		
Meliphagidae	*Philemon corniculatus*	Noisy Friarbird				X	X
Meliphagidae	*Plectorhyncha lanceolata*	Striped Honeyeater					X
Meropidae	*Merops ornatus*	Rainbow Bee-eater		Mi	X	X	
Motacillidae	*Anthus australis*	Australian Pipit			X	X	X
Oriolidae	*Oriolus sagittatus*	Olive-backed Oriole				X	
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush			X		X
Pachycephalidae	*Pachycephala pectoralis*	Golden Whistler					X
Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler			X	X	X
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote				X	X
Pardalotidae	*Pardalotus striatus*	Striated Pardalote			X	X	X
Petroicidae	*Eopsaltria australis*	Eastern Yellow Robin			X		

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Petroicidae	*Melanodryas cucullata*	Hooded Robin	V		X		
Petroicidae	*Microeca fascinans*	Jacky Winter			X		X
Petroicidae	*Petroica boodang*	Scarlet Robin	V			X	X
Petroicidae	*Petroica rosea*	Rose Robin					X
Petroicidae	*Petroica goodenovii*	Red-capped Robin			X	X	X
Phasianidae	*Coturnix pectoralis*	Stubble Quail			X		
Phasianidae	*Coturnix ypsilophora*	Brown Quail			X		X
Podargidae	*Podargus strigoides*	Tawny Frogmouth			X		
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe			X	X	X
Pomatostomidae	*Pomatostomus temporalis temporalis*	Grey-crowned Babbler	V		X	X	X
Psittacidae	*Alisterus scapularis*	Australian King-Parrot					X
Psittacidae	*Glossopsitta cocinna*	Musk Lorikeet					X
Psittacidae	*Glossopsitta spp.*				X		
Psittacidae	*Lathamus discolor*	Swift Parrot	E	E; Ma			X
Psittacidae	*Platycercus adscitus eximius*	Eastern Rosella			X	X	X
Psittacidae	*Psephotus haematonotus*	Red-rumped Parrot					X
Psittacidae	*Psephotus varius*	Mulga Parrot			X		

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Strigidae	*Ninox boobook*	Southern Boobook					X
Strigidae	*Ninox connivens*	Barking Owl	V		X		
Sturnidae	*Acridotheres tristis**	Common Myna				X	
Sturnidae	*Sturnus vulgaris**	Common Starling			X	X	X
Sylviidae	*Cincloramphus cruralis*	Brown Songlark				X	
Turnicidae	*Turnix varia*	Painted Button-quail			X		
Tytonidae	*Tyto alba*	Barn Owl				X	
Zosteropidae	*Zosterops lateralis*	Silvereye			X		X
Mammalia							
Bovidae	*Bos taurus**	European cattle				X	X
Bovidae	*Ovis aries**	Sheep				X	
Canidae	*Canis lupus familiaris**	Dog			X		
Canidae	*Vulpes vulpes**	Fox			X		X
Dasyuridae	*Sminthopsis murina*	Common Dunnart					X
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	V				X
Equidae	*Equus caballus**	Horse				X	
Leporidae	*Lepus capensis**	Brown Hare			X	X	X

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Leporidae	*Oryctolagus cuniculus**	Rabbit			X	X	X
Macropodidae	*Macropus giganteus*	Eastern Grey Kangaroo			X	X	X
Macropodidae	*Macropus robustus*	Common Wallaroo			X		
Macropodidae	*Macropus rufogriseus*	Red-necked Wallaby				X	X
Molossidae	*Austronomus australis*	White-striped Freetail-bat			X		X
Molossidae	*Mormopterus ("Species 1")*	A Freetail-bat			X		
Molossidae	*Mormopterus norfolkensis*	Eastern Freetail-bat	V		X		X
Molossidae	*Mormopterus planiceps*	Little Mastiff-bat			X		
Molossidae	*Mormopterus ridei ("Species 2")*	Eastern Freetail-bat					X
Molossidae	*Mormopterus ("Species 4")*	Eastern Freetail-bat					X
Muridae	*Mus musculus**	House Mouse			X		X
Muridae	*Rattus rattus**	Black Rat			X		
Phalangeridae	*Trichosurus vulpecula*	Common Brushtail Possum			X		X
Phascolarctidae	*Phascolarctos cinereus*	Koala	V	V	X		
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna			X		
Vespertilionidae	*Chalinolobus dwyeri*	Large-eared Pied Bat	V	V			X
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat			X		X

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Vespertilionidae	*Chalinolobus morio*	Chocolate Wattled Bat			X		X
Vespertilionidae	*Miniopterus orianae oceanensis*	Eastern Bentwing-bat	V		X		X
Vespertilionidae	*Myotis macropus*	Southern Myotis	V		X		?
Vespertilionidae	*Nyctophilus geoffroyi*	Lesser Long-eared Bat			X		
Vespertilionidae	*Nyctophilus spp.*	Long-eared bat					?
Vespertilionidae	*Nyctophilus corbeni*	Greater Long-eared Bat	V	V	X		
Vespertilionidae	*Scoteanax rueppellii*	Greater Broad-nosed Bat	V		X		
Vespertilionidae	*Scotorepens balstoni*	Inland Broad-nosed Bat			X		?
Vespertilionidae	*Scotorepens greyii*	Little Broad-nosed Bat					?
Vespertilionidae	*Vespadelus darlingtoni*	Large Forest Bat			X		X
Vespertilionidae	*Vespadelus sp.*	Forest Bat					?
Vespertilionidae	*Vespadelus troughtoni*	Eastern Cave Bat	V				?
Vespertilionidae	*Vespadelus vulturnus*	Little Forest Bat			X		?
Vombatidae	*Vombatus ursinus*	Common Wombat			X		
Reptilia							
Agamidae	*Pogona barbata*	Bearded Dragon			X	X	
Chelidae	*Chelodina longicollis*	Eastern Snake-necked Turtle			X		

Table F.1 Fauna Species Recorded in the Study Area

Family	Scientific Name	Common Name	Legal Status		Ecological Study		
			TSC Act	EPBC Act	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)
Elapidae	*Pseudechis porphyriacus*	Red-bellied Black Snake			X		X
Elapidae	*Pseudonaja textilis*	Eastern Brown Snake			X		
Gekkonidae	*Diplodactylus vittatus*	Wood Gecko			X		X
Gekkonidae	*Oedura robusta*	Robust Velvet Gecko			X		
Scincidae	*Carlia tetradactyla*	Southern Rainbow-skink			X		
Scincidae	*Cryptoblepharus virgatus*	Cream-striped Shinning-skink			X		
Scincidae	*Ctenotus robustus*	Robust Ctenotus			X		
Scincidae	*Egernia modesta*	Eastern Ranges Rock-skink			X		
Scincidae	*Egernia striolata*	Tree Skink			X		X
Scincidae	*Morethia boulengeri*	South eastern Morethia Skink			X		
Varanidae	*Varanus varius*	Lace Monitor			X	X	X

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

** denotes an introduced species*

Appendix G

Likelihood of Occurrence - Threatened Flora Species

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
Cynanchum elegans	White-flowered Wax Plant	E	E1	1 / 9	Restricted to eastern NSW as far west as Merriwa in the Hunter Valley. Climber or twiner found on the edge of dry rainforest communities. Also associated with littoral rainforest, Coastal Tea-tree - Coastal Banskia scrub, Forest Red Gum open forest and woodland, Spotted Gum open forest and woodland and Bracelet Honeymyrtle scrub. Unlikely that a soil seed bank exists.	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Olearia cordata		V	V	0 / 11	Occurs in dry open sclerophyll forest and open shrubland on sandstone ridges.	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Ozothamnus tesselatus		V	V	2 / 1	Grows in eucalypt woodland., restricted to a few sites north of Rylstone	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Senecio linearifolius var. dangarensis		-	E1	2 / -	Restricted to a single known population in Goulburn River National Park where it occurs on an open scree slope in woodland and rainforest	Unlikely to occur. Not detected in previous flora surveys. No suitable

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
					communities on basalt soils. Population estimated to contain 500- 1000 individuals in an area of over 20 ha.	habitat available.
Kennedia retrorsa		V	V	17 / -	Restricted to Mont Dangar area and Goulburn River catchment within Muswellbrook and Merriwa LGAs. Climbing perennial herb found in a variety of habitats from mountain sides to riparian zones, sheltered forest to exposed ridgelines. Seeds locally dispersed and accumulate in surrounding soil.	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Acacia dangarensis		-	E1	2 / -	Restricted to the summit and surrounding slopes of Mount Dangar south of Merriwa, within Goulburn River National Park. Small tree to 10m that occurs in pure stands or as a co-dominant tree in sclerophyll woodland on the edge of dry rainforest on basalt and basalt colluvium. Total population size estimated to be approximately 1750 individuals over 70 ha. No other known locations.	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Acacia flocktoniae		V	V	0	Found only in southern Blue Mountains in dry sclerophyll forest on sandstone.	Unlikely to occur. Not detected in previous flora surveys. No suitable

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
						habitat available.
Acacia pendula	Acacia pendula population in the Hunter catchment	V	E2	10 / 19	Restricted to 6 known locations (1000 individuals) within the Muswellbrook and Singleton LGAs. Hunter population is disjunct and at the at the eastern limit of the species' distributional range. Occur on heavy soils on margins of small floodplains but also in more undulating locations.	Presence confirmed. Individuals recorded from previous surveys. Also known from two locations in MAC mine lease. The individuals do not conform to the listing for EPBC Weeping Myall Woodland, however there is potential for the community to occur within the Study Area.
Prostanthera cryptandroides subsp. cryptandroides	Wollemi Mint-bush	V	V	12 / -	Broad but restricted distribution. In NSW, known from Sandy Hollow, Lithgow, Wollemi NP and Goulburn NP areas. Occurs in dry sclerophyll and open forest dominated by E. fibrosa, often in rocky sites. In the Denman area, occurs on Narrabeen Group sandstones. Recruitment from seed bank.	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Prostanthera discolor		V	V	1 / -	Restricted to a few localities from Bylong to Baerami Valley within Muswellbrook and	Unlikely to occur. Not detected in previous flora

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
					Rylstone LGAs. Grows in dry sclerophyll forest in the side gullies of main creeklines. On well-drained alluvial soils or rocky substrates. Recruitment from soil seed bank.	surveys. No suitable habitat available.
Prostanthera stricta	Mount Vincent Mintbush	V	V	9 / -	Restricted to areas of the central tablelands and central western slopes of NSW. Shrub to 2m that grows in areas of skeletal soils or deeper well-drained soils on steep rocky sideslopes, cliff lines, sandstone platforms or gentle slopes with sandstone outcropping. Often locally dominant understorey species. Recruitment from soil seed bank.	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Baeckea kandos		-	E1	1 / -	Restricted geographic range in Kandos area; known from a single population in Wollemi National Park comprised of less than 100 individuals. Shrub to 2m that grows in heath on sandstone.	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Darwinia peduncularis		-	V	1 / 4	Known from locally disjunct populations in coastal NSW and the Blue Mountains. Spreading shrub that grows on or near rocky outcrops on sandy, well-drained, low nutrient soil over sandstone. May resprout after disturbance.	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
Eucalyptus camaldulensis	Eucalyptus camaldulensis population in the Hunter catchment	-	E2	107 / 507	River Red Gums are the most widespread eucalypt in Australia. In NSW, occurs along western-flowing rivers. Hunter population is the only known coastal catchment and occurs on the major floodplains of the Hunter and Goulburn rivers. Currently restricted to 19 known stands in small remnants occupying a total of 100 ha and comprising 600-1000 mature and semi-mature individuals. Regeneration is limited due to hydrology, cropping, clearing and grazing pressures.	Presence confirmed. One mature individual was recorded along Saddlers Creek and others are considered likely to occur.
Eucalyptus corticosa	Creswick Apple Box	-	V	1 / -	Restricted but locally frequent to a small area near Mount Coricudgy in the Rylstone area on the Central Tablelands. Tree to 20m that grows in sclerophyll woodland on shallow infertile soils on sandstone ridges and low slope erosional terraces associated with the upper reaches of the Cudgegong River. Restricted to a small area	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Eucalyptus nicholii	Narrow-leaved Black Peppermint	V	V	1 / -	Restricted, and uncommon, to the New England Tablelands; also a widely planted urban street tree. Tree to 20m that grows in dry grassy or sclerophyll woodland, on shallow and infertile	Presence confirmed. The individuals recorded on site have been planted as a visual screen along

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
					soils, mainly on shales and granite.	Edderton Road and as they are not locally endemic or of local provenance stock, are not considered to be eligible for legislative listing.
Homoranthus darwinioides		V	V	1 / -	Restricted to the central tablelands and western slopes of NSW, including west of Muswellbrook between Merriwa and Bylong. Localised distribution ranges from rare to locally abundant. Shrub to 1m grows in woodland habitats with shrubby understoreys, usually in gravely sandy soils.	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Cymbidium canaliculatum	Cymbidium canaliculatum in the Hunter Catchment	V	E2	11 / 3	Hunter catchment population is at the south eastern limit of the species' geographic range and significant as it is one of the few epiphytic orchids occurring at temperate latitudes. Population estimated between 90-500 individuals. Large epiphytic orchid that grows in tree hollows, particularly White Box, in dry sclerophyll forests and woodlands.	Presence confirmed. Recorded from surveys of the Study Area. Also known from two locations in MAC mine lease.
Diuris pedunculata	Small Snake Orchid	E	E1	1 / -	Grows on grassy slopes or flats, often on peaty	Unlikely to occur. Not

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
					soils in moist areas. Now mainly found on the New England Tablelands, around Armidale, Uralla, Guyra and Ebor	detected in flora surveys. No suitable habitat available.
Diuris tricolor	Diuris tricolor Fitzg., the Pine Donkey Orchid, in the Muswellbrook local government area	-	E2	13 / -	Found in sclerophyll vegetation on flats or small rises, on a range of substrates including sandy or loamy soils derived from granite, porphyry, laterite or alluvium.	Presence confirmed. Recorded from surveys of the Study Area. Also known from the MAC mine lease.
Prasophyllum sp. Wybong		Critically Endangered	-	-	Endemic to NSW; known from seven populations near eastern NSW near Ilford, Premer, Muswellbrook, Wybong, Yeoval, Inverell and Tenterfield, with an area of occupancy estimated at 1.5 km². The populations are separated by large areas of cleared land, making cross pollination and genetic exchange highly unlikely. Terrestrial, perennial orchids to 30cm that grow in shrubby and grassy habitat on wet soils, as well as in open eucalypt woodland and grassland. Flower in spring and die back to a tuber over summer and autumn.	Low potential to occur. Not detected in flora surveys. Suitable habitat available in the Study Area; however outside of the 7 known populations.
Pterostylis gibbosa	Illawarra Greenhood	E	E	0 / 8	Current distribution across 5 locations; three sites in the Illawarra, one site in the Hunter Valley at	Unlikely to occur. Not detected in flora surveys,

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
					Milbrodale, and one site near Nowra in the Shoalhaven. Habitat preference is variable; Hunter population near Mibrodale comprises up to 2000 individuals growing in open woodland dominated by Box-Ironbarks on flat or gently sloping landscapes at 160m altitude. Soils derived from Narrabeen Group are leached and acidic with clay subsoil that impedes drainage.	and outside of known range in the Hunter.
Pterostylis nigricans	Dark Greenhood	-	V	1	Grows in coastal scrub and heath; north from Evans Head.	Unlikely to occur. Not detected in flora surveys. No suitable habitat available.
Bothriochloa biloba	Lobed Blue-grass	V	-	0 / -	Broad distribution in northern NSW; majority of records from the northern portions of the Brigalow Belt South and Nandewar bioregions. Perennial grass that grows on heavier textured soils such as brown or black clay soils. Found in cleared eucalypt forests and relict grassland; also known from the community 'White Box Yellow Box Blakely's Red Gum Woodland'. More prevalent in areas that are moderately disturbed or conservatively grazed e.g. on roadsides, paddocks and travelling stock routes.	Presence confirmed. Recorded from surveys of the Study Area. Also known from the MAC mine lease.

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
Digitaria porrecta	Finger Panic Grass	E	E	0 / -	Known from 4 disjunct locations extending over 1000km; total population estimated at 200,000 individuals. In NSW, found on North West Slopes and Plains. Perennial grass to 60cm that grows in grassland, woodlands or open forest on richer basaltic soils. Often found in disturbed habitats including roadsides, fallow paddocks and travelling stock routes where there is light grazing and occasional fire.	Unlikely to occur. Not detected in surveys. Not previously known from the Muswellbrook or Singleton LGAs.
Grevillea evansiana		V	V	0 / 7	Occurs in dry sclerophyll forest or woodland, or occasionally swampy heath, usually over Hawkesbury Sandstone.	Unlikely to occur. Not detected in flora surveys. No suitable habitat available.
Pomaderris bodalla	Bodalla Pomaderris	-	V	1 / -	Occurs in open forest or woodland on open slopes.	Unlikely to occur. Not detected in flora surveys. No suitable habitat available.
Pomaderris queenslandica	Scant Pomaderris	-	E1	9 / 1	Occurs in moist eucalypt forest or sheltered woodlands with a shrubby understorey, occasionally along creeks.	Unlikely to occur. Not detected in previous flora surveys. No suitable habitat available.
Pomaderris reperta	Denman Pomaderris	Critically	E1	8 / -	Very restricted area of occupation. Prefers	Unlikely to occur. Not

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
		Endangered			woodland in association with Eucalyptus crebra, E. blakelyi, Notelaea microcarpa, and Allocasuarina littoralis. Associated soil is a sandy loam on sandstone or conglomerate.	detected in flora surveys. No suitable habitat available.
Thesium australe	Austral Toadflax, Toadflax	V	V	0 / -	Scattered distribution as small populations across eastern NSW from the coast to the Northern and Southern Tablelands. Small, perennial herb to 40cm that grows in grassland or grassy woodland, often in association with Kangaroo Grass (Themeda australis) in damp sites. Root parasite that takes water and some nutrient from other plants, especially Kangaroo Grass.	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

Table G.1 Likelihood of Occurrence of Potential Threatened Flora Species

Scientific Name	Common Name	EPBC Status	TSC Status	LGA Count	Habitat Requirements	Likelihood of Occurrence
						within the Upper Hunter Valley.
Derwentia blakelyi		-	V	1 / -	Restricted to the western Blue Mountains, near Clarence, near Mt Horrible, on Nullo Mountain and in the Coricudgy Range. Occurs in eucalypt forest, often in moist areas.	Unlikely to occur. Not detected in flora surveys. No suitable habitat available.
Commersonia rosea	Sandy Hollow Commersonia	E	E1	7 / -	Known only from four locations within an 8km radius of Sandy Hollow, occurs on skeletal sandy soils in scrub or heath communities.	Unlikely to occur. Not detected in flora surveys. No suitable habitat available.
Lasiopetalum longistamineum		V	V	10 / -	Grows on rich alluvial deposits in the Gungal-Mt Dangar area.	Unlikely to occur. Not detected in flora surveys. No suitable habitat available.

Appendix H

Likelihood of Occurrence - Threatened Fauna Species

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
Amphibia							
Hylidae	*Litoria aurea*	Green and Golden Bell Frog	V	E1	2 / 5	Restricted across much of former distribution along NSW coast to approximately 50 widely separated and isolated populations. Inhabit disturbed sites including abandoned mines, grassy habitats and fringing aquatic vegetation. Marshes, dams and stream sides, particularly those containing bullrushes or spikerushes. Unshaded water bodies free of Gambusia (mosquito fish) form optimum habitat. Vegetation and/or rocks needed for shelter. Species breeds in still, shallow, ephemeral ponds.	Unlikely to occur. Not detected in fauna surveys of the Study Area. Some suitable summer habitat is available along sections of Saddlers Creek, however there is no suitable winter shelter habitat.
	Litoria booroolongensis	Booroolong Frog	E1	E1	- / 1	Distribution restricted to the tabelands and slopes to 1300m in eastern NSW; predominantly along western-flowing streams of the Great Dividing Range. Inhabits rocky, western-flowing creeks and permanent streams with some fringing vegetation cover such as ferns, sedges or grasses in both forested areas and open pasture. Found on	Unlikely to occur. No suitable habitat available.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						or under rocks and debris of suitable streams.	
	Litoria littlejohni	Littlejohn's Tree Frog, Heath Frog	V	V	- / 1	Permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops.	Unlikely to occur. No suitable habitat available.
Myobatrachidae	*Heleioporus australiacus*	Giant Burrowing Frog	V	V	3 / 10	Distributed in south eastern NSW and Victoria as two distinct populations. Northern population confined to Sydney Basin sandstone geology. Inhabits heath, woodland and open forest with sandy soils. Generally lives in the heath or forest and will travel several hundred metres to creeks to breed. Burrows into deep litter or loose soil, emerging to feed or breed after rain.	Unlikely to occur. No suitable habitat available.
	Mixophyes balbus	Stuttering Frog	-	E1	1 / 10	Distributed in the foothills and escarpment on the eastern side of the Great Dividing Range. Inhabits rainforest and wet, tall open forest. Requires freshwater streams and undisturbed riparian vegetation for habitation and breeding. Hunter Valley separates the northern and southern portions of the species' range.	Unlikely to occur. No suitable habitat available.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
	Pseudophryne australis	Red-crowned Toadlet	-	V	17	Restricted distribution on Hawkesbury and Narrabeen Sandstones of the Sydney Basin Bioregion. Inhabits open forest and periodically wet drainage lines below sandstone ridges that often have shale lenses or cappings. Shelters under rocks and amongst masses of dense vegetation or thick piles of leaf litter.	Unlikely to occur. No suitable habitat available.
Aves							
Acanthizidae	*Pyrrholaemus saggitatus*	Speckled Warbler	-	V	113 / 130	Patchy distribution in south east Australia; frequently recorded from hills and tablelands of Great Dividing Range and rarely from the coast. Inhabit a wide range of eucalypt-dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy. Large, relatively undisturbed remnants required for species to persist in an area. Sedentary with non-breeding range greater than 10 ha. Build nests in sligh	Presence confirmed. Records from multiple surveys of the Study Area and MAC mine lease.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						hollows at base of trees or low dense shrub among fallen debris.	
Accipitridae	*Circus assimilis*	Spotted Harrier	-	V	8 / 5	Widespread distribution across mainland Australia except in densely wooded habitats of the coast and ranges. Wide dispersal in NSW comprising a single population. Inhabit grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe and in native grassland and agricultural land. Prey on terrestrial mammals, birds, reptiles and insects.	Presence confirmed. Records from surveys of the Study Area.
	Hieraaetus morphnoides	Little Eagle	-	V	3 / 17	Widespread distribution across mainland Australia and New Guinea. Partly migratory; juveniles are dispersive and adults are mainly sedentary. Often seen over woodland and forested lands and open country, extending into the arid zone. It tends to avoid rainforest and heavy forest. Nest in mature living trees in woodland or along tree-lined watercourses. Prey on terrestrial mammals.	Presence confirmed. Recorded foraging in scattered paddock trees during 2011 surveys of the Study Area.
Anatidae	*Stictonetta naevosa*	Freckled Duck	-	V	1 / -	Distributed primarily in south eastern and	Unlikely to occur. No

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						south western Australia. Permanent freshwater swamps and creeks with heavy growth of Cumbungi, Lignum or Tea-tree. During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds. Breed in large temporary swamps of Riverina and Murray Darling Basin systems. Nest in dense vegetation at or near water level.	suitable habitat available.
Ardeidae	*Botaurus poiciloptilus*	Australasian Bittern	E	E	-	Distributed along coastal and sub-coastal areas of south eastern and south western mainland Australia; widespread in NSW. Inhabit densely vegetated freshwater wetlands with reedbeds comprising cumbungi, lignum and sedges. Nests in reeds in water or swamp.	Unlikely to occur. No suitable habitat available.
Burhinidae	*Burhinus grallarius*	Bush Stone-curlew	-	E1	1 / -	Woodland and open forests with a grassy groundlayer with fallen timber.	Unlikely to occur. No suitable habitat available.
Cacatuidae	*Callocephalon fimbriatum*	Gang-gang Cockatoo	-	V	40 / 138	In NSW, distributed from south east coast and Hunter Valley to tablelands and south west slopes. In summer, generally inhabits	Potential to occur. Not recorded in surveys but suitable forage, nesting and

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						tall mountain forests and woodlands. Move to lower altitudes in winter, preferring drier, more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas or urban areas. Favours old growth attributes for nesting and roosting.	roosting habitat in remnant vegetation is available.
	Calyptorhynchus lathami	Glossy Black-Cockatoo	-	V	76 / 141	Distributed along the coast and the Great Dividing Range up to 1000 m. Inhabit open forest and woodlands in which stands of she-oak species, particularly Black She-oak, Forest She-oak or Drooping She-oak occur. Feeds almost exclusively on the seeds of several species of she-oak (Casuarina and Allocasuarina species). Dependent on large hollow-bearing eucalypts for nest sites.	Potential to occur. Not recorded in surveys of the Study Area. Suitable forage and nesting habitat is available and the Study Area could be used as a movement corridor.
Ciconiidae	*Ephippiorhynchus asiaticus*	Black-necked Stork	-	E1	1 / 11	Widespread distribution in coastal and subcoastal northern and eastern Australia. Inhabit permanent freshwater wetlands including margins of billabongs, swamps, shallow floodwaters, and adjacent grasslands and savannah woodlands; can also be found occasionally on inter-tidal shorelines,	Unlikely to occur. No suitable habitat available.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						mangrove margins and estuaries. Forage in shallow, still water and open wetlands. In NSW, nest in tall, live, isolated paddock trees or in low shrubs within wetlands.	
	Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	-	V	94 / 11	Distributed along the inland slopes and plains of the Great Dividing Range. Inhabits eucalypt woodlands (including Box-Gum Woodland) and dry open forest; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; fallen timber is an important habitat component for foraging; also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains. Hollows in standing dead or live trees and tree stumps are essential for nesting.	Presence confirmed. Records from multiple surveys of the Study Area and MAC mine lease.
Estrildidae	*Stagonopleura guttata*	Diamond Firetail	-	V	35 / 36	Endemic to south eastern Australia with wide distribution in NSW. Not common in coastal areas, though recorded in Hunter Valley. Inhabit edges of eucalypt woodland and riparian vegetation adjoining clearings,	Presence confirmed. Record from multiple surveys of the Study Area and from MAC mine lease and Drayton Mine.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						timbered ridges and creeks in farmland. Nests built in shrubby understorey, and breeding occurs from August to December. Feeds exclusively on the ground for seeds and insects.	
Megapodiidae	*Leipoa ocellata*	Malleefowl	V	-	-	Mallee communities, preferring the tall, dense and floristically-rich mallee found in higher rainfall (300-450 mm mean annual rainfall) areas. Less frequently found in other eucalypt woodlands (e.g., mixed Western Grey Box and Yellow Gum or Bimble Box, Ironbark-Callitris Pine, Callitris Pine, Mulga, and Gidgee. Prefers areas of light sandy to sandy loam soils and habitats with a dense but discontinuous canopy, dense and variable shrub and herb layers.	Unlikely to occur. Not detected in fauna surveys of the Study Area. Sub-optimal habitat exists within the study area.
Meliphagidae	*Grantiella picta*	Painted Honeyeater	-	V	2 / 10	Sparse distribution along inland slopes of Great Dividing Range; nomadic with low densities throughout its range. Inhabit Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests. A specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias. Nests in outer canopy	Low potential to occur. Not detected in surveys of the Study Area. Limited suitable foraging habitat available.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						of drooping eucalypt, she-oak, mistletoe and paperbark branches.	
	Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	-	V	40 / 13	Eastern subspecies distributed from central QLD to southern Victoria. Widespread in NSW though rarely recorded east of Great Dividing Range. Inhabits upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts, especially Mugga Ironbark, White Box, Grey Box, Yellow Box, and Forest Red Gum. Have large feeding territories (over 5 ha) making the species locally nomadic. Nest in crown of high trees hidden by foliage.	Presence confirmed. Tentatively recorded from previous surveys of the Study Area.
	Anthochaera phrygia	Regent Honeyeater	E1	E1	16 / 83	Distributed on the inland slopes of south east Australia; patchy distribution in NSW and confined to two main breeding areas and fragmented woodland. Strongly nomadic in response to blossoming trees. Inhabit temperate woodland and dry open forest; generalist foragers that occur in Box-Ironbark woodland and riparian forests of River Sheoak that contain a large number of mature trees, high canopy cover and mistletoes.	Potential to occur. Not detected in fauna surveys of the Study Area however the species favours Box-Gum Woodland habitat which occurs within the Study Area. The species may forage in dry open forest, woodland and riparian forests within the

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						Nest on horizontal branches or forks of large mature eucalypts.	Study Area during migratory movements.
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella	-	V	57 / 60	Distribution nearly continuous in NSW from the coast to the far west. Inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland.	Potential to occur. Recorded from MAC mine lease. Suitable habitat available within the study area.
Petroicidae	*Melanodryas cucullata*	Hooded Robin	-	V	2 / 4	South eastern form distributed along east coast and inland NSW. Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas.Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses.	Presence confirmed. Recorded from surveys of the Study Area and from MAC mine lease.
Petroicidae	*Petroica boodang*	Scarlet Robin	-	V	12 / 31	In NSW, distributed from the coast to the inland slopes; after breeding may disperse to lower valleys and plains of tablelands and slopes. Inhabit open forests and grassy woodlands and breed in drier eucalypt forests	Presence confirmed. Recorded from previous surveys of the Study Area.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						and temperate woodlands, often on ridges and slopes, within an open understorey of shrubs and grasses and sometimes in open areas.	
Petroicidae	*Petroica phoenicea*	Flame Robin	-	V	3 / 8	Endemic to south east Australia. In NSW it breeds in upland moist eucalypt forests and woodlands, often on ridges and slopes, in areas of open understorey. Migrate in winter to more open lowland habitats such as grassland with scattered trees and open woodland on the inland slopes and plains. Forage for insects on the ground amongst litter and debris, and off tree trunks. Nest close to ground in sheltered sites such as tree cavities, stumps of banks.	Low potential to occur. Limited suitable habitat available, however the species are winter migrants and may fly over the Study Area.
Pomatostomidae	*Pomatostomus temporalis temporalis*	Grey-crowned Babbler (eastern subspecies)	-	V	45 / 250	In NSW the eastern subspecies occurs on the western slopes of the Great Dividing Range, Hunter Valley and north coast. Inhabits open Box-Gum Woodlands on the slopes, and Box-Cypress-pine and open Box Woodlands on alluvial plains. Species has laboured flight and is unable to cross large open areas. Feed on invertebrates on tree trunks and on	Presence confirmed. Recorded from multiple surveys of the Study Area and from MAC mine lease.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						the ground amongst litter and debris. Nest in sapling or mature eucalypts and shrubs.	
Psittacidae	*Lathamus discolor*	Swift Parrot	E1; M	E1	- / 10	Distributed across south eastern mainland Australia and Tasmania. Migrate to the mainland from Tasmania from February to September to forage on winter-flowering mistletoes and eucalypt species, particularly Red Ironbark, Mugga Ironbark, Grey Box, White Box and Yellow Gum. Inhabit open eucalypt forests and woodlands, including box–ironbark communities, and farmland with remnant patches of eucalypt woodland. Mainland forage locations vary with changing annual conditions and availability of forage resources.	Presence confirmed. Recorded from 2011 surveys of the Study Area, foraging in winter-flowering mistletoe.
	Glossopsitta pusilla	Little Lorikeet	-	V	95 / 76	Wide distribution across coastal and Great Divide regions of eastern Australia; much of the species' core habitat is in NSW. Nomadic movements influenced by food and habitat availability. Inhabit dry growth and logged sclerophyll forests in the eastern part of their range, and in remnant woodland patches on the western slopes. Roost in treetops distant	Potential to occur. Not detected in surveys of the Study Area. Recorded from MAC mine lease. Suitable foraging habitat available.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						from feeding areas. Feed on flowering eucalypts and paperbarks, and mistletoe fruits. Show high nest site fidelity; use small hollows in smooth barked eucalypts and riparian trees.	
	Neophema pulchella	Turquoise Parrot	-	V	49 / 10	Distributed from southern QLD to northern Victoria, from the coast to the western slopes of the Great Dividing Range. Inhabit edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland. Spends most of day foraging on the ground for seeds of grasses and herbaceous plants, or browses on vegetable matter. Nests in tree hollows, logs or posts, from August to December.	Potential to occur. Suitable habitat exists within the Study Area, within remnant and regenerating patches of Box-Gum Woodland. Recorded from MAC mine lease.
	Polytelis swainsonii	Superb Parrot	V	V	-	Distributed in south east Australia on the inland slopes of the Great Divide and on adjacent plains, especially along the major river-systems (Murray, Murrumbidgee, Edward); in NSW, mainly found west of the Great Divide. Inhabits forest and woodland dominated by eucalypts, particularly Box-Gum, Box-Cypress-pine and Boree	Unlikely to occur. Not detected in fauna surveys of the Study Area. Limited suitable habitat available within the survey area. No LGA records exist.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						Woodlands and River Red Gum Forest. Migrate to breed north near the upper Namoi and Gwydir Rivers. Nest in Blakely's Red Gum, Yellow Box, Red Box and Apple Box.	
Rostratulidae	*Rostratula australis*	Australian Painted Snipe	V	E1	-	Distribution is scattered across much of Australia; in NSW the species occurs in the Murray-Darling Basin and Paroo wetlands, Lake Cowal, Macquarie Marshes and Hexham Swamp. Inhabits fringes of shallow inland wetlands, swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests amid tall vegetation . Forages nocturnally on mud-flats and in shallow water.	Unlikely to occur. No suitable habitat available.
Strigidae	*Ninox connivens*	Barking Owl	-	V	13 / 11	Distributed throughout mainland Australia with wide but sparse distribution in NSW. Inhabits eucalypt woodland, open forest, swamp woodlands and, especially in inland areas, timber along watercourses. Denser vegetation is used occasionally for roosting. During the day they roost along creek lines, usually in tall understorey trees with dense foliage such as Acacia and Casuarina	Presence confirmed. Recorded from previous surveys (Ecotone, 2000) of the Study Area.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						species, or the dense clumps of canopy leaves in large Eucalypts.	
	Ninox strenua	Powerful Owl	-	V	15 / 34	Endemic to eastern and south east Australia; widely distributed in NSW from coastal forests to the tablelands. Inhabit a range of vegetation types including sclerophyll woodland, forest and rainforest. Require large tracts of forest or woodland habitat but can occur in fragmented landscapes. Species requires large mature trees with large, vertical hollows at least 0.5 m deep and 10-40m off the ground. Trees are typically large eucalypts (diameter at breast height of 80-240 cm) that are at least 150 years old. Roosts during the day in dense vegetation. HIgh nest site fidelity and will defend large home range of 400- 1450ha.	Potential to occur. Not detected in surveys of the Study Area. Some suitable habitat occurs, based on connectivity of remnant patches in the locality and hollow requirements. May forage in area as part of large home range.
Tytonidae	*Tyto novaehollandiae*	Masked Owl	-	V	10 / 20	Distributed from coast to western plains with no seasonal variation in distribution. Inhabit forests, open woodlands, farmlands with large trees, timbered watercourses, paperbark woodlands and caves. Species nest in moist forested gullies in eucalypts with a minimum	Potential to occur. Not detected in surveys of the Study Area. Some suitable habitat occurs; may forage in Study Area.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						age 165 years, and require large hollows with a 20-46cm diameter entry. Hunt along forest edges for arboreal and terrestrial mammals.	
	Tyto tenebricosa	Sooty Owl	-	V	2 / 19	Distributed along the coast and eastern escarpments of NSW. Inhabit rainforest, including dry rainforest, subtropical, warm temperate and moist eucalypt forests. Roost in very large hollows in tall forest trees of dense vegetation during the day. Hunt at night for arboreal and terrestrial mammals.	Unlikely to occur. No suitable habitat available.
Migratory Aves							
Accipitridae	*Haliaeetus leucogaster*	White-bellied Sea Eagle	Mar. M	-	-	Marine & migratory with distribution from New Zealand to south east Asia. Australian distribution along the coastline; in NSW, also extends inland along some of the larger waterways where it can feed on aquatic animals, birds, terrestrial mammals and carrion. Generally forage over large expanses of open water, in-shore waters and open terrestrial habitats. Build large sticks nests in trees up to 30m or on the ground amidst rocks. Total population size in	Low potential to occur. Migratory species likely to overfly the Study Area infrequently. No suitable forage or nesting habitat within the Study Area, though suitable habitat may be present at large dams.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						Australia is estimated at more than 500 pairs.	
Dicruridae	*Monarcha melanopsis*	Black-faced Monarch	Mar., M.			Restricted to coastal band of eastern Australia; resident in north of range but summer breeding migrant to coastal south eastern Australia, arriving in September and returning northwards in March. Inhabit rainforests, eucalypt woodlands, coastal scrub and damp gullies, and open woodland when migrating. Constructs nests in tree forks 3-6m high.	Low potential to occur. Migratory species that may overfly eucalypt woodlands of the Study Area infrequently. No records from LGA.
	Myiagra cyanoleuca	Satin Flycatcher	Mar. M	-	2 / 14	Widespread distribution in eastern Australia; in NSW, widespread on and east of the Great Divide and sparsely scattered on the western slopes and plains. Inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands often near wetlands and watercourses. On migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests. Nest in a fork of outer branches of trees, such as paperbarks, eucalypts, and banksias.	Potential to occur. Previously recorded within the MAC mine. On occasion may potentially utilise habitat within the Study Area.
Apodidae	*Apus pacificus*	Fork-tailed Swift	Mar. M	-	-	Marine & migratory non-breeding visitor to all	Low potential to occur.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						parts of Australia; recorded in all regions of NSW. Highly mobile whilst in Australia and almost exclusively aerial to 300m. Mostly found over dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh of inland plains but sometimes above foothills or in coastal areas. Often occur over cliffs and beaches and also over islands and sometimes well out to sea.	Migratory species likely to overfly the Study Area infrequently. Almost exclusively aerial summer migrant that does not breed in Australia.
Ardeidae	*Ardea alba(syn. Ardea modesta)*	Great Egret, White Egret	Mar. M	-	3 / 9	Marine & migratory with widespread distribution across Australia except arid regions of the western and central deserts. In NSW, breeding colonies restricted to Riverina regions and north eastern NSW. Inhabit shallow water and wetland habitats (such as inland and coastal, freshwater and saline, permanent and ephemeral, open and vegetated, large and small, natural and artificial). In Australia, breeding sites are located in wooded and shrubby swamps . Construct shallow platform nests in the upper strata of trees or shrubs standing in or near	Low potential to occur. Migratory species that has low potential to forage in dams within the Study Area. No suitable nesting habitat present.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						water or inundated reed beds.	
Ardeidae	*Ardea ibis*	Cattle Egret	Mar. M	-	-	Marine & migratory species found on nearly every continent where it occurs in tropical and temperate grasslands, woodlands, terrestrial wetlands and cropland with poor drainage. Distributed across Australia except the most arid inland areas. Non-breeding range comprises east and south Australia. Principal breeding sites in Australia are the central east coast from Newcastle to Bundaberg. Construct platform nests in high trees and bushes in wetland areas.	Low potential to occur. Migratory species that may infrequently forage within the Study Area. No suitable nesting habitat available.
Scolopacidae	*Gallinago hardwickii*	Latham's Snipe, Japanese Snipe	Mar. M	-	-	Migratory wetlands species that breeds in Japan and Russia; non-breeding visitor to south eastern Australia. Fragmented distribution as preferred habitat (i.e. freshwater wetlands) occur in patches throughout the non-breeding grounds. In Australia, inhabit permanent and ephemeral open, freshwater wetlands with low, dense vegetation up to 2000 m above sea-level. Forage in areas of mud (either exposed or beneath a very shallow covering of water)	Low potential to occur. Summer migrant only that breeds exclusively in the northern hemisphere. May forage infrequently near dams and inundated areas within the Study Area.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						and some form of cover (e.g. low, dense vegetation). Roost in sheltered sites on the ground near forage areas.	
Rostratulidae	*Rostratula benghalensis s. lat.*	Painted Snipe	V; Mar. M	V	-	Migratory wetlands species with scattered distribution in Australia; most common in eastern Australia. Inhabit inland and coastal shallow freshwater wetlands in both ephemeral and permanent wetlands, particularly where there is a cover of vegetation. Specific breeding habitat requirements of shallow wetlands with areas of bare wet mud and both upper and canopy cover nearby. Nests in scrapes on the ground.	Unlikely to occur. No suitable forage or breeding habitat within the Study Area.
Apodidae	*Hirundapus caudacutus*	White-throated Needletail	Mar. M	-	-	Marine & migratory non-breeding visitor to Australia, with widespread distribution in eastern and south eastern Australia. Almost exclusively aerial, from heights of less than 1 m up to more than 1000 m above the ground. Occur over most types of habitat, particularly above wooded areas including open forest and rainforest, between trees or in clearings and below the canopy. Less commonly	Presence confirmed. Recorded from previous surveys of the Study Area and from MAC mine lease and Drayton mine lease. Migratory species found over most types of habitat including open wooded areas.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						recorded flying above woodland and treeless areas, such as grassland or swamps. Roost in trees in forests and woodlands among dense foliage in the canopy or in hollows.	
Meropidae	*Merops ornatus*	Rainbow Bee-eater	Mar. M	-	52 / 87	Marine & migratory species widely distributed throughout Australia, Indonesia, Japan and Pacific Island. Breeding populations in southern Australia migrate north and remain there for the duration of the Australian winter after breeding. Populations that breed in northern Australia are considered to be resident. Inhabit healthland, open forests and woodlands, shrublands, and various cleared or semi-cleared habitats, including farmland and areas of human habitation. Often occur in open, cleared or lightly-timbered areas located in close proximity to permanent water. Nest in enlarged chambers at the end of long burrow or tunnel in flat or sloping ground, in the banks of rivers, creeks or dams, roadside cuttings, the walls of gravel pits or quarries, in mounds of gravel, or in cliff-faces. Forages from open perches and captures most prey in	Presence confirmed. Recorded from previous surveys of the Study Area. Also known from MAC mine lease and Drayton mine lease. Migratory species found over a range of habitats including open forests and woodlands, shrubland and in various cleared or semi-cleared habitats.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						flight, although it also takes food items from the ground and from foliage.	
Insecta							
Petaluridae	*Petalura gigantea*	Giant Dragonfly	-	E1	1 / -	Distributed along east coast of NSW, east of the Great Dividing Range. Inhabit permanent swamps and bogs with some free water and open vegetation. Hunt for flying insects over swamp and along swamp margins. Eggs laid into soft ground vegetation including moss, moist litter and humic soils often associated with groundwater seepage. Do not inhabit areas of standing water in wetlands. Larvae dig long branching burrows under the swamp.	Unlikely to occur. No suitable habitat available.
Mammalia							
Dasyuridae	*Dasyurus maculatus*	Spotted-tailed Quoll	E1	V	25 / 117	Restricted in its former distribution to eastern Australia. Inhabits a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Use hollow-bearing trees, logs, caves, crevices and rocky cliff-faces as den sites. Large home ranges from 750 ha (female) to 3500	Potential to occur. Not detected in fauna surveys but may utilise open forests, woodlands and riparian forest within the Study Area. Previously recorded in the MAC mine lease.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						ha (males), generally traversing ranges along densely vegetated creeklines. Ground and tree-climbing nocturnal mammal that may raid bird and arboreal mammal nests.	
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	-	V	7 / 2	Wide-ranging species distributed through northern and eastern Australia. Possible seasonal migrations from southern Australia in late summer and autumn. Roosts singly or in small groups in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. Forage in most habitats and appear to defend aerial territories. When foraging for insects, flies high and fast over the forest canopy, but lower in more open country.	Presence confirmed. Recorded during 2011 surveys of the Study Area. Also known from the MAC mine lease and Drayton mine lease.
Macropodidae	*Macropus parma*	Parma Wallaby	-	V	1 / 4	Distribution restricted to coast and ranges of central and northern NSW. Inhabit moist eucalypt forest with thick, shrubby understorey, often with nearby grassy areas, rainforest margins and occasionally drier eucalypt forest. Typically feed at night on grasses and herbs in more open eucalypt forest and the edges of nearby grassy areas.	Unlikely to occur. Not detected in surveys of the Study Area. No suitable habitat available within the Study Area.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
	Petrogale penicillata	Brush-tailed Rock-wallaby	V	E1	34 / 63	Distribution patchy and restricted, from south east QLD to western Victoria along the Great Dividing Range. Inhabit rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north. Feed on vegetation in and adjacent to rocky areas. Highly territorial with strong site fidelity and home range of 15 ha.	Unlikely to occur. Not detected in surveys of the Study Area. No suitable habitat available.
Molossidae	*Mormopterus norfolkensis*	Eastern Freetail-bat	-	V	9 / 141	Distributed along the east coast from southern QLD to southern NSW. Inhabits dry sclerophyll forest and woodland east of the Great Dividing Range. Roost singly and communally, mainly in tree hollows but will also roost under decorticating bark or in man-made structures.	Presence confirmed. Recorded during 2011 and previous surveys of the Study Area. Also known from MAC mine lease and Drayton mine lease.
Muridae	*Pseudomys novaehollandiae*	New Holland Mouse	V	-	6 / -	Distribution fragmented but clumped across south eastern Australia due to specific habitat requirements. Inhabit open heathland, open woodland and vegetated sand dunes in coastal areas and up to 100 km inland on sandstone country up to 900m altitude.	Unlikely to occur. Not detected in fauna surveys. No suitable sandstone habitat availablee.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						Require deeper top soils and softer substrates for digging burrows. Require forage habitat with high floristic diversity	
Petauridae	*Petaurus australis*	Yellow-bellied Glider	-	V	71 / 355	Distributed along the eastern coast to western slopes of Great Dividing Range. Inhabit tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Highly mobile with large home ranges (20-85 ha) to encompass dispersed and seasonally variable forage resources. Feed primarily on plant and insect exudates.	Low potential to occur. Not detected in fauna surveys of the Study Area. Limited tall forest habitat available.
	Petaurus norfolcensis	Squirrel Glider	-	V	23 / 44	Wide but sparse distribution in eastern Australia. Inhabit mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas. Prefers mixed species stands with a shrub or Acacia midstorey. Require abundant tree hollows for refuge and nest sites. Diet is seasonal and includes sap, pollen, nectar, insects and eucalypt gum.	Potential to occur. Known from MAC mine lease and Drayton mine lease

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
Phascolarctidae	*Phascolarctos cinereus*	Koala	V	V	21 / 77	Distributed throughout eastern Australia; mainly on the central and north coasts of NSW. Inhabit eucalypt woodlands and forests. Feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species. Spend majority of time in trees but will traverse open ground to move between trees. Home ranges vary depending on habitat quality, generally less than 2 ha to several hundred hectares.	Unlikely to occur. Not detected in fauna surveys. Limited woodland habitat and connected tree canopy available; although individuals are known to travel across open landscapes. The Study Area is unlikely to provide good movement corridors because of surrounding land use and poor connectivity to significant areas of habitat offsite. Some suitable habitat is available within the surrounding area and likely to occur in the wider area in low densities. An individual was recorded in early 2011 on a haul road in the MAC mine lease. The Study Area does not support core

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
							habitat.
Pteropodidae	*Pteropus poliocephalus*	Grey-headed Flying-fox	V	V	3 / 120	Distributed within 200km of the east coast of Australia. Inhabits subtropical and temperate habitats including mangroves, rainforests, tall sclerophyll forests and woodlands, heaths and swamps. Migrate up to 50km according to the availability of native fruits, nectar and pollen. Roost in large "camps" which are generally within 20km of a food source and commonly found in gullies close to water and dense vegetation.	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.
Vespertilionidae	*Chalinolobus dwyeri*	Large-eared Pied Bat	V	V	45 / 48	Distributed along the east coast in areas with extensive cliffs and caves. In NSW, rare and patchy distribution in southern highlands, tablelands and north west slopes. Inhabit well-timbered areas containing gullies. High site fidelity and roost in caves, crevices in cliffs and old mine workings frequenting low to mid-elevation dry open forest and woodland close to these features. Hibernate in cooler months.	Presence confirmed. Recorded during 2011 surveys of the Study Area. Also known from MAC mine lease.
	Falsistrellus	Eastern False	-	V	16 / 28	Distributed along south east coast and ranges	Unlikely to occur. Not

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
	tasmaniensis	Pipistrelle				of Australia. Inhabit moist habitats with trees taller than 20 m. Generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings. Prey on insects above or just below tree canopy. Hibernate in winter.	detected in fauna surveys of the Study Area. No suitable habitat available.
	Miniopterus australis	Little Bentwing-bat	-	V	1 / 5	Distributed along east coast and ranges of Australia from northern QLD to Wollongong, NSW. Inhabit well timbered areas including rainforest, wet and dry sclerophyll forest, Melaleuca swamps and coastal forests. Roost in caves, artificial structures and tree hollows. Forage for insects at night beneath canopy of densely vegetated habitats. Only 5 maternity colonies/ nursery sites recorded in Australia.	Unlikely to occur. Not detected in fauna surveys of the Study Area. Sub-optimal habitat exists within the study area.
Vespertilionidae	*Miniopterus schreibersii oceanensis*	Eastern Bentwing-bat	-	V	87 / 73	Distributed along the east and north east coast of Australia. Inhabit forested valleys but also found in rainforests, wet/dry schlerophyll forests, monsoon forests, open woodlands, paperbark forests & open grasslands. Roost in caves, tunnels and other artificial structures. Maternity caves have specific temperature and humidity	Presence confirmed. Recorded from surveys of the Study Area. Recorded from the MAC mine lease and Drayton mine lease.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						regimes. Prey on flying insects above the treetops in forested areas. Disperse within 300km of maternity caves in non-breeding season.	
	Myotis macropus	Southern Myotis	-	V	7 / 10	Distributed along coastal band from north east Australia to western Victoria. Rarely found more than 100km inland, except along major rivers. Fishing bat that occurs in habitats near water, including mangroves, paperbark swamps, riverine monsoon forest, rainforest, wet and dry sclerophyll forest, open woodland and River red gum woodland. Roost in groups in caves, hollow-bearing trees, dense foliage and artificial structures. Forage for insects and small fish over streams and pools.	Presence confirmed. Recorded during 2011 and previous surveys of the Study Area. Also recorded in MAC mine lease
	Nyctophilus corbeni	Greater Long-eared Bat	V	V	16 / 2	Distribution of south eastern form associated with Murrary Darling Basin. Inhabits variety of vegetation types, including mallee, Bulloak and Box eucalypt dominated communities, but it is distinctly more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western	Presence confirmed. Recorded from previous surveys of the Study Area. Inhabits a variety of vegetation types including forest and woodland areas within the Study Area.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
						slopes and plains of NSW and southern Queensland. Roost in tree hollows, crevices and under loose bark. Hunt for non-flying prey in the understorey.	
	Scoteanax rueppellii	Greater Broad-nosed Bat	-	V	11 / 21	Distributed along gullies and river systems that drain the Great Dividing Range and to the coast. In NSW, widespread on New England Tablelands. Inhabit cool temperate to tropical moist forests, woodland and rainforest. Prefer moist gullies within mature coastal forest or rainforest. May roost in tree hollows and buildings. Forages in open woodland and forest edges and flies directly along creek corridors at 3-6m altitude. Maternity sites located in suitable trees.	Presence confirmed. Recorded from surveys of the Study Area. Recorded from Drayton mine lease.
	Vespadelus troughtoni	Eastern Cave Bat	-	V	14 / 9	Distributed in a broad band on both sides of Great Dividing Range. Cave-roosting species that usually inhabits dry open forest and woodland and occasionally in wet rainforest, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings.	Potential to occur. Calls recorded during 2011 surveys of the Study Area but not positively identfied. Recorded from MAC mine lease and Drayton mine lease.

Table H.1 Likelihood of Occurrence of Potential Threatened Fauna Species

Family	Scientific Name	Common Name	EPBC	TSC	LGA Records	Preferred Habitat	Likelihood of Occurrence
Reptilia							
Elapidae	*Hoplocephalus bungaroides*	Broad-headed Snake	V	E1	1 / 2	Distribution largely restricted to Triassic and Permian sandstones within the coast and ranges within approximately 250km of Sydney. Nocturnal species that inhabits rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring. Moves from the sandstone rocks to shelters in hollows in large trees within 200 m of escarpments in summer. Feeds on small reptiles, amphibians and mammals.	Unlikely to occur. Not detected in fauna surveys of the Study Area. No suitable habitat available.
Varanidae	*Varanus rosenbergi*	Rosenberg's Goanna	-	V	2 / 2	Distribution in NSW restricted to Sydney sandstone in Wollemi NP, Goulburn, ACT and south west slopes. Hawkesbury sandstone outcrop specialist. Inhabits woodlands, dry open forests and heathland sheltering in burrows, hollow logs, rock crevices and outcrops. Termite mounds critical for nesting. Require large areas of habitat.	Unlikely to occur. Not detected in fauna surveys of the Study Area. No suitable habitat available.

Appendix I

Assessments of Significance (The Seven-part Test)

I.1 Introduction

This appendix contains a number of Assessments of Significance (hereafter referred to as the Seven-part Test), which is typically prepared for a Section 5A assessment under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). There is no legal requirement to complete such assessments for inclusion in an Environmental Assessment as they are not legally required for documents prepared under Part 3A of the Act.

The Seven-part Test provides a means by which a qualitative risk analysis can be conducted to determine the magnitude and significance of impacts on threatened flora and fauna species, populations and ecological communities as listed under the TSC Act. Threatened species that are known to occur within or in close proximity to the Study Area, or are considered highly likely to occur based on suitable habitat availability and distribution (as indicated in Fauna and Flora Likelihood of Occurrence assessments (**Appendices G** and **H**) were assessed. Each Seven-part Test prepared for the Project comprises a series of questions (presented in italics) for which a response is supplied below it (in plain text).

i. Seven-part Test Terminology

The following guidelines prescribe a list of terminology to be used in Seven-part Tests:

- **Subject site:** means the area directly affected by the proposal;
- **Study area:** means the subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly. The study area should extend as far as is necessary to take all potential impacts into account;
- **Locality:** the occurrence of the ecological community, species or population within the study area.
- **Local occurrence:** the ecological community that occurs within the study area. The local occurrence may include adjacent areas if the ecological community on the study area forms part of a larger contiguous area of that ecological community and the movement of individuals and exchange of genetic material across the boundary of the study area can be clearly demonstrated;
- **Local population:** the population that occurs in the study area. The assessment of the local population may be extended to include individuals beyond the study area if it can be clearly demonstrated that contiguous or interconnecting parts of the population continue beyond the study area, according to the following definitions:
    - The local population of a threatened plant species comprises those individuals occurring in the study area or the cluster of individuals that extend into habitat adjoining and contiguous with the study area that could reasonably be expected to be cross-pollinating with those in the study area;

- The local population of resident fauna species comprises those individuals known or likely to occur in the study area, as well as any individuals occurring in adjoining areas (contiguous or otherwise) that are known or likely to utilise habitats in the study area; and
- The local population of migratory or nomadic fauna species comprises those individuals that are likely to occur in the study area from time to time.

➢ **Life cycle:** the series or stages of reproduction, growth, development, ageing and death of an organism;

➢ **Viable:** the capacity to successfully complete each stage of the life cycle under normal conditions; and

➢ **Risk of extinction:** the likelihood that the local population will become extinct either in the short-term or in the long-term as a result of direct or indirect impacts on the viability of that population.

The following Seven-part Tests that were prepared for the Project use the terminology above. Note that the term '*subject site*' was always taken to mean the '*Project Disturbance Footprint*' and the term '*study area*' was taken to be the '*Study Area*' as used within this ecology impact assessment report.

ii. Consideration of Ameliorative and Compensation Measures

Each Seven-part Test has been prepared without considering the ameliorative and compensatory measures proposed for the Project as instructed under the Assessment of Significance guidelines (DECC (NSW) 2007b):

> *"Proposed measures that mitigate, improve or compensate for the action, development or activity should not be considered in determining the degree of the effect on threatened species, populations or ecological communities, unless the measure has been used successfully for that species in a similar situation".*

However, it is noted that the Project proposes substantial mitigation and compensatory measures, including on site mitigation measures such as habitat rehabilitation, creekline restoration and erosion control, and off site compensatory habitat. The ultimate conclusions to this ecology impact assessment take such measures into consideration when assessing the long term implications for threatened species, populations and communities.

Table I.1 below summarises the results of the Seven-part Tests for the Project.

Table I.1 Ecological Communities and Species Subject to a Seven-part Test

Common Name	Scientific Name	Significant Impact?
Threatened Ecological Communities		
Box-Gum Woodland		Yes, without amelioration or compensation
Central Hunter Box-Ironbark Woodland		Yes, without amelioration or compensation
Narrabeen Footslopes Slaty Box Woodland		Yes, without amelioration or compensation
Hunter Lowland Redgum Forest		No
Threatened Flora		
Weeping Myall	*Acacia pendula*	Yes, without amelioration or compensation
Pine Donkey Orchid	*Diuris tricolor*	Yes, without amelioration or compensation
Tiger Orchid	*Cymbidium canaliculatum*	Yes, without amelioration or compensation
Threatened Nectarivorous Birds		
Black-chinned Honeyeater	*Melithreptus gularis gularis*	No
Little Lorikeet	*Hieraaetus morphnoides*	No
Regent Honeyeater	*Anthcchaera phrygia*	Yes, without amelioration or compensation
Swift Parrot	*Lathamus discolour*	Yes, without amelioration or compensation
Threatened Woodland Birds		
Brown Treecreeper (eastern subspecies)	*Climacteris picumnus victoriae*	Yes, without amelioration or compensation
Diamond Firetail	*Stagonopleura guttata*	Yes, without amelioration or compensation
Flame Robin	*Petroica phoenicea*	No
Gang-gang Cockatoo	*Callocephalon fimbriatum*	No
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	No
Grey-crowned Babbler (eastern subspecies)	*Pomatostomus temporalis temporalis*	Yes, without amelioration or compensation

Table I.1 Ecological Communities and Species Subject to a Seven-part Test

Common Name	Scientific Name	Significant Impact?
Hooded Robin (south eastern form)	*Melanodryas cucullata cucullata*	Yes, without amelioration or compensation
Satin Flycatcher	*Myiagra cyanoleuca*	No
Scarlet Robin	*Petroica boodang*	Yes, without amelioration or compensation
Speckled Warbler	*Pyrrholaemus sagittatus*	Yes, without amelioration or compensation
Turquoise Parrot	*Neophema pulchella*	Yes, without amelioration or compensation
Varied Sittella	*Daphoenositta chrysoptera*	Yes, without amelioration or compensation
Threatened Raptors		
Barking Owl	*Ninox connivens*	No
Little Eagle	*Hieraaetus morphnoides*	No
Masked Owl	*Tyto novaehollandiae*	No
Powerful Owl	*Ninox strenua*	No
Spotted Harrier	*Circus assimilis*	No
Threatened Microbats		
Eastern Bentwing-bat	*Miniopterus orianae oceanensis*	No
Eastern Cave Bat	*Vespadelus troughtoni*	No
Eastern Freetail-bat	*Mormopterus norfolkensis*	Yes, without amelioration or compensation
Greater Broad-nosed Bat	*Scoteanax rueppellii*	Yes, without amelioration or compensation
Greater Long-eared Bat	*Nyctophilus corbeni*	Yes, without amelioration or compensation
Large-eared Pied Bat	*Chalinolobus dwyeri*	No
Southern Myotis	*Myotis macropus*	No
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	Yes, without amelioration or compensation
Threatened Mammals		
Spotted-tailed Quoll	*Dasyurus maculatus*	No
Squirrel Glider	*Petaurus norfolcensis*	No

I.2 Box-Gum Woodland Seven-part Test

Box-Gum Woodland is listed as an EEC under the TSC Act and as a CEEC under the EPBC Act. A total of 303 ha of this community (both woodland and derived grassland forms) has been calculated to occur within the study area, of which 181 ha (or 60%) is proposed to be cleared.

Box-Gum Woodland was once a widespread and floristically diverse complex of communities that extended from Victoria to Queensland. In NSW, the community is found on semi-fertile to fertile soils on the tablelands and western slopes which are preferred landscapes for agriculture; as a result, most of the community was historically cleared. It now exists as isolated and fragmented remnant paddock trees or patches with reduced structural complexity and little evidence of regeneration (DECCW (NSW) 2010b). This community now supports a low diversity of flora and fauna species.

Box-Gum Woodland is an open woodland community characterised by the current or prior dominance of one or more of the following pure or intergrade tree species: *Eucalyptus albens* (White Box), *Eucalyptus melliodora* (Yellow Box) and *Eucalyptus blakelyi* (Blakely's Red Gum). The understorey is characterised by native grasses and wild flowers.

Modified forms of the community, which exist in the Hunter Valley, are typically:

- Areas where the main tree species are present ranging from an open woodland formation to a forest structure, and the ground layer is predominantly composed of exotic species; or
- Sites where the trees have been removed and only the grassy ground layer and some herbs remain.

A number of Hunter Valley vegetation communities described by Peake (2006) conform to the legislative listing for Box-Gum Woodland. Two that occur in the study area are:

- Upper Hunter White Box-Ironbark Grassy Woodland (and derived grasslands); and
- Hunter Floodplain Red Gum Woodland (and derived grasslands).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable to endangered communities.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable to endangered communities.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

The Project will clear 60% of the extent of Box-Gum Woodland that is currently present in the study area. The Project is likely to have an adverse effect on the extent of the community such that its local occurrence is likely to be at place at risk of extinction. The Project will adversely modify the composition of the community within the subject site and potentially modify the extent within the study area. The Project is likely to have an adverse effect on the composition of the community such that its local occurrence is placed at risk of extinction.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

The Project will clear 60% of the extent of the habitat for Box-Gum Woodland that is currently present in the study area. The Project will clear approximately 3% of the reported habitat for Box-Gum Woodland in the Central Hunter Valley.

The Project will further fragment the community within the study area and increase the isolation of the community from other areas of habitat outside of the study area.

Box-Gum Woodland has suffered a large decline in the Central Hunter Valley and a reported 11% of the original distribution is estimated to remain (Peake 2006). The community is not well conserved in the locality. The conservation of remaining remnants is critical to the recovery of the community. Within the study area, only 40% will remain as a result of the Project and is at risk of modification, will be further fragmented and will be further isolated from other areas of habitat. The importance of the habitat to be removed from the subject site is considered to be important to the long-term survival of the community in the locality (where the locality is the occurrence in the study area).

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for this TEC has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A Draft National Recovery Plan has been prepared for the EPBC Act-listed Box-Gum Woodland. The Project is inconsistent with this plan.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTP:

- **Clearing of native vegetation** as this directly removes and reduces the extent of this ecological community, reduces the area of forage and nesting habitat available for various flora and fauna species, and correlated to a general decline in biodiversity;
- **Loss of hollow-bearing trees** as this directly removes remnant trees of this community and reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this removes structural components of the community and reduces the abundance of important ground foraging and nesting habitat;
- **Invasion and establishment of exotic vines and scramblers** as this impacts on the community structure and increases competition;
- **Invasion of native plant communities by exotic perennial grasses** as this impacts regeneration capabilities and results in loss of structural complexity and of key food plants and habitat;
- **Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands** as this can significantly reduce the ecological function of the community;
- **Degradation of native riparian vegetation along NSW water courses** as this removes and alters the community;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they alter the structure and composition of vegetation, and degrade the land;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion; and

- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project will result in the direct loss of 181 ha of remnant and regenerating Box-Gum Woodland. Further degradation of the remaining areas of this community is expected without active management. The community is recognised to have suffered a large reduction in extent through past clearing. Without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the long-term viability of the community in the locality by further fragmenting remaining Box-Gum Woodland.

I.3 Central Hunter Box-Ironbark Seven-part Test

Central Hunter Box-Ironbark Woodland is listed as an EEC under the TSC Act. Approximately 479 ha of this community have been calculated to occur within the study area.

The community generally occurs on Permian geology characteristic of the Hunter Valley where it forms woodland to open forest on slopes and undulating hills (NSW Scientific Committee 2010a). The community occurs between Singleton and Muswellbrook in the central and upper Hunter region.

Floristic composition can vary depending on location and disturbance history; however a number of flora species have been identified as typical of the community assemblage (NSW Scientific Committee 2010a). These include Narrow-leaved Ironbark, Kurrajong and Grey Box as dominant canopy species. The community also includes micro-organisms, fungi, cryptogamic plants and both vertebrate and invertebrate fauna, however these components of the community are poorly documented (DECCW (NSW) 2010a). It is known to contain the vulnerable species *Diuris tricolor* and endangered population *Cymbidium canaliculatum*, both of which have also been recorded within the study area.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable for an ecological community.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable for an ecological community.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

The Project will result in the removal of approximately 181 ha (or 38%) of Central Hunter Box-Ironbark Woodland that occurs in the study area. The Project is likely to have an adverse effect on the extent of the community such that its local occurrence is likely to be at place at risk of extinction. The Project will adversely modify the composition of the community within the subject site and potentially modify the extent within the study area.

The Project is likely to have an adverse effect on the composition of the community such that its local occurrence is placed at risk of extinction.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

The Project will result in the removal of approximately 38% of habitat for Central Hunter Box-Ironbark Woodland that in the study area. The Project will clear approximately 1% of the reported habitat for Central Hunter Box-Ironbark Woodland in the Central Hunter Valley.

The Project will further fragment the community within the study area and increase the isolation of the community from other areas of habitat outside of the study area.

Central Hunter Box-Ironbark Woodland has suffered a large decline in the Central Hunter Valley and a reported 32% of the original distribution is estimated to remain (Peake 2006). The community is not well conserved in the locality. The conservation of remaining remnants is important to the recovery of the community. Within the study area, only 62% will remain as a result of the Project and is at risk of modification, will be further fragmented and will be further isolated from other areas of habitat. The importance of the habitat to be removed from the subject site is considered to be important to the long-term survival of the community in the locality (where the locality is the occurrence in the study area).

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for this EEC has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plans or threat abatement plans exist for this community. No priority actions have been identified for this community.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTP:

- **Clearing of native vegetation** as this directly removes and reduces the extent of this ecological community, and reduces the area of forage and nesting habitat available for various flora and fauna species;
- **Loss of hollow-bearing trees** as this directly removes remnant trees of this community and reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this removes structural components of the community and reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this impacts regeneration capabilities and results in loss of structural complexity and of key food plants and habitat;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they alter the structure and composition of vegetation, and degrade the land;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa***as wallowing and rooting causes direct disturbance to habitats and may increase erosion; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to result in the direct removal of approximately 181 ha of remnant and regenerating Central Hunter Box-Ironbark Woodland. Further degradation of the remaining areas of this community is expected without active management. The community is recognised to have suffered a large reduction in extent through past clearing. Without the implementation of appropriate mitigation and offset measures, the Project is likely to have a significant impact on the long-term viability of the community in the locality. This will also directly and indirectly affect a range of flora and fauna, including threatened species, by removing potential forage, roosting and breeding habitat.

I.4 Narrabeen Footslopes Slaty Box Woodland Seven-part Test

Narrabeen Footslopes Slaty Box Woodland (Peake 2006) is listed as a Vulnerable Ecological Community (VEC) under the TSC Act. Approximately 100 ha of this community have been calculated to occur within the study area.

Narrabeen Footslopes Slaty Box Woodland is a woodland, and occasionally forest, community that occurs on colluvial soils at the interface between Triassic Narrabeen sandstones and conglomerates, and Permian sediments (Peake 2006; NSW Scientific Committee 2009a). Its distribution is mostly restricted to the base of the southern valley escarpment. Floristically, the tree and shrub strata of this community are sparse to mid-dense and the groundcover is sparse with low diversity.

This community occurs as fairly large patches in the central-north of the study area; mapping considers the community occurring in the study area to be outliers of the community (Peake 2006).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable for an ecological community.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable for an ecological community.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

The Project will result in the removal of approximately 98 ha (or 98%) of Narrabeen Footslopes Slaty Box Woodland that occurs in the study area.

The Project is likely to have an adverse effect on the extent of the community such that its local occurrence is likely to be at place at risk of extinction. The Project will adversely modify the composition of the community within the subject site and potentially modify the extent within the study area. The Project is likely to have an adverse effect on the composition of the community such that its local occurrence is placed at risk of extinction.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

The Project will clear 98% of the extent of the habitat for Narrabeen Footslopes Slaty Box Woodland that is currently present in the study area. The Project will clear approximately 4% of the reported habitat for Narrabeen Footslopes Slaty Box Woodland in the Central Hunter Valley.

The Project will further fragment the community within the study area and increase the isolation of the community from other areas of habitat outside of the study area.

Narrabeen Footslopes Slaty Box Woodland has suffered a large decline in the Central Hunter Valley. It is unknown what percentage of the original distribution is estimated to remain (Peake 2006). The community is not well conserved in the locality. The conservation of remaining remnants is critical to the recovery of the community. Within the study area, only 5% will remain as a result of the Project and is at risk of modification, will be further fragmented and will be further isolated from other areas of habitat. The importance of the habitat to be removed from the subject site is considered to be critical to the long-term survival of the community in the locality (where the locality is the occurrence in the study area).

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for this VEC has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery or threat abatement plans have been prepared for this VEC. No priority actions have been identified for this community.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTP:

- **Clearing of native vegetation** as this directly removes and reduces the extent of this ecological community, and reduces the area of forage and nesting habitat available for various flora and fauna species;
- **Loss of hollow-bearing trees** as this directly removes remnant trees of this community and reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this removes structural components of the community and reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this impacts regeneration capabilities and results in loss of structural complexity and of key food plants and habitat;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they alter the structure and composition of vegetation, and degrade the land;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to result in the direct removal of approximately 98 ha of Narrabeen Footslopes Slaty Box Woodland. Further degradation of the remaining areas of this community is expected without active management. The community is recognised to have suffered a large reduction in extent through past clearing. Without the implementation of appropriate mitigation and offset measures, the Project will have a significant impact on the long-term viability of the community in the locality. This will also directly and indirectly affect a range of flora and fauna, including threatened species, by removing potential forage, roosting and breeding habitat.

I.5 Hunter Lowland Redgum Forest Seven-part Test

Hunter Lowland Redgum Forest is listed as an EEC under the under the TSC Act. Approximately 0.4 ha of Hunter Lowland Redgum Forest occurs as a narrow band adjacent to the existing industrial dam in the eastern minor additional mining area at Drayton Mine. It is proposed to be removed as part of the Project.

Hunter Lowland Redgum Forest occurs on gentle slopes arising from depressions and drainage flats on Permian sediments of the Hunter Valley floor in the Sydney Basin and NSW North Coast Bioregions. The community is generally an open forest with most common canopy trees species being *Eucalyptus tereticornis* and *Eucalyptus punctata* although other frequently occurring canopy species are *Angophora costata*, *Corymbia maculata*, *Eucalyptus crebra* and *Eucalyptus moluccana*, with a number of other eucalypts being less frequently recorded. The mid stratum is characterised as open with sparse shrubs of *Breynia oblongifolia*, *Leucopogon juniperinus*, *Daviesia ulicifolia* and *Jacksonia scoparia*. There is consistently a ground layer of grasses and herbs, characterised by *Microlaena stipoides* var. *stipoides*, *Cymbopogon refractus*, *Echinopogon caespitosus* var. *caespitosus*, *Cheilanthes sieberi* subsp. *sieberi* and *Pratia purpurascens* (NSW Scientific Committee 2011a).

During past surveys the area in question was previously identified as Derived Native Grassland. However, it has since regenerated to immature woodland corresponding to the Hunter Lowland Redgum Forest EEC. The band of Hunter Lowland Redgum Forest being assessed is a small, degraded remnant of this forest community and is characterised by relatively low species diversity. It is immature vegetation comprised mostly of regrowth that lacks structural complexity and contains a number of invasive plant species.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable for an ecological community.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable for an ecological community.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

The Project is unlikely to have an adverse effect on the extent of the community such that its local occurrence is likely to be at place at risk of extinction. The Project will remove 0.4 ha of the local occurrence that occurs in the study area. Approximately 130 ha of this woodland community will remain within the study area, which includes the Drayton Mine Northern Offset Area and Drayton Wildlife Refuge to the north. These areas of Hunter Lowland Redgum Forest are of higher quality and are substantially larger than the occurrence on the subject site. 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.

The Project will not adversely modify the composition of the community such that its local occurrence is placed at risk of extinction. The removal of the occurrence of the community within the subject site will not modify the composition of the community in the locality.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

The entire occurrence of Hunter Lowland Redgum Forest on the subject site will be removed as part of the Project.

The Project is unlikely to fragment, isolate or increase fragmentation of the local occurrence of this community because the occurrence of Hunter Lowland Redgum Forest on the subject site is currently fragmented and completely isolated from other occurrences in the locality.

The occurrence of Hunter Lowland Redgum Forest on the subject site is not considered to be important to the long term survival of the community due to its small size, isolation, and highly modified condition. Approximately 130 ha of this woodland community will remain within the study area, which includes the Drayton Mine Northern Offset Area and Drayton Wildlife Refuge to the north. These areas of Hunter Lowland Redgum Forest are of higher quality and are substantially larger than the occurrence on the subject site. 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.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for this EEC has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery or threat abatement plans have been prepared for this EEC. No priority actions have been identified for this community.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTP:

- **Clearing of native vegetation** as this directly removes and reduces the extent of this ecological community, and reduces the area of forage and nesting habitat available for various flora and fauna species;
- **Invasion of native plant communities by exotic perennial grasses** as this impacts regeneration capabilities and results in loss of structural complexity and of key food plants and habitat;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they alter the structure and composition of vegetation, and degrade the land;
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to result in the direct removal of approximately 0.4 ha of Hunter Lowland Redgum Forest. The current condition, size and context of this patch of regrowth forest means that there is little capacity for recovery; in its current state and without active management, this remnant is expected to continue to be subject to edge effects and degradation that will severely limit its viability. Better representatives of this community in the locality are currently being conserved and managed by Anglo American and will ensure that the local occurrence of the community will not be placed at risk of extinction. Therefore, the Project is unlikely to have a significant impact on the long-term viability of the community in the locality.

I.6 Weeping Myall Population Seven-part Test

Acacia pendula (Weeping Myall) in the Hunter Valley is listed as an Endangered Population under the TSC Act and is an erect or spreading small to medium tree 5 to13 m high (Harden 2002). The tree has a pendulous habit, with long silver-grey phyllodes and hard, dark and fissured bark (Botanic Gardens Trust 2011). The tree has irregular flowering periods which are generally not annual. The species occurs in woodlands, shrublands and grasslands where it often forms low open woodland on heavy loam soils on the slopes and plains of western NSW where the tree has widespread distribution (Tame 1992).

A disjunct population Weeping Myall, estimated to be comprised of fewer than 1,000 individuals, occurs at the eastern limit of its distributional range in the Hunter Valley. In the Hunter region, the species has been recorded on the margins of small floodplains and undulating country, extending from Warkworth in the east, to Muswellbrook in the northwest (Threatened Species Scientific Committee 2008). Most plants are found along roadsides and cemeteries, where the land is not, or only infrequently, disturbed or grazed.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable to threatened populations or communities.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove the local population of *Acacia pendula* (Weeping Myall).

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened populations.

(d) in relation to the habitat of a threatened species, population or ecological community:

> *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*
>
> *(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

The Project will clear approximately 1928 ha of habitat for the population. As the population can occur in grassland, the Project is unlikely to fragment or isolate habitat for the population from other areas of habitat. As the species is a poor reproducer and the population size low, the habitat to be removed is likely to be important to the long-term survival of the population.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for either the population or TEC has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery or threat abatement plans have been prepared for this population. No priority actions have been identified for this population.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The main threats to the population of *Acacia pendula* (Weeping Myall) in the Hunter catchment are small-scale vegetation clearing and fragmentation of suitable habitat (Threatened Species Scientific Committee 2008). These include the clearing of the community and fragmentation of suitable habitat. Heavy grazing by livestock, disturbance of soil and groundcovers, competition from invasive weed species and herbivory by caterpillars also affect the viability of the population.

The Project constitutes or will exacerbate the following KTP:

- **Clearing of native vegetation** as this directly removes and reduces the extent of this population; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to result in the direct removal of the local occurrence of the Hunter Valley population of *Acacia pendula* (Weeping Myall). The species is a poor reproducer and the population size in the Hunter Valley is small. Without ameliorative measures, the population is likely to be significantly impacted by the Project.

I.7 Pine Donkey Orchid Species/Population Seven-part Test

Diuris tricolor (Pine Donkey Orchid) is listed as Vulnerable under the TSC Act. The *Diuris tricolor* (Pine Donkey Orchid) population in the Muswellbrook local government area is also listed as an Endangered Population under the TSC Act. There are 13 records of the species within the Muswellbrook LGA and no records within the Singleton LGA (OEH 2011). Individuals of the species have been recorded within the study area and Mt Arthur Coal Mine lease.

Diuris tricolor (Pine Donkey Orchid) is a deciduous terrestrial orchid with sparse distribution on the western slopes of NSW (Bishop 2000). The species is usually recorded from disturbed habitats, but typically grows in sclerophyll vegetation on flats or small rises, on a range of substrates including sandy or loamy soils (NSW Scientific Committee 2006). This species experiences short flowering events anytime between early September to late October (DEC (NSW) 2005j) and is unlikely to be readily detectable outside of flowering season.

The Muswellbrook population 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. This population is disjunct from other populations and highly restricted in its geographic distribution, found within an area measuring less than 50 km^2. This population exists at the eastern limit of the species' range.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove the known local population of the species.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove the known local population of the species.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species or populations.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

The Project will clear approximately 1928 ha of habitat for the population. As the population can occur in grassland, the Project is unlikely to fragment or isolate habitat for the population from other areas of habitat. As the species occurs in discrete colonies numbering from a few individuals to many, and since the Muswellbrook population appears to be patchily distributed, the habitat to be removed is likely to be important to the long-term survival of the population.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for Pine Donkey Orchid has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery or abatement plans have been prepared for this species or population.

No priority actions have been identified for this species or population.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The following KTP are relevant to both individuals and the Muswellbrook population of Pine Donkey Orchids:

- **Clearing of native vegetation** as this directly removes individuals and suitable habitat;
- **Invasion of native plant communities by exotic perennial grasses** as they compete with native ground covers;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they graze on and alter the structure and composition of vegetation, and degrade the land;

- **Competition and habitat degradation by Feral Goats *Capra hircus*** as they graze on and alter the structure and composition of vegetation, and degrade the land;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 1928 ha of habitat for this species through direct and indirect impacts. This includes the removal of habitat known to support individuals. Without the implementation of appropriate mitigation and offset measures, the removal of these individuals of this threatened species would be considered to result in a significant impact to both the species and Muswellbrook population.

I.8 Tiger Orchid Population Seven-part Test

Cymbidium canaliculatum (Tiger Orchid) is not listed as a threatened species. However, it is listed as an Endangered Population in the Hunter catchment under the TSC Act. There are 11 records of the species within the Muswellbrook LGA and none for the Singleton LGA (OEH 2011). A single individual was recorded within the study area by Cumberland Ecology.

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 estimated at between 90 to 300 individuals where they are commonly found in White Box-dominated woodlands, usually occurring singly or as a single clump, typically between 2 and 6 m above the ground (NSW Scientific Committee 2011). This 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).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable to endangered populations.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove the known local population of *Cymbidium canaliculatum* (Tiger Orchid).

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to endangered populations.

(d) in relation to the habitat of a threatened species, population or ecological community:

> *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*
>
> *(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of forest and woodland are proposed to be removed as part of the Project. This includes the direct removal of habitat known to support individuals of *Cymbidium canaliculatum* (Tiger Orchid).

The species is known to occur within the Wollemi and Goulburn River National Parks (Peake 2006) however less than 10% of the population is estimated to occur on land managed for conservation (NSW Scientific Committee 2011).

As the orchids are spread by birds, broad-scale vegetation removal which will result in habitat fragmentation may impact on the dispersal capabilities of relevant bird species and thus the incidence of seed deposit in the locality. Removal of suitable habitat is likely to adversely affect the long-term survival of individuals within the vicinity of the study area as large mature White Box intergrade trees with hollows are a limiting resource in the Hunter Valley.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for Tiger Orchid has been identified by the Director-General of OEH under the TSC Act.

The study area and surrounding habitat within the locality does constitute core habitat for the Hunter catchment population of this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans or priority actions have been identified for this population.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTP:

- **Clearing of native vegetation** as this directly removes individuals and suitable habitat, and fragments habitat for bird vectors;
- **Loss of hollow-bearing trees** as this reduces the abundance of hollows in which the species can settle;
- **Removal of dead wood and dead trees** as this reduces the abundance of important potential habitat; and

- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for this species through direct and indirect impacts. This includes the removal of habitat known to support individuals of *Cymbidium canaliculatum* (Tiger Orchid). Without amelioration, the removal of *Cymbidium canaliculatum* (Tiger Orchid) species is considered to result in a significant impact to the Hunter catchment population.

I.9 Black-chinned Honeyeater Seven-part Test

The Black-chinned Honeyeater (eastern subspecies) (*Melithreptus gularis gularis*) is listed as Vulnerable under the TSC Act. There are 40 records of the species within Muswellbrook LGA and 13 records within the Singleton LGA (OEH 2011). The species was tentatively recorded within the study area in 2000.

The eastern subspecies of the Black-chinned Honeyeater is endemic to eastern Australia from inland slopes of the Great Dividing Range to the coast (Pizzey & Knight, 2003). They are a blossom-dependent species that follow locally flowering trees where it forages among the canopy for nectar and honeydew. The species is most commonly found in the upper levels of dry open eucalypt woodlands and forest containing Box-Ironbark associations where they build suspended nests and feed on insects, nectar and lerps (DEC (NSW) 2005a).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove 389 ha of potential forage and breeding habitat for the Black-chinned Honeyeater. However, this is unlikely to place any local populations of the species at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

> *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*
>
> *(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*
>
> *(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and*

Approximately 389 ha of woodland and forest are proposed to be removed as part of the Project. This includes potential forage and nesting habitat for the Black-chinned Honeyeater, particularly preferred species such as *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), which are found in the study area. The removal of patches of native vegetation and scattered trees may affect connectivity and thus inhibit fauna movement and dispersal within the locality.

The study area lies within the known range of the Black-chinned Honeyeater. The species has only been tentatively recorded once in the study area and surrounds, which indicates that habitat within the study area is not core habitat and does not form part of the territorial range of a local population.

The long-term genetic viability of the Black-chinned Honeyeater in the locality is unlikely to be impacted as the species is an infrequent visitor, is mobile and has the capacity to disperse to areas of forest such as Wollemi National Park that will still provide extensive habitat greater than 200 ha. This is considered the minimum area of habitat required to support and maintain viable populations of the species (Higgins and Peter 2002; DECC (NSW) 2005a). Also, the remaining forest will provide important habitat features for the species including structurally intact habitat and complexity.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Black-chinned Honeyeater has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans or priority actions have been developed for this species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;

- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for this species through direct and indirect impacts. This includes the removal of potential forage, roosting and breeding habitat. While suitable habitat and feed trees are available, a resident population of Black-chinned Honeyeaters does not seem to occur within the study area or locality. As such, the Project is not considered likely to have a significant impact on the local occurrence of the Black-chinned Honeyeater.

I.10 Little Lorikeet Seven-part Test

The Little Lorikeet (*Glossopsitta pusilla*) is listed as Vulnerable under the TSC Act. There are 95 records of the species within the Muswellbrook LGA and 76 records within the Singleton LGA (OEH 2011). The species has not been recorded within the study area; however it has been recorded from surveys of the Mt Arthur Coal Mine lease (Cumberland Ecology 2009).

The Little Lorikeet (*Glossopsitta pusilla*) is a nectarivorous species endemic to eastern mainland Australia. In NSW, the species is most commonly found in dry, open sclerophyll forests and woodlands dominated by eucalypts, from the coast to the western slopes of the Great Dividing Range (Barrett, Silcocks et al. 2003; Pizzey and Knight 2003). The species has been found in both old-growth and logged forests in the eastern part of their range, and in remnant woodland patches and roadside vegetation on the western slopes, where it forages in the canopy. It is generally thought to be nomadic in response to food availability 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 (Higgins 1999). In some areas the species is considered resident, particularly during breeding season from April to December (NSW Scientific Committee 2009b).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage and breeding habitat for the Little Lorikeet. Based on a previous record in the adjoining Mt Arthur Coal Mine lease and high number of records within the LGA, the species is considered to have potential to occur based on the availability of suitable habitat. However, due to a lack of observations within the study area, the Project is considered unlikely to support and thus displace any resident populations of Little Lorikeet that would place the species at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of remnant woodland and forest is proposed to be removed as part of the Project. This includes potential forage, breeding and nesting habitat for the Little Lorikeet. Due to the species' capacity for dispersal, the removal of patches of native vegetation and scattered trees is unlikely to affect connectivity within the locality.

The study area lies within the known range of the Little Lorikeet. The species has not been recorded in the study area despite multiple surveys, which indicates that habitat within the study area does not constitute core habitat or form part of the territorial range of a local population.

The long-term genetic viability of the Little Lorikeet (*Glossopsitta pusilla*) in the locality is unlikely to be impacted as the species is an infrequent visitor, is mobile and has the capacity to disperse to areas of forest such as Wollemi National Park that will still provide extensive habitat greater than 100 ha. This is considered to be the minimum area of habitat required to support and maintain viable populations of the species (Higgins & Peter, 2002). Also, the remaining forest will provide important habitat features for the species including structurally intact habitat and complexity.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Little Lorikeet has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The "Threat Abatement Plan for Beak and Feather Disease affecting endangered psittacine species" is relevant to the species. The Proposal is unlikely to increase the likelihood of extinction or escalate the threatened status of psittacine birds and is therefore consistent with the objectives of this plan.

No other recovery plans have been prepared for this species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;

- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources;
- **Infection by Psittacine Circoviral (beak and feather) Disease** affecting endangered psittacine species and populations as this can lead to a severe reduction in populations;
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for this species through direct and indirect impacts. This includes the removal of potential forage, roosting and breeding habitat. The Little Lorikeet (*Glossopsitta pusilla*) is partly nomadic in response to food availability and is likely to occur elsewhere in the locality and Wollemi National Park. While suitable habitat and feed trees are available, a resident population of Little Lorikeet (*Glossopsitta pusilla*) does not seem to occur within the study area or locality. As such, the Project is not considered likely to have a significant impact on the local occurrence of the Little Lorikeet (*Glossopsitta pusilla*).

I.11 Regent Honeyeater Seven-part Test

The Regent Honeyeater (*Anthochaera phrygia*) is listed as Endangered under the TSC and EPBC Act. There are 16 records of the species within the Muswellbrook LGA and 83 within the Singleton LGA (OEH 2011). The species has not been recorded within the study area but has potential to occur during migrations.

The Regent Honeyeater (*Anthochaera phrygia*) is a nectarivorous migratory species endemic to south eastern Australia where it is widespread but sparsely scattered in temperate woodlands and open forests. In NSW the species mainly occurs around the Great Dividing Range, but has been recorded in the Hunter Valley and Pilliga regions (Pizzey & Knight, 2003; Birds Australia, 2011). They prefer Box-Ironbark associations in wet, fertile sites along creeklines and river valleys. There are only three known key breeding regions remaining: north east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region (NSW Scientific Committee 2004p). Numbers fluctuate greatly between years and sites, and movement outside of breeding season is poorly understood. Only 1,500 individuals are thought to make up the single subpopulation of this species. Regent Honeyeaters forage in the canopy tops of mature feed trees, but roost in saplings (Oliver D. L. 1998). This suggests that the species requires a more extensive area of habitat than other similar nectarivorous species.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage habitat for the Regent Honeyeater. The species is considered to have potential to occur during migrations. However, Regent Honeyeaters are unlikely to make significant recurrent use of the study area and as the species is migratory, the Project is unlikely to displace any populations or place the species at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable to threatened species.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

> *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of forest and woodland are proposed to be removed as part of the Project. This includes potential forage habitat for the Regent Honeyeater and the potential of forest and woodland areas of the study area to be "stepping stone" habitat within the wider locality and region.

The study area lies within the known migratory range of the Regent Honeyeater. The species has not been recorded in the study area despite multiple surveys, which indicates the sparse distribution of the species and that habitat within the study area does not constitute core habitat or form part of the territorial range of a local population. Regent Honeyeaters forage in the canopy tops of taller trees and thus mature trees are an important component of the forest and woodland matrix (Oliver, 2000). The species has been observed to roost in saplings of a variety of tree species and rarely use roost trees for feed trees (Oliver, 1998). This suggests that the area of habitat required by the Regent Honeyeater could be more extensive than for some other similar species.

The long-term genetic viability of the Regent Honeyeater is unlikely to be impacted by the Project as the species infrequently visits the region, is highly mobile; and has the capacity to disperse to areas of forest such as Wollemi National Park that will still provide extensive habitat. However, the removal of important flowering resources may be locally significant for the species in times of drought or low flowering season as remnant patches are already a limiting resource within the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Regent Honeyeater has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The Regent Honeyeater (*Anthochaera phrygia*) Recovery Plan 1999-2003 was prepared by the Commonwealth government in 1999 (Department of Enviroment and Conservation NSW 2004). The general aims of the plan included the protection and enhancement of key breeding and foraging habitats for this species. The study area does not occur in any key breeding or foraging areas for the Regent Honeyeater and is therefore consistent with recovery plans.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources;
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for this species through direct and indirect impacts. This includes the removal of potential forage habitat. While this species is migratory, flowering resources within the study area and wider locality may be locally significant for Regent Honeyeater (*Anthochaera phrygia*) as the vegetation represents islands of foraging habitat within a predominantly cleared agricultural landscape. The availability of remnant patches of woodland and forest becomes more significant during drought periods and poor flowering seasons elsewhere in the region which may increase the species' reliance on these conservation areas. Without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the local occurrence of the Regent Honeyeater.

I.12 Swift Parrot Seven-part Test

The Swift Parrot (*Lathamus discolor)* is listed as Endangered under the TSC Act. There are no records of the species within the Muswellbrook LGA and 10 records within the Singleton LGA (OEH 2011). The species was recorded within the study area in 2011. An individual was observed foraging on mistletoe and *E. moluccana* for lerps, and another individual was heard calling.

The Swift Parrot is a predominantly nectarivorous, migratory species endemic to south eastern Australia (Garnett and Crowley 2000). The species only breeds in Tasmania and is semi nomadic in winter when it migrates to south eastern Australia from March to October (Pizzey & Knight, 2003). On the mainland it is most commonly found in dry, open sclerophyll eucalypt forests and woodlands such as Box-Gum Woodland that occurs in the study area (NSW Scientific Committee 2004s). Swift Parrots often occur in urban areas, including farmland with remnant patches of eucalypt woodland. The timing of their migration causes a heavy reliance on the availability of lerps and winter-flowering eucalypts such as *Eucalyptus robusta* (Swamp Mahogany)*, Corymbia maculata* (Spotted Gum)*, Corymbia gummifera* (Red Bloodwood)*, Eucalyptus sideroxylon* (Mugga Ironbark)*,* and *Eucalyptus albens* (White Box) (Kennedy & Tzaros, 2005; Saunders & Heinsohn, 2008). The species has high site fidelity and returns to sites on a cyclic basis. However, this site fidelity depends on availability of foraging resources.

Winter-forage habitat for Swift Parrots occurs in the study area 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.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove known and potential forage habitat for the Swift Parrot. Individuals were recorded in the study area during 2011 surveys and are considered to have potential to forage in the study area during migrations.

Swift Parrots are unlikely to make significant recurrent use of the study area and as the species is migratory, the Project is unlikely to displace any populations or place the species at risk of extinction. However, the Project may reduce forage availability within an otherwise cleared locality that may be particularly important during times of drought.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of forest and woodland are proposed to be removed as part of the Project. This includes known forage habitat for the Swift Parrot.

The study area lies within the known migratory range of the Swift Parrot. The species been recorded once in the study area which indicates that while habitat within the study area does not constitute core habitat or form part of the territorial range of a local population, it does provide suitable 'stepping stone' habitat during migrations within the wider locality and region in the predominantly cleared surrounding locality.

The long-term genetic viability of the Swift Parrot is unlikely to be impacted by the Project as the species infrequently visits the region, is highly mobile; and has the capacity to disperse to areas of forest such as Wollemi National Park that will still provide extensive habitat. However, the removal of important flowering resources may be locally significant for the species in times of drought or low flowering season as remnant patches are already a limiting resource within the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Swift Parrot has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The Swift Parrot (*Lathamus discolor*) Recovery Plan 2001-2005 was prepared by the Tasmanian Department of Primary Industries, Water and Environment for the Commonwealth government in 2001.

The general aims of this plan include the protection and enhancement of key breeding and foraging habitats for the species. The study area occurs in foraging areas for the Swift Parrot and is therefore inconsistent with recovery plans.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for this species through direct and indirect impacts. This includes the removal of potential forage habitat. While this species is migratory, flowering resources within the study area and wider locality may be locally significant for Swift Parrots as the vegetation represents islands of foraging habitat within a predominantly cleared agricultural landscape. The availability of remnant patches of woodland and forest becomes more significant during drought periods and poor flowering seasons elsewhere in the region which may increase the species' reliance on these conservation areas.

Without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the local occurrence of the Swift Parrot.

I.13 Brown Treecreeper Seven-part Test

The Brown Treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*) is listed as Vulnerable under the TSC Act. There are 94 records of the species within the Muswellbrook LGA and 11 records within the Singleton LGA (OEH 2011). The species 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.

The Brown Treecreeper is an insectivorous woodland species endemic to eastern NSW. They are a sedentary species most commonly found in open woodlands and dry forest with an open grassy understorey for foraging, and in grasslands with scattered mature trees (Birds Australia, 2011; Garnett & Crowley, 2000). Suitable nesting and foraging habitat typically contains a high abundance of important habitat components such as fallen timber, hollows in stags and live trees (Garnett and Crowley 2000; DEC (NSW) 2005b). 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.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove known and potential forage and breeding habitat for the Brown Treecreeper, which is likely to have an adverse effect on the life cycle of individuals known to occur within the study area. The Project will displace a known breeding pair of Brown Treecreepers which may impact on local population dynamics and may place the local population at risk of extinction.

Low recruitment of females within isolated fragments indicates that female Brown Treecreepers rarely disperse naturally to territories within and between isolated fragments of habitat. This has an obvious effect on breeding and nesting success (Cooper and Walters, 2002) and will thus have significant impacts on the life cycle of local populations.

Remaining areas of remnant woodland and Wollemi National Park will continue to provide good quality habitat for Brown Treecreepers within the locality.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of remnant woodland and forest is proposed to be removed as part of the Project. This includes known and potential forage, breeding and nesting habitat for the Brown Treecreeper. The removal of patches of native vegetation and scattered trees will affect connectivity and thus inhibit fauna movement and dispersal within the locality.

The study area lies well within the known range of the Brown Treecreeper. The species has been consistently recorded in the study area and surrounds, which indicates that habitat within the study area constitutes core habitat and forms part of the 11 ha territorial range of at least one pair.

While habitat degradation plays a role in the decline of the species at a regional level, patch isolation is considered to be the main cause of breeding decline in the species (Cooper & Walters, 2002). The species' sedentary nature and limited capacity for dispersal means they are generally unable to move across open country greater than 100 m, making them susceptible to habitat fragmentation and genetic isolation (Cooper et al, 2002, Doerr et al, 2011). The species requires areas of habitat that are at least 300 ha to maintain viable populations (DECC (NSW) 2007a). Apart from Wollemi National Park, habitat of this extent and in the vicinity of the Project is limited, which will reduce the availability of suitable habitat such as ground forage and nesting habitat features. Also, limiting resources such as hollows may affect the emigration and nesting success of some individuals.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Brown Treecreeper has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species. Seven recommended actions have been identified to promote the recovery of this species and the abatement of KTP affecting its occurrence.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources;
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for this species through direct and indirect impacts. This includes the removal of known and potential forage, roosting and breeding habitat for locally occurring populations and isolation of habitat. The Brown Treecreeper is a woodland bird likely to occur elsewhere in the locality; however the Project will clear a large area of known habitat that provides limiting habitat resources for this sedentary species resulting in the likely displacement and loss of individuals. Without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the local occurrence of the Brown Treecreeper.

I.14 Diamond Firetail Seven-part Test

The Diamond Firetail (*Stagonopleura guttata*) is listed as Vulnerable under the TSC Act. There are 35 records of the species within the Muswellbrook LGA and 36 records within the Singleton LGA (OEH 2011). The species has been recorded in the study area on multiple occasions. Two individuals, including a juvenile, were recorded in remnant box woodland during the 2011 survey. The species has also been recorded from surveys of the Mt Arthur Coal Mine lease and Drayton Mine.

The Diamond Firetail is a woodland species endemic to south eastern Australia with scattered distribution in NSW (NSW Scientific Committee 2004d). This species occurs predominantly west of the Great Dividing Range, although populations are known from drier coastal areas such as the Cumberland Plain of western Sydney and the Hunter, Clarence, Richmond and Snowy River valleys. They are 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 2004d). They also occur in farmland and grassland with remnant trees and a sparse understorey, and along watercourses (Birds Australia, 2011). The species breeds from August to December in small breeding colonies and nest in shrubby understorey, preferentially in mistletoe (Cooney and Watson, 2005).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove known and potential forage and breeding habitat for the Diamond Firetail, which is likely to have an adverse effect on the life cycle of individuals known to occur within the study area. A juvenile was observed being fed by an adult during 2011 surveys. This strongly suggests that breeding took place on site, rather than immigration, as the capacity for a dependent juvenile to disperse is limited (Higgins, Peter et al. 2006). The Project will displace a known pair of Diamond Firetail which may impact on local population dynamics and may place the local population at risk of extinction. Remaining areas of remnant woodland and Wollemi National Park will continue to provide good quality habitat for Diamond Firetails within the locality.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of woodland and forest is proposed to be removed as part of the Project. This includes known and potential forage, breeding and nesting habitat for the Diamond Firetail. The removal of patches of native vegetation and scattered trees will affect connectivity and thus inhibit fauna movement and dispersal within the locality.

The study area lies well within the known range of the Diamond Firetail. The species has been recorded in the study area and surrounds on multiple occasions, which indicates that habitat within the study area constitutes core habitat and is within the territorial range of a local population.

The species is vulnerable to fragmentation and genetic isolation due to its sedentary nature and dispersal capacity is restricted to local movements (Lindenmayer and Cunningham 2011). The Project will displace individuals of the species known to occur within the study area which may impact on population dynamics within the locality, particularly as populations are unable to persist in areas which lack remnant native vegetation larger than 200 ha (NSW Scientific Committee 2004d).

However, the long-term genetic viability of the species in the locality is unlikely to be impacted as remaining areas of forest will still provide suitable habitat, including important ground habitat features such a grassy understorey for foraging, thus supporting and maintaining viable populations of the species (Higgins & Peter, 2002).

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Diamond Firetail has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species. Eight recommended actions have been identified to promote the recovery of this species and the abatement of KTP affecting its occurrence.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for this species through direct and indirect impacts. This includes the removal of known forage, roosting and breeding habitat for locally occurring populations of the species. The Diamond Firetail is a woodland bird likely to occur elsewhere in the locality; however the Project will clear a large area of known habitat that provides limiting habitat resources for this sedentary species, resulting in the likely displacement and loss of individuals. Without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the local occurrence of the Diamond Firetail.

I.15 Flame Robin Seven-part Test

The Flame Robin (*Petroica phoenicea*) is listed as Vulnerable under the TSC Act. There are three records of this species within the Muswellbrook LGA and eight records within the Singleton LGA (OEH 2011). The species has not been recorded within the study area, however it is considered to have potential to fly over during winter migrations.

The Flame Robin 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, 2011). 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. They construct small cup nests in tree cavities or rock faces.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage habitat for this species when it migrates to the slopes and plains of the region during winter. Although the species has not been recorded within the study area and has a low LGA count, the study area offers some suitable habitat as the species feeds mainly in extensive open areas such as pastures and uses remnant native vegetation for shelter and roosting,

Despite this, the study area is considered unlikely to support local winter-populations of the Flame Robin. Remaining areas of remnant woodland and Wollemi National Park will continue to provide good quality habitat for Flame Robins within the locality. It is thus considered that the Project will not place the species at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of woodland and forest is proposed to be removed as part of the Project. This includes potential forage habitat for the Flame Robin. The study area lies within the known migration range of the Flame Robin and while the species prefers open grassland habitat and patches of remnant vegetation such as that in the study area, the Project is unlikely to affect connectivity for this migratory species or affect its dispersal capacity within the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Flame Robin has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species. Three recommended actions have been identified to promote the recovery of this population and the abatement of KTP affecting its occurrence.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of forest and woodland. This includes the removal of potential forage habitat. Due to the species' irregular migratory movements and high capacity for dispersal, it is considered unlikely that the Project will have a significant impact on the local occurrence of the Flame Robin.

I.16 Gang-gang Cockatoo Seven-part Test

The Gang-gang Cockatoo (*Callocephalon fimbriatum*) is listed as Vulnerable under the TSC Act. There are 40 records of the species within the Muswellbrook LGA and 138 records within the Singleton LGA (OEH 2011). The species has not been recorded in the study area.

The Gang-gang Cockatoo is endemic to south eastern Australia, with distribution along the coast and tablelands of NSW. The species breeds in heavily timbered and mature wet sclerophyll mountain forests (DEC (NSW), 2005f), then migrate to open forest and woodland such as Box-Ironbark in the lower valleys and coastal regions for the winter (Schodde and Tidemann 1986). The species requires tree hollows in tall old growth living trees, often near water, for nesting. They form close monogamous pairs with high nest fidelity and often breed semi-colonially where densities are high. Breeding usually occurs in tall mature sclerophyll forests that have a dense understorey (DEC (NSW) 2005f) and nest territories range from 7 to 22 km^2. The Gang-gang Cockatoo feeds primarily on the seeds of native shrubs and trees, including eucalypts, acacias and cypress pine (Schodde and Tidemann, 1986).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage and breeding habitat for the Gang-gang Cockatoo. The species is considered sedentary with some limited movement within nest territories of 7 to 22 km^2. Habitat clearance may affect the capacity of some individuals to disperse and successfully relocate to surrounding habitat. However, as the species has not been recorded within the study area or surrounds despite multiple surveys, the study area is not considered to support a resident local population and is therefore unlikely to have an adverse effect on the life cycle of the species.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of woodland and forest is proposed to be removed as part of the Project. This includes potential forage, breeding and nesting habitat for the Gang-gang Cockatoo. The removal of patches of native vegetation and scattered trees will affect connectivity and thus inhibit fauna movement and dispersal within the locality.

The study area lies within the known range of the Gang-gang Cockatoo. The species is vocal and has high nest fidelity, and if a local population occurred, would be easily detectable. Despite multiple surveys of the study area and surrounding habitat in the Mt Arthur Coal Mine lease, no individuals have been recorded. This indicates that habitat within the study area does not constitute core habitat or form part of the territorial range of a local population. The Project is unlikely to affect the long-term genetic viability of the species and will not place any local populations of the species at risk of extinction.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Gang-gang Cockatoo has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The "Threat Abatement Plan for Beak and Feather Disease affecting endangered psittacine species" is relevant to the Gang-gang Cockatoo. The Proposal is unlikely to increase the likelihood of extinction or escalate the threatened status of psittacine birds and is therefore consistent with the objectives of this plan.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;

- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Infection by Psittacine Circoviral (beak and feather) Disease** affecting endangered psittacine species and populations as this can lead to a severe reduction in populations;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees *(Apis mellifera)*** as they compete with native fauna for tree hollows and floral resources;
- **Predation by the feral cat (*Felis catus*)** as this directly reduces species abundance, particularly as they predate on nests and nesting females; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of forest and woodland that includes habitat for the Gang-gang Cockatoo. This includes the removal of potential forage, roosting and breeding habitat. The species has not been recorded in the study area. Despite the removal of forest and woodland habitat, the Project is considered unlikely to have a significant impact on any potentially occurring local populations of the Gang-gang Cockatoo.

I.17 Glossy Black-Cockatoo Seven-part Test

The Glossy Black-Cockatoo (*Calyptorhynchus lathami*) is listed as Vulnerable under the TSC Act. There are 76 records of the species within the Muswellbrook LGA and 141 records within the Singleton LGA (OEH 2011). The species has not been recorded in the study area.

The Glossy Black-Cockatoo 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, and they prefer to fly over intact habitat rather than open country. 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 (NSW NPWS 1999a; NSW Scientific Committee 2004g).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage and breeding habitat for the Glossy Black-Cockatoo. Glossy Black-Cockatoos are highly mobile and may use wooded areas in the locality, including the study area, as habitat 'stepping stones' to forage during long-distance commutes of up to 60 km. However, as the species tends not to inhabit cleared areas and has not been recorded within the study area despite multiple surveys, the study area is not considered to support a local population and is therefore unlikely to have an adverse effect on the life cycle of the species.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

> *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of woodland and forest is proposed to be removed as part of the Project. This includes potential forage, breeding and nesting habitat for the Glossy Black-Cockatoo. The removal of patches of native vegetation and scattered trees will affect connectivity which may inhibit the species' movement and dispersal within the locality, as well as remove suitable hollows for nesting.

The study area lies within the known range of the Glossy Black-Cockatoo. Despite multiple surveys of the study area and surrounding habitat in the Mt Arthur Coal Mine lease, no individuals have been recorded. This indicates that habitat within the study area does not constitute core habitat or form part of the territorial range of a local population. The Project is unlikely to affect the long-term genetic viability of the species and will not place any local populations of the species at risk of extinction.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Glossy Black-Cockatoo has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The "Threat Abatement Plan for Beak and Feather Disease affecting endangered psittacine species" is relevant to the Glossy Black-Cockatoo. The Proposal is unlikely to increase the likelihood of extinction or escalate the threatened status of psittacine birds and is therefore consistent with the objectives of this plan.

Three recommended actions have been identified to promote the recovery of this species and the abatement of KTP affecting its occurrence.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;

- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Infection by Psittacine Circoviral (beak and feather) Disease** affecting endangered psittacine species and populations as this can lead to a severe reduction in populations;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees *(Apis mellifera)*** as they compete with native fauna for tree hollows and floral resources;
- **Predation by the feral cat (*Felis catus*)** as this directly reduces species abundance, particularly as they predate on nests and nesting females; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of forest and woodland that includes habitat for the Glossy Black-Cockatoo. The species has not been recorded in the study area and despite the removal of forest and woodland habitat, the Project is considered unlikely to have a significant impact on any potentially occurring local populations of the Glossy Black-Cockatoo.

I.18 Grey-crowned Babbler Seven-part Test

The Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*) is listed as Vulnerable under the TSC Act. There are 45 records of the species within the Muswellbrook LGA and 250 records within the Singleton LGA (OEH 2011). The species is considered locally abundant, having been consistently recorded within the study area and Mt Arthur Coal Mine lease. A number of individuals were recorded in planted vegetation during the 2011 survey session.

The Grey-crowned Babbler (eastern subspecies) is a woodland insectivorous species endemic to eastern Australia. The species is abundant and widespread in northern Queensland, but is in considerable decline in the southern part of its range in Victoria and NSW. It is a ground-dwelling, sedentary species most commonly found in open forest and woodland dominated by acacias or eucalypt Box-Ironbark associations where they live in extended family groups (NSW Scientific Committee 2004i). The species forages for insects on trunks and branches of eucalypts and other woodland trees, and on the ground amongst litter and tussock grasses (Garnett & Crowley, 2000).

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, 2011).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove known and potential forage and breeding habitat for the Grey-crowned Babbler, which is likely to have an adverse effect on the life cycle of individuals known to occur within the study area.

The Project will displace known subpopulations of the species which will impact on population dynamics within the area. Habitat in the study area supports at least two separate groups of Grey-crowned Babblers, where active nests were observed at both sites in both young and mature eucalypts. The Project is thus likely to impact on the capacity of some individuals to disperse and relocate to surrounding habitat within the locality, leading to social consequences such as smaller group size and reduced breeding success. This may place the local population at risk of extinction. Remaining areas of remnant woodland and Wollemi National Park will continue to provide good quality habitat for Grey-crowned Babblers within the locality.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 1928 ha of remnant and regenerating forest and woodland, and some areas of grassland are proposed to be removed as part of the Project. This includes known and potential forage, breeding and nesting habitat for the Grey-crowned Babbler. The removal of patches of native vegetation and scattered trees will affect connectivity and thus inhibit fauna movement and dispersal within the locality.

The study area lies well within the known range of the Grey-crowned Babbler. The species has been consistently recorded in the study area and surrounds. The presence of active nests at two sites indicates that habitat within the study area constitutes core habitat and constitutes the territorial range of a local breeding population.

The Project is expected to have some adverse affects on the relocation of individuals of the local population due to a loss of critical habitat features listed above and as the species has limited capacity to disperse due to its sedentary nature. The species is highly susceptible to habitat fragmentation. Laboured flight and their inability to cross large open areas greater than 900 m (Blackmore et al, 2011), 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 (Birds Australia, 2011). Once lost from a fragment, natural recolonisation is unlikely (Garnett & Crowley, 2000).

The long-term genetic viability of the species in the locality is unlikely to be impacted as areas of forest elsewhere in the locality will still provide suitable habitat greater than 100 ha. This is considered the minimum area of habitat required to support and maintain viable populations of the species (Higgins & Peter 2002). Also, the remaining forest will provide critical habitat features for the species including structurally intact habitat and complexity, and important midstorey and ground habitat features such as nesting debris and foraging substrates (NSW Scientific Committee 2004i).

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Grey-crowned Babbler has been identified by the Director-General of OEH under the TSC Act.

The study area and surrounding habitat does not constitute critical habitat for this species. However, it does provide suitable nesting and forage habitat.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species. Nine recommended actions have been identified to promote the recovery of this species and the abatement of KTP affecting its occurrence.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 1928 ha of woodland habitat for this species through direct and indirect impacts. This includes the removal of known forage, roosting and breeding habitat for locally occurring populations of the species. The Grey-crowned Babbler is a woodland bird likely to occur elsewhere in the locality; however the Project will clear a large area of known habitat that provides limiting habitat resources for this sedentary species, resulting in the likely displacement and loss of individuals. Without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the local occurrence of the Grey-crowned Babbler.

I.19 Hooded Robin Seven-part Test

The Hooded Robin (south eastern form) (*Melanodryas cucullata cucullata*) is listed as Vulnerable under the TSC Act. There are two records of the species within the Muswellbrook LGA and four records within the Singleton LGA (OEH 2011). The species has been recorded once during previous surveys of the study area, and once from surveys of the Mt Arthur Coal Mine lease.

The Hooded Robin (south eastern form) is a woodland species with a sparse distribution 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, 2011). 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 and 5 m (NSW Scientific Committee 2004k; DECC (NSW) 2005b).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage and breeding habitat for individuals of the species that may occur within the study area and surrounds. Due to a general lack of observations within the study area and very low LGA count, the study area is considered unlikely to support a resident local population of Hooded Robins and will thus not place the species at risk of extinction. Remaining areas of remnant woodland and Wollemi National Park will continue to provide good quality habitat for Hooded Robins within the locality.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

> *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of remnant and regenerating woodland and forest is proposed to be removed as part of the Project. This includes potential forage, breeding and nesting habitat for the Hooded Robin. The removal of patches of native vegetation and scattered trees will affect connectivity and thus inhibit fauna movement and dispersal within the locality.

The study area lies within the known range of the Hooded Robin. The species has a low count in the locality and has only been recorded in the study area on one occasion, which indicates that habitat within the study area does not form part of the territorial range of a local population.

The species is particularly affected by understorey clearing which impacts on their foraging and nesting success. The species' sedentary nature and limited capacity for dispersal means they are susceptible to habitat fragmentation and genetic isolation; even in large remnant patches Hooded Robins are unable to sustain populations in the long term, which can lead to local extinctions (Birds Australia, 2011). Once forced from a fragment they are unlikely to recolonise new habitat without assistance (Cooper et al, 2002, Garnett & Crowley, 2000).

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Hooded Robin has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;

- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of forest and woodland that has been used as habitat for this species through direct and indirect impacts. This includes the removal of potential forage, roosting and breeding habitat. Although only limited records exist for this species in the study area, on a precautionary basis it is concluded that due to the extent of forest and woodland removal, without the implementation of appropriate mitigation and offset measures, the Project would be likely to have a significant impact on the local occurrence of the Hooded Robin.

I.20 Satin Flycatcher Seven-part Test

The Satin Flycatcher (*Myiagra cyanoleuca*) is listed as Marine and Migratory under the EPBC Act. There are two records of the species within the Muswellbrook LGA and 14 records within the Singleton LGA (OEH 2011). The species has not been recorded within the study area, but has previously been recorded during surveys of the Mt Arthur Coal Mine lease.

The Satin Flycatcher is a widely distributed insectivore in eastern Australia; in NSW they are widespread on the east of the Great Divide and sparsely scattered on the western slopes, with very occasional records on the western plains (Blakers, Davies et al. 1984; Cooper and McAllan 1995). The species has erratic migration movements but are generally recorded in passage across NSW between September and October. They are 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. Satin Flycatchers prefer 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.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage habitat for this species if individuals overfly the study area infrequently during migrations. Due to a general lack of observations within the study area, low LGA count and fact the species only migrates across NSW in September through to October, the study area will not support a resident local population of Satin Flycatchers. It is thus considered that the Project will not place the species at risk of extinction.

Remaining areas of remnant woodland and Wollemi National Park will continue to provide good quality habitat for Satin Flycatchers within the locality.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of forest and woodland is proposed to be removed as part of the Project. This includes potential forage habitat for the Satin Flycatcher. While the study area lies within the known migration range of the Satin Flycatcher, the removal of patches of native vegetation and scattered trees is unlikely to affect connectivity for this migratory species or affect its dispersal capacity within the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Satin Flycatcher has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of forest and woodland. This includes the removal of potential forage habitat. Due to the species' irregular migratory movements and high capacity for dispersal, it is considered unlikely that the Project will have a significant impact on the local occurrence of the Satin Flycatcher.

I.21 Scarlet Robin Seven-part Test

The Scarlet Robin (*Petroica boodang*) is listed as Vulnerable under the TSC Act. There are 12 records of the species within the Muswellbrook LGA and 31 records within the Singleton LGA (OEH 2011). The species has been recorded on multiple occasions within the study area, including the 2011 survey session.

The Scarlet Robin is an insectivorous, woodland species endemic to south eastern NSW and south western WA. Core bioregions for the species are on the slopes and tablelands of NSW. 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, although it may also use paddocks with scattered remnant trees (Birds Australia, 2011). 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 – January and builds nests in tree forks (DECCW (NSW) 2010c).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will displace known and potential breeding and forage habitat for the Scarlet Robin, which is likely to have an adverse effect on the life cycle of individuals known to occur within the study area. 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 and local populations are present in the study area.

The Project is likely to displace locally occurring pairs or a population of Scarlet Robins and impact on the capacity of some individuals to disperse and relocate to surrounding habitat within the locality. This may impact on population dynamics within the area, particularly as the species is not well represented in the LGA, and lead to social consequences such as smaller group size and reduced breeding success. Remaining areas of remnant woodland and Wollemi National Park will continue to provide good quality habitat for Scarlet Robins within the locality.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable to threatened species.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of remnant forest and woodland, and some areas of grassland are proposed to be removed as part of the Project. This includes known and potential forage, breeding and nesting habitat for the Scarlet Robin. The removal of patches of native vegetation and scattered trees will affect connectivity and thus inhibit fauna movement and dispersal within the locality.

The study area lies within the known range of the Scarlet Robin. The species has a low count in the locality but has been recorded in the study area on multiple occasions. Individuals were recorded in 2011 in regenerating and remnant sheoak and Box-Gum Woodland in the study area to the west of Edderton Road. Territorial calls of males were heard at different locations, which indicates that habitat within the study area may support two separate, permanent territories.

The species is particularly affected by understorey clearing which impacts on their foraging and nesting success. Due to low recruitment rates and short distance movements (Debus 2006), habitat fragmentation will increase the species' vulnerability to genetic isolation by restricting dispersal. The species is rarely found, and unlikely to recover unassisted, in isolated patches of vegetation less than 30 ha where tree cover is absent within 200 m (NSW Scientific Committee 2010c). Populations begin to recover once grazing is excluded from a suitable habitat site and where native grasses dominate.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Scarlet Robin has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of woodland habitat for this species through direct and indirect impacts. This includes the removal of known forage, roosting and breeding habitat for locally occurring populations of the species. The Scarlet Robin is a woodland bird uncommon in the locality, however it has been recorded on multiple occasions in the study area indicating habitat represents core habitat for a local group. The Project will clear a large area of known habitat that provides limiting habitat resources for this sedentary species, resulting in the likely displacement and loss of individuals. As such, without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the local occurrence of the Scarlet Robin.

I.22 Speckled Warbler Seven-part Test

The Speckled Warbler (*Pyrrholaemus saggitatus*) is listed as Vulnerable under the TSC Act. There are 113 records of the species within the Muswellbrook LGA and 130 records within the Singleton LGA (OEH 2011) and the species is considered locally abundant within the locality. The species has been recorded in the study area on multiple occasions. Speckled Warblers were consistently detected in regenerating sheoak and box woodland at four locations during the 2011 survey session.

The Speckled Warbler is a woodland species endemic to south eastern Australia. The species is most commonly found in eucalypt-dominated dry sclerophyll forest and woodland with a grassy understorey (NSW Scientific Committee 2004q), particularly on the western slopes and tablelands of the Great Dividing Range and along the drier sections of the coast (Garnett & Crowley, 2002). It is a territorial, sedentary species with a typical home range of approximately 10 ha (DEC (NSW) 2005l). It 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.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove known and potential forage and breeding habitat for the Speckled Warbler, which is likely to have an adverse effect on the life cycle of individuals known to occur within the study area. The Project will displace known populations of the species at four locations, which will impact on local population dynamics within the area. This may affect the capacity of some individuals to disperse and relocate to surrounding habitat elsewhere in the locality which may place the local population at risk of extinction. However, the species is considered to have long-term viability due to the local abundance of the species.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of remnant and regenerating woodland and forest is proposed to be removed as part of the Project. This includes known and potential forage, breeding and nesting habitat for the Speckled Warbler. The removal of patches of native vegetation and scattered trees will affect connectivity and thus inhibit fauna movement and dispersal within the locality.

The study area lies well within the known range of the Speckled Warbler. The species has consistently been recorded in the study area and surrounds, which indicates that habitat within the study area constitutes core habitat for local populations. The consistent recording on individuals during 2011 surveys suggests up to four discrete and stable social groups are utilising habitat within the study area throughout winter (Gardner 2004).

The Project is expected to have some adverse affects on the relocation of locally occurring individuals. The species currently exists as small isolated groups and requires large, relatively undisturbed patches of remnant vegetation to persist in an area. 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 & Crowley, 2002), thus also impacting on genetic viability of subpopulations (Birds Australia, 2011). Subpopulations of the species have been known to decline some 30 years after isolation as a result of smaller, fragmented habitat (Garnett & Crowley, 2000). The Project is thus likely to impact on the long-term genetic viability of the species in the locality, despite the availability of habitat elsewhere in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Speckled Warbler has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of potential forage and shelter habitat;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for this species through direct and indirect impacts. This includes the removal of known and potential forage, roosting and breeding habitat for locally occurring populations of the species. The Speckled Warbler is a woodland bird likely to occur elsewhere in the locality; however the Project will clear a large area of known habitat that provides limiting habitat resources for this sedentary species, resulting in the likely displacement and loss of individuals. As such, without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the local occurrence of the Speckled Warbler.

I.23 Turquoise Parrot Seven-part Test

The Turquoise Parrot (*Neophema pulchella*) is listed as Vulnerable under the TSC Act. There are 49 records of the species within the Muswellbrook LGA and 10 records within the Singleton LGA. The species has not been recorded in the study area, although it has been recorded from surveys of the Mt Arthur Coal Mine lease.

The Turquoise Parrot is a woodland species endemic to south eastern Australia with patchy distribution in NSW. It occurs on the western side of the tablelands and inland slopes, plains and some dry coastal valleys in eastern NSW (Pizzey & Knight, 2003). The species is most commonly found in and on the edges of open, grassy woodland composed of mixed assemblages of eucalypt species, including Box-Ironbark, with abundant hollow-bearing trees and stags for nesting (NSW NPWS 1999c; NSW Scientific Committee 2004t). The Turquoise Parrot occurs solitarily, in pairs, in family groups, or in small flocks. It breeds in solitary pairs, though pairs are possibly clumped in favoured nesting patches. Turquoise Parrots are generally resident in an area, but some local seasonal movement occurs. Foraging is typically ground-based among seeding grasses and weeds, and sometimes near cropland (Birds Australia, 2011). It nests in tree hollows, logs or posts, from August to December (DEC (NSW) 2005p).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage and breeding habitat for the Turquoise Parrot. The species is highly territorial and defends nest sites against others of the species. It is also a sedentary species with a limited home range and habitat clearance would affect the capacity of some individuals to disperse and successfully relocate to surrounding habitat. However, as the species has not been recorded within the study area despite multiple surveys, the study area is not considered to support a resident local population and is therefore unlikely to have an adverse effect on the life cycle of the species.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of remnant and regenerating woodland and forest is proposed to be removed as part of the Project. This includes potential forage, breeding and nesting habitat for the Turquoise Parrot. The removal of patches of native vegetation and scattered trees will affect connectivity and thus inhibit fauna movement and dispersal within the locality.

The study area lies well within the known range of the Turquoise Parrot. The study area has potential to support a population of Turquoise Parrots as breeding density can be between four to seven breeding pairs per hectare, with nests as little as 8 m apart in suitable habitat (NSW Scientific Committee 2004t). Also, Turquoise Parrots are generally resident species with limited home territories ranging up to 1.4 km, though feeding mostly occurs within 100 m of the nest. They have infrequent seasonal movements between forested and open areas, typically less than 10 km along treed corridors (Higgins 1999).

The species has not been recorded in the study area, which indicates that habitat within the study area does not constitute core habitat or form part of the territorial range of a local population. The Project is unlikely to affect the long-term genetic viability of the species and will not place any local populations of the species at risk of extinction.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Turquoise Parrot has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The “Threat Abatement Plan for Beak and Feather Disease affecting endangered psittacine species” is relevant to the Turquoise Parrot. The Proposal is unlikely to increase the likelihood of extinction or escalate the threatened status of psittacine birds and is therefore consistent with the objectives of this plan.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;

- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Infection by Psittacine Circoviral (beak and feather) Disease** affecting endangered psittacine species and populations as this can lead to a severe reduction in populations;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees *(Apis mellifera)*** as they compete with native fauna for tree hollows and floral resources;
- **Predation by the feral cat (*Felis catus*)** as this directly reduces species abundance, particularly as they predate on nests and nesting females; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of forest and woodland that includes habitat for this species. This includes the removal of potential forage, roosting and breeding habitat. Although only limited records exist for this species in the locality, on a precautionary basis it is concluded that due to the extent of forest and woodland removal, without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the local occurrence of the Turquoise Parrot.

I.24 Varied Sittella Seven-part Test

The Varied Sittella (*Daphoenositta chrysoptera)*is listed as Vulnerable under the TSC Act. There are 57 records of the species within the Muswellbrook LGA and 60 records within the Singleton LGA (OEH 2011). The species has not been recorded within the study area. It has been recorded from surveys of the Mt Arthur Coal Mine lease.

The Varied Sittella is an insectivorous woodland species endemic and widespread in across mainland Australia with a nearly continuous distribution in NSW from the coast to the far west (Higgins and Peter 2002; Barrett, Silcocks et al. 2003). They are a sedentary species most commonly found in eucalypt woodlands and dry forest, and acacia woodland containing mature trees and dead branches (Birds Australia, 2011). The species feeds on arthropods and insects on stags, dead branches, in decorticating bark and in the canopy. The Varied Sittella often re-uses the same fork or living tree to build its nest in successive years (NSW Scientific Committee 2010e).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage and breeding habitat for the Varied Sittella. As the species has not been recorded within the study area despite multiple surveys, the study area is not considered to support a local population and is therefore unlikely to have an adverse effect on the life cycle of the species.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

> *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*
>
> *(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of remnant and regenerating forest and woodland are proposed to be removed as part of the Project. This includes potential forage, breeding and nesting habitat for the Varied Sittella. The removal of patches of native vegetation and scattered trees will affect connectivity which may inhibit the species' movement and dispersal within the locality. The species is susceptible to decline due to a reduction of habitat patch size and quality, habitat isolation and reduction in vegetation cover (NSW Scientific Committee 2010e). The species' sedentary nature and limited capacity for dispersal means they are generally unable to move across open country, which is also attributed to their decline.

However, the species has not been recorded in the study area, which indicates that habitat within the study area does not constitute core habitat or form part of the territorial range of a local population. The Project is unlikely to affect the long-term genetic viability of the species and will not place the species at risk of extinction.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Varied Sittella has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;

- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of forest and woodland that includes habitat for this species. This includes the removal of potential forage, roosting and breeding habitat. Although only limited records exist for this species in the locality, on a precautionary basis it is concluded that due to the extent of forest and woodland removal, without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the local occurrence of the Varied Sittella.

I.25 Barking Owl Seven-part Test

The Barking Owl (*Ninox connivens*) is listed as Vulnerable under the TSC Act. There are 13 records of the species within the Muswellbrook LGA and 11 records within the Singleton LGA (OEH 2011). The species was tentatively recorded during nocturnal bird surveys within the study area in 2000 (Ecotone 2000).

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 red gums (Birds Australia, 2011). 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).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

For the purposes of the following assessment of significance, for such widely dispersed raptorial birds with relatively large territories, it is assumed that a viable local population may be as little as a single nesting pair of birds.

The Project will remove potential forage and roosting habitat for the Barking Owl; however this is unlikely to affect the life cycle or overall viability of the species. The species is not well represented in the locality, most likely due to the lack of suitable hollows for roosting.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of these species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

The study area lies well within the known range of the Barking Owl. The removal of patches of native vegetation and scattered trees is unlikely to affect connectivity or the species' movement and dispersal within the locality as they are highly mobile species with naturally sparse distribution and extensive home ranges.

Approximately 389 ha of forest and woodland are proposed to be removed as part of the Project. The species has not been positively identified in the study area and no roost sites were identified during surveys. The study area supports forage resources (mammal and bird prey) and is likely to form part of the home range for individuals or pairs that may occur within the LGA.

The species has specific roosting requirements and any loss of remnant habitat will reduce the availability of large hollows for the Barking Owl. Hollows of the size and depth required for the species are a severely limited resource and depend on remnant trees that are at least 150 years old, of which there are few stands left in the Hunter region. Loss of structural complexity and agricultural practices such as grazing also reduces habitat for prey species (Garnett and Crowley 2000).

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Barking Owl has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The Project will remove remnant hollow-bearing trees and is therefore not consistent with the objectives and actions of the 2003 Draft "Recovery Plan for the Barking Owl". No Threat Abatement Plans apply to this species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;

- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for this species through direct and indirect impacts. This includes the removal of potential roosting, breeding and forage habitat, including the removal of suitable habitat for prey species. However, this species is an infrequent visitor to the locality and is highly mobile with a large home range. As such, the Project is not considered likely to have a significant impact on the local occurrence of the Barking Owl.

I.26 Little Eagle Seven-part Test

The Little Eagle (*Hieraaetus morphinoides*) is listed as Vulnerable under the TSC Act. There are three records of the species within the Muswellbrook LGA and 17 records within the Singleton LGA (OEH 2011). An individual was observed feeding in riparian vegetation in the study area during the 2011 survey session.

The Little Eagle is a small, territorial raptor, uncommon but with widespread distribution across mainland Australia (Pizzey & Knight, 2003). 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 (Debus, 1984). The species is tolerant of agricultural landscapes provided woodland habitat is available for nesting (Marchant & Higgins, 1993), where they require a tall living tree within a remnant patch.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove known and potential forage and breeding habitat of the Little Eagle. For such widely dispersed raptorial birds with relatively large territories, it is assumed that a viable local population may be as little as a single nesting pair of birds.

Survey results and LGA records indicate the species forages and may potentially breed within forest and woodland habitat in the locality. The species has sparse but widespread distribution across most of Australia; as a higher order predator, the species naturally occurs in low numbers. The species is highly mobile and has the capacity to disperse and relocate to surrounding habitat within the locality

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

> *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

The study area lies well within the known range of the Little Eagle. Approximately 389 ha of forest and woodland, and 1539 ha of grassland are proposed to be removed as part of the Project. This includes known and potential forage, breeding and nesting habitat for the Little Eagle. The species requires tall, mature living trees in open eucalypt woodland for nesting, which will be removed by the Project. The Project will also remove habitat for prey species. These may have some adverse effects on locally occurring individuals but habitat within the study area is not considered to represent core habitat.

The long-term genetic viability of the species in the locality is unlikely to be impacted as the species is highly mobile, has a large home range and naturally sparse distribution, and will be able to disperse to woodland margins and surrounding agricultural land elsewhere in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Little Eagle has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;

- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 1928 ha of habitat for this species through direct and indirect impacts. This includes the removal of potential roosting, breeding and forage habitat, including the removal of suitable habitat for prey species. However, this species is an infrequent visitor to the locality and is highly mobile with a large home range. As such, the Project is not considered likely to have a significant impact on the local occurrence of the Little Eagle.

I.27 Masked Owl Seven-part Test

The Masked Owl (*Tyto novaehollandiae*) is listed as Vulnerable under the TSC Act. There are 10 records of the species within the Muswellbrook LGA and 20 records within the Singleton LGA. The species has previously been recorded in the Mt Arthur Coal Mine lease.

The Masked Owl is restricted to the coast of NSW and Victoria (Pizzey & Knight, 2003), with approximately 90% of records within NSW. There is no seasonal variation in its distribution. The species is found within a diverse range of habitats that provide large hollow-bearing trees for roosting and nesting, typically in riparian vegetation, and adjacent open areas for foraging. The Masked Owl is also tolerant of disturbed areas and has a close association with drier, unlogged, or selectively logged forests (Kavanagh, 2002). It is most commonly found within dry eucalypt forests and woodland from sea level to 1100 m. Pairs of Masked Owls have a large home range of 500 to 1000 ha (NSW Scientific Committee 2004n). The species is threatened by clearing which reduces habitat availability, particularly by limiting nesting resources, and because regrowth after logging makes the habitat less suitable for foraging on key prey such as terrestrial mammals.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage and roosting habitat for the Masked Owl; however this is unlikely to affect the life cycle or overall viability of the species. For such widely dispersed raptorial birds with relatively large territories, it is assumed that a viable local population may be as little as a single nesting pair of birds.

The Project will remove potential forage habitat for this species however this is unlikely to adversely affect the life cycle of the Masked Owl. The species is not well represented in the locality, most likely due to the lack of suitable hollows for roosting. This species is unlikely to roost or breed in the study area as no large tree hollows in moist forested gullies or caves is available within the study area.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of these species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

The study area lies well within the known range of the Masked Owl. The removal of patches of native vegetation and scattered trees is unlikely to affect connectivity or the species' movement and dispersal within the locality as they are highly mobile species with naturally sparse distribution and extensive home ranges.

Approximately 1928 ha of forest, woodland and grasslands are proposed to be removed as part of the Project. The species has not been identified in the study area and no roost sites were identified during surveys. However, the study area supports forage resources (mammal and bird prey) and is likely to form part of the home range for individuals or pairs that may occur within the LGA.

The species has specific roosting requirements and any loss of remnant habitat will reduce the availability of large hollows for the Masked Owl. Hollows of the size and depth required for the species are a severely limited resource and depend on remnant trees that are at least 150 years old, of which there are few stands left in the Hunter region. Loss of structural complexity and agricultural practices such as grazing also reduces habitat for prey species (Garnett and Crowley 2000).

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Masked Owl has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The Approved Recovery Plan for the Large Forest Owls was prepared by DEC (NSW) in 2006, the objectives and actions of which cover the Masked Owl.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;

- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 1928 ha of habitat for this species through direct and indirect impacts. This includes the removal of potential forage habitat with the removal of suitable habitat for prey species. However, as the study area supports few suitable hollows and the species is an infrequent visitor to the locality, the Project is not considered likely to have a significant impact on the local occurrence of the Masked Owl.

I.28 Powerful Owl Seven-part Test

The Powerful Owl (*Ninox strenua*) is listed as Vulnerable under the TSC Act. There are 15 records of the species within the Muswellbrook LGA and 34 records within the Singleton LGA (OEH 2011). The species has not been recorded within the study area.

The Powerful Owl 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, Silcocks et al. 2003). It requires large tracts of native vegetation but can survive in fragmented landscapes. The species requires dense vegetation and large hollows up to 1 m wide and 2 m deep in large remnant trees for nesting (NSW Scientific Committee 2004o). It feeds on arboreal mammals, particularly ringtail possums. Breeding pairs usually maintain a territory of between 300 and 1500 ha, although size is dependent on the availability of suitable prey densities and habitat quality.

For such widely dispersed raptorial birds with relatively large territories, it is assumed that a viable local population may be as little as a single nesting pair of birds.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage habitat for the Powerful Owl; however this is unlikely to affect the life cycle or overall viability of the species.

Given the lack of records, absence of suitable hollows, large home range of the species (pairs maintain and hunt throughout a home range that may be up to 1000 ha), and its ability to adapt to disturbance within its home range, it is unlikely that the viability of the local population will be adversely affected by the Project.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of these species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

The study area lies within the known range of the Powerful Owl. The removal of patches of native vegetation and scattered trees is unlikely to affect connectivity or the species' movement and dispersal within the locality as they are highly mobile species with naturally sparse distribution and extensive home ranges. Fragmentation is unlikely to have a deleterious impact upon habitat corridors or habitat connectivity for dispersal of the species.

Approximately 1928 ha of forest, woodland and grasslands are proposed to be removed as part of the Project. The species has not been identified in the study area and is considered unlikely to roost or nest in the study area as very few trees have hollows of the required size. However, individuals may visit the study area as habitat supports forage resources in the form of arboreal and terrestrial prey and the area may form part of the home range for individuals or pairs that may occur within the LGA.

The species has specific roosting requirements and generally any loss of remnant habitat will reduce the availability of large hollows for the Powerful Owl as hollows of the size and depth required for the species are a severely limited resource and depend on remnant trees that are at least 150 years old, of which there are few stands left in the Hunter region. The study area supports few hollows that fit these requirements, and the Project is considered unlikely to have significant impacts on the species.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Powerful Owl has been identified by the Director-General of OEH under the TSC Act.

The study area and surrounding habitat does not constitute critical habitat for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The Approved Recovery Plan for the Large Forest Owls was prepared by DEC (NSW) in 2006, the objectives and actions of which cover the Powerful Owl.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this destroys populations of the species and their habitats;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 1928 ha of habitat for this species through direct and indirect impacts. This includes the removal of potential forage habitat with the removal of suitable habitat for prey species. However, as the study area supports few suitable hollows and is an infrequent visitor to the locality, the Project is not considered likely to have a significant impact on the local occurrence of the Powerful Owl.

I.29 Spotted Harrier Seven-part Test

The Spotted Harrier (*Circus assimilis*) is listed as Vulnerable under the TSC Act. There are eight records of the species within the Muswellbrook LGA and five records within the Singleton LGA (OEH 2011) but it is likely to be a species that is not commonly reported or recorded. An individual has previously been recorded in the study area.

The Spotted Harrier is a partly nomadic raptor with widespread but sparse distribution across mainland Australia (Pizzey & 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 2010d). The species is irruptive in response to local availability of key prey species such as terrestrial grassland birds, including quail, pipits and larks.

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove forest, woodland and grassland that could potentially include forage and nesting habitat for the Spotted Harrier. The species prefers living close to open woodland on the edge of native grassland and cropland which support key prey species.

Assuming that a viable local population could consist of just a single pair of birds, the Project has potential to make a viable local population become extinct by clearing and disturbing habitat.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

> *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 1928 ha of forest, woodland and grassland is proposed to be removed as part of the Project. This includes potential forage, breeding and nesting habitat for the Spotted Harrier.

The study area lies well within the known range of the Spotted Harrier. Current locality records, results from previous surveys, distributional range and habitat requirements indicate the species has potential to utilise habitat within the study area. Spotted Harriers prefer foraging in open woodland margins, grassland and agricultural land which provide suitable habitat for key prey species such as terrestrial grassland birds, including quail, pipits and larks. As the study area is surrounded by agricultural land, suitable forage habitat will still exist for the species regardless of the Project. The long-term genetic viability of the species in the locality is unlikely to be impacted as the species is highly mobile and will be able to disperse to habitat elsewhere in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Spotted Harrier has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for this species. No threat abatement plans are relevant to this species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat and encourages flock-foraging species;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-

nesting birds at greatest risk, particularly as they predate on nests and nesting females;

- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 1928 ha of habitat for this species through direct and indirect impacts. This includes the removal of potential roosting, breeding and forage habitat, including the removal of suitable habitat for prey species. However, this species is highly mobile, has a large home range and is an infrequent visitor to the locality. As such, the Project is not considered likely to have a significant impact on the local occurrence of the Spotted Harrier.

I.30 Cave-roosting Microbats Seven-part Test

The following Seven-part Test has been prepared as a composite test for a number of cave-roosting microbat species known or likely to occur within the study area.

i. Eastern Bentwing-bat (Miniopterus orianae oceanensis)

The Eastern Bentwing-bat (*Miniopterus orianae oceanensis*) is listed as Vulnerable under the TSC Act. There are 87 records of the species within the Muswellbrook LGA and 73 records within the Singleton LGA (OEH 2011). This species is well documented and has been consistently detected in surveys of the study area and elsewhere in the locality.

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, 2008). 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 (Van Dyck & Strahan, 2008). The species changes roosts in response to seasonal needs, and in turn long-distance movements occur occasionally (DECC (NSW) 2005c).

ii. Eastern Cave Bat (Vespadelus troughtoni)

The Eastern Cave Bat (*Vespadelus troughtoni*) is listed as Vulnerable under the TSC Act. There are 14 records of the species within the Muswellbrook LGA and nine records within the Singleton LGA (OEH 2011). Based on echolocation data, *Vespadelus troughtoni* is considered highly likely to have been recorded in the study area; however its calls could not be positively identified.

The Eastern Cave Bat is a cave-roosting species typically found in dry open forest and woodland (Churchill 2008; Van Dyck and Strahan 2008). It generally roosts in large colonies near cave entrances in moderately well-lit areas or in crevices of cliffs and overhangs (NSW Scientific Committee 2004e).

iii. Large-eared Pied Bat (Chalinolobus dwyeri)

The Large-eared Pied Bat (*Chalinolobus dwyeri*) is listed as Vulnerable under both the EPBC and TSC Acts. There are 44 records of the species within the Muswellbrook LGA and 48 records within the Singleton LGA (OEH 2011). The species was recorded in the study area in 2011 and is known from the Mt Arthur Coal Mine lease and Wollemi National Park.

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 (DECC (NSW) 2005d). 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 dry open forest and woodland close to these roost features, particularly areas containing gullies. They typically exist in small colonies consisting of less than 50 individuals and use the same cave over many years (SEWPaC 2011a).

iv. Southern Myotis (Myotis macropus)

The Southern Myotis (*Myotis macropus*) is listed as Vulnerable under the TSC Act. There are seven records of the species within the Muswellbrook LGA and 10 records within the Singleton LGA (OEH 2011). The only record for the species in the study area is from 2000. The 2011 echolocation data 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 is a water-foraging, cave-dependent. The species is primarily distributed along the east coast of Australia to the Kimberley, and along major rivers in south eastern Australia. Colony size can range from less than 15 to hundreds, in caves, mine shafts, hollow-bearing trees, storm-water channels, buildings, under bridges and in dense foliage (Churchill, 2008). Day-roost sites are often close to water where the species can forage over streams and pools to catch insects, prawns and small fish (DEC (NSW) 2005k).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Eastern Cave Bat, Eastern Bentwing-bat, Southern Myotis and Large-eared Pied Bat are predominantly cave-roosting species, although bentwing-bat species have also been known to roost in mine shafts, culverts, roof cavities and other artificial structures. It is unlikely that the study area would provide suitable roosting habitat for these species. No rock outcrops or caves are present in the study area. It is likely that these species roost in rock outcrops around Mt Arthur and Mt Ogilvie and travel to the study area to forage.

The lifecycles of these species are unlikely to be adversely affected as no caves or artificial roost sites are to be impacted by the Project.

The Project will remove known and potential foraging habitat for all of these cave-dependent microbat species. The removal of vegetation will fragment and reduce the availability of foraging resources within the locality, however these species are unlikely to be restricted or adversely impacted as they frequently travel across large distances to find suitable forage habitat.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of this species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of forest and woodland are proposed to be removed as part of the Project. An industrial dam with a surface area of approximately 7 ha will also be removed from Drayton Mine. These represent potential forage habitat for these species.

The removal of vegetation will fragment and reduce the availability of foraging resources within the locality, however these species are unlikely to be restricted or adversely impacted as they frequently travel across large distances to find suitable forage habitat.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Eastern Cave Bat, Eastern Bentwing-bat, Southern Myotis and Large-eared Pied Bat has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The Action Plan for Australian Bats recovery plan published in 1999 is applicable to these species and outlines actions to promote the recovery of these species and the abatement of KTP affecting their occurrence.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for these species through direct and indirect impacts. This includes the removal of known and potential forage habitat. These microbat species are cave-roosting species that tend to have large forage ranges. While the species may utilise the study area on occasion, they are not reliant on it, and woodland elsewhere in the locality will still provide forage habitat. As such, the Project is not considered likely to have a significant impact on the local occurrence of the Eastern Cave Bat, Eastern Bentwing-bat, Southern Myotis and Large-eared Pied Bat.

I.31 Hollow-roosting Microbats Seven-part Test

The following Seven-part Test has been prepared as a composite test for a number of hollow-roosting microbat species known or likely to occur within the study area.

i. Yellow-bellied Sheathtail-bat (Saccolaimus flaviventris)

The Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) is listed as Vulnerable under the TSC Act. There are seven records of the species within the Muswellbrook LGA and two records within the Singleton LGA (OEH 2011). The species has been recorded once in the study area and is known from the Mt Arthur Coal Mine lease.

The Yellow-bellied Sheathtail-bat is a tree-hollow roosting species with wide-ranging distribution through tropical Australia, although is considered rare in south eastern Australia. It is an insectivorous species that primarily forages above the tree canopy in almost all habitats (DEC (NSW) 2005q). 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 thirty (Churchill, 2008).

ii. Greater Long-eared Bat (Nyctophilus corbeni)

The Greater Long-eared Bat (*Nyctophilus corbeni*) is listed as Vulnerable under the TSC Act. There are 16 records of the species within the Muswellbrook LGA and two records within the Singleton LGA (OEH 2011). The species has previously been recorded in the study area.

The Greater Long-eared Bat is an insectivorous, hollow-dependent species with rare distribution around south eastern Australia (DEC (NSW) 2005h; Churchill 2008). The species is most commonly found in inland woodland vegetation types including Box-Ironbark dominated communities and mallee. 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 parches of trees (Lunney, Curtin et al. 2000).

iii. Eastern Freetail-bat (Mormopterus norfolkensis)

The Eastern Freetail-bat (*Mormopterus norfolkensis* syn. *Micronomus norfolkensis*) is listed as Vulnerable under the TSC Act. There are nine records of the species within the Muswellbrook LGA and 141 records within the Singleton LGA (OEH 2011). The species has been recorded in the study area on multiple occasions and is known from the Mt Arthur Coal Mine lease.

The Eastern Freetail-bat is a solitary, insectivorous bat most commonly found in open spaces in dry sclerophyll forests, woodland and swamp forests in eastern NSW. The species mainly roost in spout hollows of large mature trees and sometimes under bark or in man-made structures (NSW NPWS 2004a). They tend to forage in gaps in upper-slope vegetation and over larger waterways.

iv. Greater Broad-nosed Bat (Scoteanax rueppellii)

The Greater Broad-nosed Bat (*Scoteanax rueppellii*) is listed as Vulnerable under the TSC Act. There are 11 records of the species within the Muswellbrook LGA and 21 records within the Singleton LGA (OEH 2011). The species has previously been recorded within the study area and is known from the Mt Arthur Coal Mine lease.

The Greater Broad-nosed Bat is a large insectivorous species with limited distribution along the east coast of Australia. They are found in a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest (NSW NPWS 2004b). 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 six metres, foraging for beetles and other large, slow-flying insects after sunset (DEC (NSW) 2005g). They are known to prey on other microbat species (Churchill, 2008).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove known and potential forage and roosting habitat for the Yellow-bellied Sheathtail-bat, Greater Long-eared Bat, Eastern Freetail-bat and Greater Broad-nosed Bat. The direct loss of habitat, including large, mature trees that support hollows, is likely to have an adverse affect on locally occurring populations of these species. Despite being highly mobile species, the removal of vegetation will fragment and reduce the availability of foraging resources within the locality.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

There are currently no endangered populations of these species listed under Part 2 of Schedule 1 of the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

> *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*
>
> *(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of woodland and forest is proposed to be removed as part of the Project. This includes known and potential forage and roosting habitat for the Yellow-bellied Sheathtail-bat, Greater Long-eared Bat, Eastern Freetail-bat and Greater Broad-nosed Bat which have previously been recorded within the study area.

The species will be adversely impacted by woodland clearing, removal of hollow-bearing trees of any size and fragmentation as they show a preference for larger habitats. There is potential for the Project to affect the roosting success of these species; despite being highly mobile species that regularly move roost locations, the Project may impact the relocation of individuals through a loss of available roosting resources within their normal ranges. It is considered extremely likely that any hollow, no matter how small, may provide habitat for these species (Menkhorst and Knight 2001; DEC (NSW) 2005g), and it is the smaller more obscure hollows rather than the larger more obvious hollows that are important for survival.

The Project is considered likely to have a significant effect on the foraging behaviour and roosting capabilities of these species.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Yellow-bellied Sheathtail-bat, Greater Long-eared Bat, Eastern Freetail-bat and Greater Broad-nosed Bat has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The Action Plan for Australian Bats recovery plan published in 1999 is applicable to these species and outlines actions to promote the recovery of these species and the abatement of KTP affecting their occurrence.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and nesting habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat;

- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion;
- **Competition from feral honey bees (*Apis mellifera*)** as they compete with native fauna for tree hollows and floral resources; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for these species through direct and indirect impacts. This includes the removal of known and potential forage, roosting and breeding habitat. These microbat species are highly mobile but as they have consistently been recorded within the locality and study area, it is likely that habitat such as hollows for roosting are available in the locality, fall within their home ranges and are thus important for local populations. This may affect the capacity of some individuals to disperse and relocate to surrounding habitat elsewhere in the locality.

As such, without the implementation of appropriate mitigation and offset measures, the Project would be considered likely to have a significant impact on the local occurrence of the Yellow-bellied Sheathtail-bat, Greater Long-eared Bat, Eastern Freetail-bat and Greater Broad-nosed Bat.

I.32 Spotted-tailed Quoll Seven-part Test

The Spotted-tailed Quoll (*Dasyurus maculatus*) is listed as Vulnerable under the TSC Act and Endangered under the EPBC Act. There are 25 records of the species within the Muswellbrook LGA and 117 records within the Singleton LGA (OEH 2011). The species has not been recorded within the study area. An individual has previously been recorded in the Mt Arthur Coal Mine lease.

The Spotted-tailed Quoll is rare across its range in south eastern Australia. It has been recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest (Van Dyck and Strahan 2008). They require forest with suitable den site features including rock crevices, caves, large hollow logs, burrows and tree hollows (NSW NPWS 1999b). This is a nocturnal, solitary species with a large home range. Females occupy home ranges up to about 750 ha and males up to 3500 ha, and they have been known to travel more than 6 km a night, usually traversing their ranges along densely vegetated creeklines (DEC (NSW) 2005m). The species hunts medium-sized reptiles and mammals including possums and rabbits, and carrion.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential forage habitat for species on which the Spotted-tailed Quoll depends. Fragmentation may restrict the movement of individuals through the landscape, which could adversely affect some individuals by restricting their capacity to disperse and potentially affect their ability to find mates and reproduce. However, the home ranges of this species greatly exceed the habitat to be removed within the subject site. Vegetated creeklines to the east of the study area will be retained that will provide a corridor for movement.

Furthermore, no suitable den sites are available in the study area; the species requires caves, which are not present and large hollow logs which are limited as most of the understorey and woody debris of the study area has previously been cleared for agriculture.

Therefore the Project is unlikely to have adverse effects on the life cycle of the species or place it at risk of extinction.result in a significant impact to the Spotted-tailed Quoll.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable to threatened species.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of forest and woodland are proposed to be removed as part of the Project. This comprises potential forage habitat for the Spotted-tailed Quoll; its removal may restrict the availability and abundance of prey species for the species.

The Project is likely to increase the fragmentation of existing habitats in the study area, which may affect the capacity of some individuals to disperse across the open landscape in the locality, particularly as surrounding land is predominantly cleared. Potential secondary impacts include increased vulnerability to isolation, predation, disease, vehicle strike or accidental poisoning from any 1080 used in future pest control strategies.

Notwithstanding the above, the home ranges of this species greatly exceed the habitat to be removed within the subject site. It is likely that the species occurs in the locality in very low numbers and only infrequently visits the study area. Risks such as predation by foxes and vehicle strike already exist and are unlikely to be significantly increased by the Project. The study area is unlikely to have a signficant corridor value or provide important foraging habitat. The study area is also unlikely to be an important breeding habitat as no suitable denning sites occur in the study area.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Spotted-tailed Quoll has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A draft national recovery plan for the Spotted-tailed Quoll is currently being prepared. The Action Plan for Australian Marsupial and Monotremes, prepared by Wildlife Australia in 1996, is applicable to the Spotted-tailed Quoll.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species and its prey;
- **Loss of hollow-bearing trees** as this reduces the abundance of den habitat;
- **Removal of dead wood and dead trees** as this reduces the abundance of important ground foraging and den habitat;
- **Invasion of native plant communities by exotic perennial grasses** as this results in the loss of key food plants and habitat;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for this species through direct and indirect impacts. This includes the removal of potential forage habitat and increased restriction of movement due to increased habitat fragmentation. Notwithstanding the above, the home ranges of this species greatly exceed the habitat to be removed within the subject site. It is likely that the species occurs in the locality in very low numbers and only infrequently visits the study area. Risks such as predation by foxes and vehicle strike already exist and are unlikely to be significantly increased by the Project. The study area is unlikely to have a signficant corridor value or provide important foraging habitat. The study area is also unlikely to be an important breeding habitat as no suitable denning sites occur in the study area. Therefore the Project is unlikely to result in a significant impact to the Spotted-tailed Quoll.

I.33 Squirrel Glider Seven-part Test

The Squirrel Glider (*Petaurus norfolcensis*) is listed as Vulnerable under the TSC Act. There are 23 records of the species within the Muswellbrook LGA and 44 records within the Singleton LGA (OEH 2011). The species has not been recorded within the study area. It has been recorded from surveys of the Mt Arthur Coal Mine lease.

The Squirrel Glider is widely, but sparsely distributed in eastern Australia from northern Queensland to western Victoria. It commonly inhabits mature or old growth Box-Gum, Box-Ironbark woodlands and River Red Gum forest as the species requires abundant tree hollows for refuge during the day, and nest sites (NSW Scientific Committee 2004r; DEC (NSW) 2005n). They live in family groups and nest in tree hollows and prefer Eucalypt stands with a shrubby or an Acacia midstorey where they can forage at night. Diet varies seasonally but consists of Acacia gum, eucalypt sap, nectar, pollen and insect material. They prefer stands of mixed forests with at least one species of winter-flowering eucalypt or banksia to provide a reliable food source year round (DEC (NSW) 2005n; Van Dyck and Strahan 2008).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Project will remove potential nesting and forage habitat for the Squirrel Glider. The direct loss of habitat, including large, remnant trees that support hollows, is likely to have an adverse affect on locally occurring individuals of this species by reducing the availability of potential nesting habitat.

The removal of vegetation will fragment and reduce the availability of foraging resources within the locality. Fragmentation is also likely to restrict the movement of individuals through the landscape, particularly as surrounding land is largely cleared and without 'stepping stone' habitat. This could adversely affect some individuals by restricting their capacity to disperse, potentially impacting on their ability to find mates and reproduce.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable to threatened species.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

Not applicable to threatened species.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality, and

Approximately 389 ha of forest and woodland are proposed to be removed as part of the Project. This includes potential nesting and forage habitat for the Squirrel Glider.

The species is adversely impacted by woodland clearing, particularly of remnant hollow-bearing trees. These are limited resources in the Hunter Valley and may impact on the availability of suitable nesting habitat for this species. Direct removal of vegetation is also likely to remove important feed trees for the Squirrel Glider.

As the species currently exists as scattered populations, fragmentation may increase the vulnerability of locally occurring individuals to isolation, predation and disease. As such, habitat fragmentation and isolation are considered to be significant impacts that may affect the capacity of some individuals to disperse across the open landscape in the locality, particularly as surrounding land is predominantly cleared.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the Squirrel Glider has been identified by the Director-General of OEH under the TSC Act.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The Action Plan for Australian Marsupial and Monotremes, prepared by Wildlife Australia in 1996, is applicable to the Squirrel Glider.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project constitutes, or will exacerbate the following KTPs:

- **Clearing of native vegetation** as this reduces the area of forage and nesting habitat available for this species;
- **Loss of hollow-bearing trees** as this reduces the abundance of nesting habitat;
- **Removal of dead wood and dead trees** as this reduces structural complexity and the abundance of important ground foraging and nesting habitat;

- **Invasion of native plant communities by exotic perennial grasses** as this structural complexity and results in the loss of key food plants and habitat;
- **Competition and grazing by the feral European rabbit *Oryctolagus cuniculus*** as they compete with native fauna for resources, alter the structure and composition of vegetation, and degrade the land;
- **Predation by the European Red Fox *Vulpes vulpes*** as they pose a major threat to the survival of native Australian fauna, with non-flying mammals and ground-nesting birds at greatest risk, particularly as they predate on nests and nesting females;
- **Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa*** as wallowing and rooting causes direct disturbance to habitats and may increase erosion; and
- **Anthropogenic climate change** as this can reduce the geographic range of species and alter the structure and composition of communities.

Conclusion

The Project is expected to impact on approximately 389 ha of habitat for the Squirrel Glider through direct and indirect impacts. This includes the removal of potential forage and nesting habitat. Fragmentation is considered likely to have a significant impact on locally occurring individuals of this species by restricting movement through the landscape. This may affect the capacity of some individuals to disperse and relocate to surrounding habitat elsewhere in the locality; however it is unlikely to place the species at risk of extinction. Therefore no significant impact is predicted for this species.

Appendix J

Australian Commonwealth and NSW Principles for Biodiversity Offsetting

Principles for the use of biodiversity offsets in NSW

Biodiversity offsets counterbalance specific impacts of development on biodiversity. Offsets are undertaken elsewhere and result in the legal protection of land and the implementation of management actions to remove threats.



View a short video about how biodiversity offsetting works

Offsetting is a practical tool for decision makers who balance the relative environmental, social and economic merits of development proposals. Formal offset arrangements are a feature of:

- developments under the EP&A Act using the Biobanking Scheme
- land use planning under the EP&A Act using biodiversity certification
- native vegetation regulation under the Native Vegetation Act 2003.

These regulatory schemes use a range of mechanisms to secure offsets including biobanking agreements, biodiversity certification agreements and property vegetation plans.

Offsets are calculated using an assessment methodology which quantifies the impacts and determines the offset required. These outcomes must meet the improve or maintain standard.

Biodiversity offsets are also commonly required for major developments under Part 3A of the EP&A Act. Offsets are secured under the mechanisms mentioned above as well as conservation agreements under the National Parks and Wildlife Act 1974 and planning agreements under the EP&A Act. The improve or maintain standard is not mandatory.

The Department of Planning and Infrastructure makes Part 3A decisions by considering a range of social, economic and environmental factors (based on the advice of OEH). The BioBanking Assessment Methodology is increasingly being used by proponents and OEH to inform these decisions.

The following principles provide a useful framework for considering environmental impacts and developing offset proposals. The principles do not apply where legislation defines requirements for biodiversity offsets.

1. Impacts must be avoided first by using prevention and mitigation measures.

Offsets are then used to address remaining impacts. This may include modifying the proposal to avoid an area of biodiversity value or putting in place measures to prevent offsite impacts.

2. All regulatory requirements must be met.

Offsets cannot be used to satisfy approvals or assessments under other legislation, e.g. assessment requirements for Aboriginal heritage sites, pollution or other environmental impacts (unless specifically provided for by legislation or additional approvals).

3. Offsets must never reward ongoing poor performance.

Offset schemes should not encourage landholders to deliberately degrade or mismanage offset areas in order to increase the value from the offset.

4. Offsets will complement other government programs.

A range of tools is required to achieve the NSW Government's conservation objectives, including the establishment and management of new national parks, nature reserves, state conservation areas and regional parks and incentives for private landholders.

5. Offsets must be underpinned by sound ecological principles.

They must:

- include the consideration of structure, function and compositional elements of biodiversity, including threatened species
- enhance biodiversity at a range of scales
- consider the conservation status of ecological communities
- ensure the long-term viability and functionality of biodiversity.

Biodiversity management actions, such as enhancement of existing habitat and securing and managing land of conservation value for biodiversity, can be suitable offsets. Reconstruction of ecological communities involves high risks and uncertainties for biodiversity outcomes and is generally less preferable than other management strategies, such as enhancing existing habitat.

6. Offsets should aim to result in a net improvement in biodiversity over time.

Enhancement of biodiversity in offset areas should be equal to or greater than the loss in biodiversity from the impact site.

Setting aside areas for biodiversity conservation without additional management or increased security is generally not sufficient to offset against the loss of biodiversity. Factors to consider include protection of existing biodiversity (removal of threats), time-lag effects, and the uncertainties and risks associated with actions such as revegetation.

Offsets may include enhancing habitat, reconstructing habitat in strategic areas to link areas of conservation value, or increasing buffer zones around areas of conservation value and removal of threats by conservation agreements or reservation.

7. Offsets must be enduring - they must offset the impact of the development for the period that the impact occurs.

As impacts on biodiversity are likely to be permanent, the offset should also be permanent and secured by a conservation agreement or reservation and management for biodiversity. Where land is donated to a public authority or a private conservation organisation and managed as a biodiversity offset, it should be accompanied by resources for its management. Offsetting should only proceed if an appropriate legal mechanism or instrument is used to secure the required actions.

8. Offsets should be agreed prior to the impact occurring.

Offsets should minimise ecological risks from time-lags. The feasibility and in-principle agreements to the necessary offset actions should be demonstrated prior to the approval of the impact. Legal commitments to the offset actions should be entered into prior to the commencement of works under approval.

9. Offsets must be quantifiable - the impacts and benefits must be reliably estimated.

Offsets should be based on quantitative assessment of the loss in biodiversity from the clearing or other development and the gain in biodiversity from the offset. The methodology must be based on the best available science, be reliable and used for calculating both the loss from the development and the gain from the offset. The methodology should include:

- the area of impact
- the types of ecological communities and habitat/species affected
- connectivity with other areas of habitat/corridors
- the condition of habitat
- the conservation status and/or scarcity/rarity of ecological communities
- management actions
- level of security afforded to the offset site.

The best available information/data should be used when assessing impacts of biodiversity loss and gains from offsets. Offsets will be of greater value where:

- they protect land with high conservation significance
- management actions have greater benefits for biodiversity
- the offset areas are not isolated or fragmented
- the management for biodiversity is in perpetuity (e.g. secured through a conservation agreement).

Management actions must be deliverable and enforceable.

10. Offsets must be targeted.

They must offset impacts on the basis of like-for-like or better conservation outcome. Offsets should be targeted according to biodiversity priorities in the area, based on the conservation status of the ecological community, the presence of threatened species or their habitat, connectivity and the potential to enhance condition by management actions and the removal of threats. Only ecological communities that are equal or greater in conservation status to the type of ecological community lost can be used for offsets. One type of environmental benefit cannot be traded for another: for example,

biodiversity offsets may also result in improvements in water quality or salinity but these benefits do not reduce the biodiversity offset requirements.

11. Offsets must be located appropriately.

Wherever possible, offsets should be located in areas that have the same or similar ecological characteristics as the area affected by the development.

12. Offsets must be supplementary.

They must be beyond existing requirements and not already funded under another scheme. Areas that have received incentive funds cannot be used for offsets. Existing protected areas on private land cannot be used for offsets unless additional security or management actions are implemented. Areas already managed by the government, such as national parks, flora reserves and public open space cannot be used as offsets.

13. Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or a contract.

Offsets must be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes.

Page last updated: 17 June 2011

FOLLOW US SHARE

NSW Government | jobs.nsw
Accessibility | Privacy | Disclaimer | Copyright | Feedback

Australian Government

Department of Sustainability, Environment, Water, Population and Communities



Environment Protection and Biodiversity Conservation Act 1999
Environmental Offsets Policy

October 2012

© Commonwealth of Australia 2012
This work is copyright. Apart from any use as permitted under the Copyright Act 1968, no part may be reproduced by any process without prior written permission from the Commonwealth. Requests and enquiries concerning reproduction and rights should be addressed to Department of Sustainability, Environment, Water, Population and Communities, Public Affairs, GPO Box 787 Canberra ACT 2601 or email public.affairs@environment.gov.au

Disclaimer

The contents of this document have been compiled using a range of source materials and are valid as at October 2012. The Australian Government is not liable for any loss or damage that may be occasioned directly or indirectly through the use of reliance on the contents of the document.

2

1. EPBC ACT ENVIRONMENTAL OFFSETS POLICY **4**
Introduction 4
2. SCOPE OF THIS POLICY **5**
2.1 Application of the policy to heritage values 5
3. AIMS OF THE POLICY AND OVERARCHING OFFSET REQUIREMENTS **6**
4. WHAT ARE ENVIRONMENTAL OFFSETS? **7**
4.1 How are offsets different to avoidance and mitigation measures? 7
4.2 Types of offsets 8
4.2.1 Direct offsets 8
4.2.2 Other compensatory measures 9
4.2.3 Advanced offsets 9
5. THE ROLE OF OFFSETS IN ENVIRONMENTAL IMPACT ASSESSMENT UNDER THE EPBC ACT **11**
5.1 Referral stage 11
5.2 Assessment stage 11
5.3 Decision stage 12
5.4 Post-approval stage 12
6. PLANNING AN OFFSET PROPOSAL **14**
7. OFFSET REQUIREMENTS **16**
7.1 Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the protected matter 17
7.2 Suitable offsets must be built around direct offsets but may include other compensatory measures 18
7.2.1 Tenure for direct offsets 18
7.2.2 Impacting on existing EPBC Act offsets 19
7.3 Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter 20
7.4 Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter 20
7.5 Suitable offsets must effectively account for and manage the risks of the offset not succeeding 21
7.6 Suitable offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs 22
7.6.1 Links with state and territory approval processes 23
7.7 Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable 23
7.8 Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced 24
8. GOVERNMENT DECISION-MAKING RELATING TO OFFSETS **25**
8.1 Decisions will be informed by scientifically robust information 25
8.2 Conducted in a consistent and transparent manner 25
9. OFFSET DELIVERY OPTIONS **26**
9.1 Use of market-based mechanisms to deliver offsets 26
9.2 Use of third parties to deliver offsets 27
10. FURTHER INFORMATION **28**
Appendix A: Criteria for research and educational programs 29

1. EPBC ACT ENVIRONMENTAL OFFSETS POLICY

Introduction

This policy outlines the Australian Government's approach to the use of environmental offsets ('offsets') under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It replaces the draft policy statement *Use of environmental offsets under the* EPBC Act (2007).

Offsets are defined as measures that compensate for the residual adverse impacts of an action on the environment. Where appropriate, offsets are considered during the assessment phase of an environmental impact assessment under the EPBC Act, as outlined in Section 5 of this document. This policy provides transparency around how the suitability of offsets is determined. The suitability of a proposed offset is considered as part of the decision as to whether or not to approve a proposed action under the EPBC Act.

There are different ways to achieve good environmental outcomes. This policy provides flexibility in delivering those outcomes. For example, the enduring protection and management of a threatened species' habitat can be achieved through a variety of methods, including through conservation land management by rural landholders, or in partnerships with Indigenous communities. The policy is intended to provide a transparent framework to give greater certainty for businesses and others considering actions that may potentially be subject to an offset requirement, while also promoting consistency and providing robust, positive environmental outcomes.

The *Offsets assessment guide*, which accompanies this policy, has been developed in order to give effect to the requirements of this policy, utilising a balance sheet approach to measure impacts and offsets. It applies where the impacted protected matter is a threatened species or ecological community. The *Offsets assessment guide* is a tool that has been developed for expert users in the department to assess the suitability of offset proposals. The guide is also available to proponents to assist with planning for future development proposals and estimating future offset requirements.

A technical review of the policy and guide will be undertaken one year after they come into effect. Subsequent reviews will be undertaken every five years. The use of offsets is a developing policy area, and this policy incorporates current international best practice.

This policy was finalised on 20 September 2012, and applies to any new referrals and variations to approval conditions from 2 October 2012. It also applies to any projects currently under assessment for which a proposed decision has not yet been made.

2. SCOPE OF THIS POLICY

The EPBC Act is the Australian Government's principal piece of environmental legislation. It is designed to protect national environmental assets, known as matters of national environmental significance, and other protected matters. If a proposed development or other action ('proposed action') is likely to have a significant impact upon a protected matter then it must be referred for assessment under the EPBC Act. Proposed actions may range from a housing development, an offshore gas project, a mining project, to the construction of a road. Further information on the EPBC Act can be found at **www.environment.gov.au/epbc/index.html**.

This policy relates to all matters protected under the EPBC Act ('protected matters'). These are:

- world heritage properties
- national heritage places
- wetlands of international importance (listed under the Ramsar Convention)
- listed threatened species and ecological communities
- migratory species protected under international agreements
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- the environment, where nuclear actions are involved;
- the environment, where actions proposed are on, or will affect Commonwealth land and the environment,
- the environment, where Commonwealth agencies are proposing to take an action.

The policy applies to offsetting requirements in terrestrial and aquatic (including marine) environments.

The policy applies to both project-by-project assessments and approvals under Parts 8 and 9 of the EPBC Act and to strategic assessments under Part 10 of the EPBC Act. Proposed new strategic assessments may consider alternative metrics other than the *Offset assessment guide* (e.g. if a jurisdiction has developed a metric tailored to their needs) provided the principles of this policy are met. This will be considered on a case by case basis.

2.1 Application of the policy to heritage values

The use of offsets to compensate for adverse impacts to heritage values is appropriate in some circumstances. In cases where offsetting of adverse impacts on heritage values is considered possible and appropriate, the principles of this policy apply with regard to determining what constitutes a suitable offset. Offsets for impacts on heritage values should improve the integrity and resilience of the heritage values of the property involved. This may include offsets in areas adjacent to the property. For further information, please contact the department (contact details are at section 10).

3. AIMS OF THE POLICY AND OVERARCHING OFFSET REQUIREMENTS

The *EPBC Act environmental offsets policy* has five key aims, to:

1. ensure the efficient, effective, timely, transparent, proportionate, scientifically robust and reasonable use of offsets under the EPBC Act
2. provide proponents, the community and other stakeholders with greater certainty and guidance on how offsets are determined and when they may be considered under the EPBC Act
3. deliver improved environmental outcomes by consistently applying the policy
4. outline the appropriate nature and scale of offsets and how they are determined
5. provide guidance on acceptable delivery mechanisms for offsets.

Box 1 provides the overarching principles that are applied in determining the suitability of offsets.

Box 1: Offset Principles
Suitable offsets must:

1. deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action
2. be built around direct offsets but may include other compensatory measures
3. be in proportion to the level of statutory protection that applies to the protected matter
4. be of a size and scale proportionate to the residual impacts on the protected matter
5. effectively account for and manage the risks of the offset not succeeding
6. be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action, see section 7.6)
7. be efficient, effective, timely, transparent, scientifically robust and reasonable
8. have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.

In assessing the suitability of an offset, government decision-making will be:

9. informed by scientifically robust information and incorporate the precautionary principle in the absence of scientific certainty
10. conducted in a consistent and transparent manner.

4. WHAT ARE ENVIRONMENTAL OFFSETS?

The term 'environmental offsets' refers to measures that compensate for the residual adverse impacts of an action on the environment. Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining, unavoidable impacts are termed 'residual impacts'. For assessments under the EPBC Act, offsets are only required if residual impacts are significant.[1]

Offsets can help to achieve long-term environmental outcomes for matters protected under the EPBC Act, while providing flexibility for proponents seeking to undertake an action that will have residual impacts on those protected matters.

Offsets do not mean proposals with unacceptable impacts will be approved. They simply provide an additional tool that can be used during the environmental impact assessment process.

[1] As defined in Significant impact guidelines 1.1 – matters of national environmental significance and Significant impact guidelines 1.2 – actions on, or impacting upon, Commonwealth land and actions by Commonwealth agencies, available at **www.environment.gov.au/epbc/guidelines-policies.html**.

4.1 How are offsets different to avoidance and mitigation measures?

Avoidance and mitigation measures are the primary strategies for managing the potential significant impact of a proposed action. They directly reduce the scale and intensity of the potential impacts of a proposed action. Offsets do not reduce the likely impacts of a proposed action, but instead compensate for any residual significant impact.

Avoidance of impacts on protected matters may be achieved through comprehensive planning and suitable site selection, for example by changing the route of an access road to avoid an endangered ecological community.

After all reasonable avoidance measures have been put in place, mitigation of any remaining significant impact must be undertaken, for example putting in place measures to reduce sediment runoff from a development site that may otherwise affect a threatened fish species.

Avoidance and mitigation measures can reduce and, in some cases, remove the need for offsets if the residual impact is not significant. Offsets will not be considered until all reasonable avoidance and mitigation measures are considered, or acceptable reasons are provided as to why avoidance or mitigation of impacts is not reasonably achievable.

In proposing avoidance, mitigation and offset measures, the proponent must provide clear information about the scale and intensity of impacts of the proposed action and the on-ground benefits to be gained through each of these measures.

4.2 Types of offsets

An offsets package is a suite of actions that a proponent undertakes in order to compensate for the residual significant impact of a project. It can comprise a combination of *direct offsets* and *other compensatory measures*. Offsets should align with conservation priorities for the impacted protected matter and be tailored specifically to the attribute of the protected matter that is impacted in order to deliver a conservation gain. For instance, if the proposed action is likely to have impacts on foraging habitat for a particular protected matter, then the offset should create, improve, protect and/or manage foraging habitat.

Offsets should compensate for an impact for the full duration of the impact. Offsets that deliver an outcome prior to the impact commencing are encouraged, as they minimise effects on the protected matter resulting from offset time delays (see section 4.2.3 Advanced offsets).

Offsets that deliver social, economic and/or environmental co-benefits are encouraged (See Box 2).

4.2.1 Direct offsets

Direct offsets are those actions that provide a measurable conservation gain for an impacted protected matter.

Direct offsets are an essential component of a suitable offsets package. A minimum of 90 per cent of the offset requirements for any given impact must be met through direct offsets.

Deviation from the 90 per cent direct offset requirement will only be considered where:

- it can be demonstrated that a greater benefit to the protected matter is likely to be achieved through increasing the proportion of other compensatory measures in an offsets package or;
- scientific uncertainty is so high that it isn't possible to determine a direct offset that is likely to benefit the protected matter. For example, this can be the case in some poorly understood ecosystems in the Commonwealth marine environment

Conservation gain is the benefit that a direct offset delivers to the protected matter, which maintains or increases its viability or reduces any threats of damage, destruction or extinction. A conservation gain may be achieved by:

- improving existing habitat for the protected matter
- creating new habitat for the protected matter
- reducing threats to the protected matter
- increasing the values of a heritage place, and/or
- averting the loss of a protected matter or its habitat that is under threat.

Conservation gain in the marine environment may include improving protection of important protected species habitat, such as sea grass, or by addressing pressures on the protected matter or its habitat, such as removing derelict fishing nets and other marine debris.

Averting the loss of a protected matter or its habitat is considered to deliver a conservation gain where there is an immediate threat of destruction or degradation, and the risk of loss of that particular site is averted by securing its future for conservation purposes (for example through a conservation covenant on the title of the land). In the *Offsets assessment guide,* considering future risks to a specific site in order to quantify averted loss is undertaken over either a 20 year time-frame or for the duration of the offset, whichever is the shorter period.

4.2.2 Other compensatory measures

Other compensatory measures are those actions that do not directly offset the impacts on the protected matter, but are anticipated to lead to benefits for the impacted protected matter, for example funding for research or educational programs. Requirements for other compensatory measures are outlined at Appendix A.

Other compensatory measures should relate to the impacted aspect of the protected matter. For example, research into effective re-vegetation techniques for a particular ecological community may be an appropriate component of an offsets package for an action that involves clearing of that ecological community.

4.2.3 Advanced offsets

Advanced environmental offsets are a supply of offsets for potential future use, transfer or sale. An example of an advanced offset is protection or improvement of habitat for the conservation of a protected matter before an impact is undertaken. Advanced offsets are encouraged where practical, given that they provide a means to better manage the risks associated with the time delay in realising the conservation gain for a protected matter. The *Offsets assessment guide* places higher value on offsets that deliver a conservation gain in a shorter time period. This can reduce overall offset requirements.

Proponents or offset providers looking to establish advanced offsets should discuss these with the department at the earliest possible opportunity. Proponents should monitor and record baseline data associated with the establishment of the offset and improvements over time.

The department will consider advanced offsets that deliver a conservation gain after the commencement of the EPBC Act, on 16 July 2000.

Advanced offsets must satisfy all requirements in this policy, including those relating to offsets being additional to other legislation and schemes, as outlined in section 7.6. It is important to note that advanced offsets do not in any way prejudice the outcome of any future assessment of an action. That is, while planning advanced offsets may result in lower overall offset requirements, it does not influence whether or not an action referred under the EPBC Act will be determined as acceptable.

Box 2: Delivering social, economic and/or environmental co-benefits

While the primary consideration in determining suitable offsets is delivering a conservation gain for the impacted protected matter, the delivery of offsets that establish positive social or economic co-benefits is encouraged.

Social and economic or environmental co-benefits may be delivered where an offset aligns with broader strategic environmental objectives such as those outlined in the National Wildlife Corridors Plan, the Indigenous health strategy Closing the gap, or policies that enhance the environment of regional Australia. For example:

- an offset contributing to an area recognised as important to increasing landscape connectivity, above and beyond what is required by the impacted protected matter
- an offset that employs local Indigenous rangers to undertake management actions
- an offset delivered by paying rural landholders to protect and manage land for conservation purposes.

10

5. THE ROLE OF OFFSETS IN ENVIRONMENTAL IMPACT ASSESSMENT UNDER THE EPBC ACT

Figure 1 shows the role of offsets within the broader environmental impact assessment process under the EPBC Act.

5.1 Referral stage

The referral stage, under Part 7 of the EPBC Act, is the initial screening stage of the environmental impact assessment process. Referrals are used to determine whether significant adverse impacts on protected matters are likely to occur and to make a formal decision on whether a proposed action requires full assessment under the EPBC Act. If the Minister or the Minister's delegate (the decision maker) decides the proposed action is a 'Controlled Action', it requires full assessment under Part 9 of the EPBC Act. If significant impacts on protected matters are determined to be unlikely then the action may be declared 'Not a Controlled Action' and can proceed. The offsets policy does not apply to actions that have been declared as 'Not a Controlled Action'.

The EPBC Act does not allow for any beneficial impacts, such as offsets, to be considered at the referral stage.

5.2 Assessment stage

In order to determine if an offset is necessary, the impacts of a proposed action need to be fully understood. At the assessment stage the decision maker considers the following issues in detail:

- **What is the nature of the likely impacts on protected matters?** – which protected matters are likely to be impacted by the action? What is the scale and size of impacts? What are the risks to the viability of protected matters arising from the action? Will impacts on protected matters be permanent or temporary?
- **Can impacts on protected matters be avoided?** – can the proposed action be redesigned to avoid impacting protected matters? What alternatives have been considered? Have environmental considerations been factored into the project's design?
- **Can impacts on protected matters be mitigated?** – what actions can take place that will reduce the impacts arising from the proposed action? For example, developing environmental management plans, implementing erosion control measures, fencing off environmentally sensitive areas etc.

- **Are the residual impacts likely to be significant?** – what are the residual impacts on protected matters that are still likely to occur after the proposed activities to avoid and mitigate all impacts are taken into account? E.g. will the proposed action only slightly disturb an area of potential habitat for a threatened species or will it destroy an area of habitat known to be used by a threatened species?
- **Are offsets a suitable approach?** – are offsets needed to help compensate for residual impacts on the protected matter and are they feasible?

It is important to note that offsets are not required for all approvals under the EPBC Act. Offsets are not required where the impacts of a proposed action are not thought to be significant or could reasonably be avoided or mitigated.

If an offset is appropriate, then the proponent should discuss offset options with the department and submit an offsets proposal. This proposal should describe the offset and demonstrate how it will provide an appropriate benefit to compensate for any residual impact on the protected matter. The department will then assess this proposal against the policy and – where the impacted protected matter is a threatened species or ecological community – the *Offsets assessment guide*. If the proposed offset is not considered to be suitable, the department will discuss this finding with the proponent and provide them with an opportunity to submit a revised proposal.

5.3 Decision stage

Following assessment, the decision maker considers the offset proposal in deciding whether the proposed action should be approved. In some cases, a suitable offset may not be proposed or available and a decision on the overall acceptability of the project will need to be made.

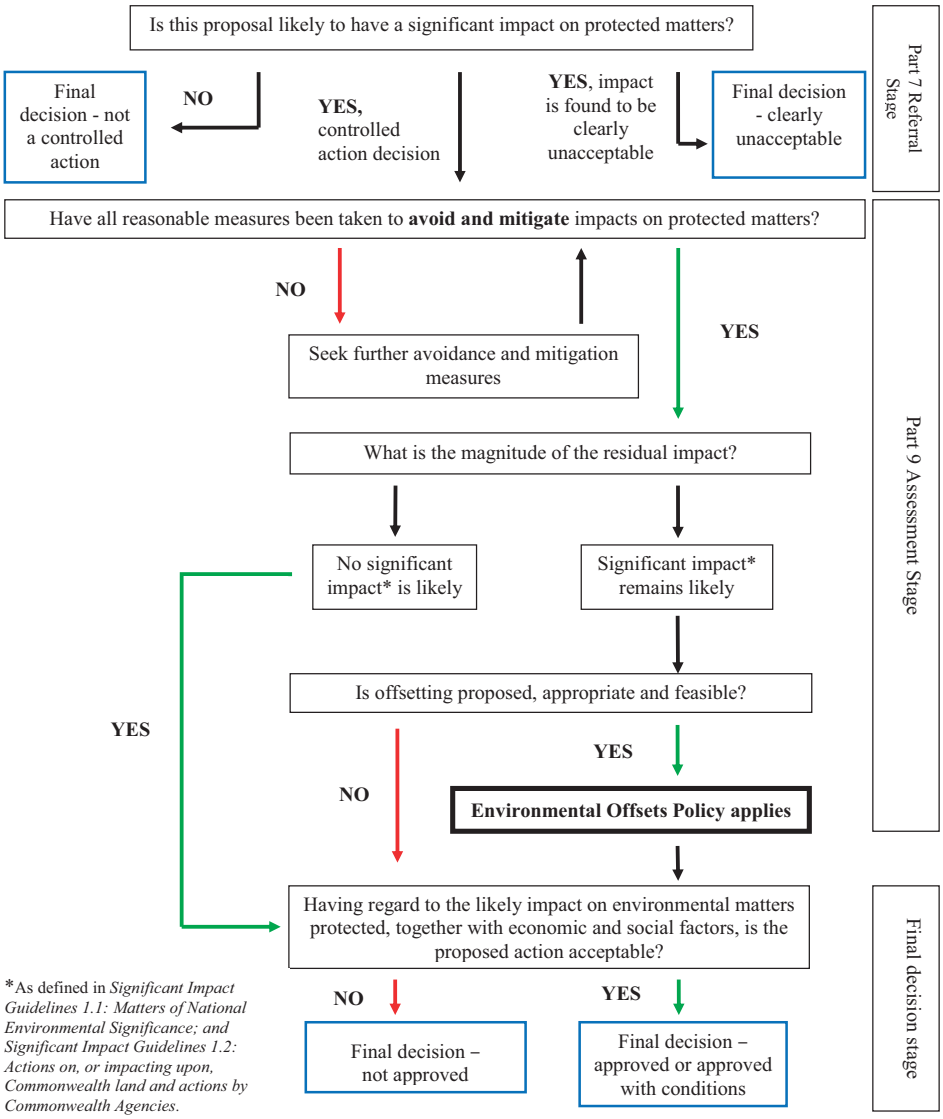
The offset proposal is one of many considerations that are weighed at the decision stage in determining the overall acceptability of the proposed action, including economic and social matters. These considerations are outlined in the EPBC Act in Sections 136–140A.

Offset requirements are included as a condition of approval under section 134 of the EPBC Act.

5.4 Post-approval stage

If an approval has been granted that incorporates offsets into the conditions of approval, the proponent is responsible for ensuring that the offsets are delivered in accordance with the approved conditions. The department has an active monitoring and audit program to ensure that conditions of approval are implemented. Where a proponent becomes aware that they may not be able to fulfil a condition of approval, they should approach the department in the first instance to discuss the matter and see what options are available to remedy the situation. Breaches of approval conditions, including those relating to offsets, can incur significant penalties. Further information on the department's *EPBC Act Compliance and Enforcement Policy* is available at **www.environment.gov.au/epbc/publications/index.html**.

Figure 1 – The role of offsets within the broader environmental impact assessment process.



6. PLANNING AN OFFSET PROPOSAL

An appropriate offsets package should be developed by proponents in consultation with the department. There are two key types of information utilised in planning an offset proposal – determining what types of activities would be appropriate as offsets for a given impact, and determining the specific size and scope of an offsets package.

In determining the appropriateness of the offset activities proposed, the department will consult the relevant Commonwealth approved recovery plan, threat abatement plan, conservation advice, ecological character description, management plan and/or listing document. Where Commonwealth approved guidance documents are not available or are insufficient in detail, the department will review additional information sources such as state and territory management plans or peer-reviewed scientific literature to inform priority offset activities.

If the department is satisfied that the offset activities are suitable, the department will consider whether appropriateness of the magnitude and composition of the proposed offset package in detail on a case-by-case basis. There are a range of considerations taken into account at both the impact site and the proposed offset site as discussed in sections 7 and 8. Proponents should include detailed information pertaining to these considerations in their offsets proposal. The *Offsets assessment guide* will be used by the department at this stage if the impacted protected matter is a threatened species or ecological community.

Matters to be considered at the impact site include the:

- presence and conservation status of protected matters likely to be impacted by the proposed action
- specific attributes of the protected matter being impacted at a site, for example: the type of threatened species or ecological community habitat, the quality of habitat, population attributes such as recruitment or mortality, landscape attributes such as habitat connectivity, or heritage values
- scale and nature of the impacts of the proposed action – including direct and indirect impacts
- duration of the impact (not of the action).

Matters to be considered at the offset site include the:

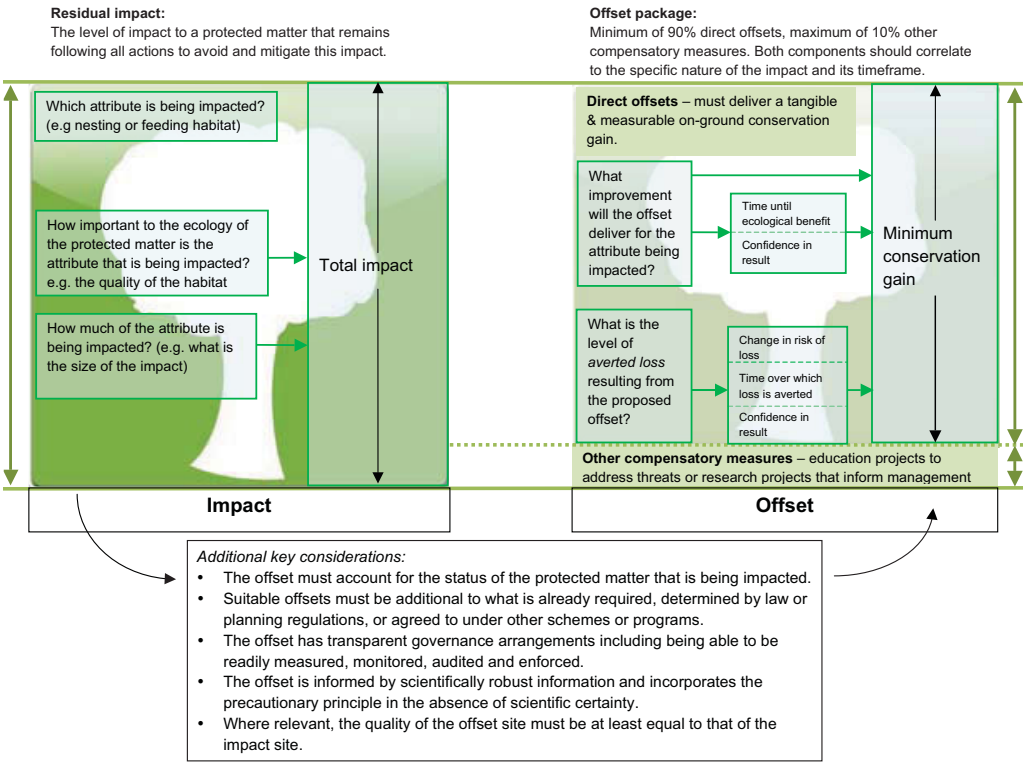
- extent to which the proposed offset actions correlate to, and adequately compensate for, the impacts on the attributes for the protected matter
- conservation gain to be achieved by the offset. This may be through positive management activities that improve the viability of the protected matter or averting the future loss, degradation or damage of the protected matter
- current land tenure of the offset and the proposed method of securing and managing the offset for the life of the impact
- time it will take to achieve the proposed conservation gain
- level of certainty that the proposed offset will be successful. In the case of uncertainty, such as using a previously untested conservation technique, a greater variety and/or quantity of offsets may be required to minimise risk
- suitability of the location of the offset site. In most cases this will be as close to the impact site as possible. However, if it can be shown that a greater conservation benefit for the impacted protected matter can be achieved by providing an offset further away, then this will be considered.

7. OFFSET REQUIREMENTS

Suitable offsets are determined by applying the requirements outlined in Box 1, and as illustrated by Figure 2.

The *Offsets assessment guide* gives effect to these requirements and provides a decision-making framework for the department to consider the appropriateness and adequacy of proposed offsets for listed threatened species and ecological communities.

Figure 2 – Determining suitable offsets under the EPBC Act



7.1 Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the protected matter

Offsets must directly contribute to the ongoing viability of the protected matter impacted by the proposed action, and deliver an overall conservation outcome that *improves or maintains* the viability of the protected matter as compared to what is likely to have occurred under the status quo, that is if neither the action nor the offset had taken place.

Offsets should be tailored specifically to the attribute of the protected matter that is impacted in order to deliver a conservation gain. For example, if the impact is the removal of foraging habitat for a listed threatened bird species, then an appropriate offset would be creating new similar habitat through re-vegetation works, improving the quality of existing foraging habitat for the species, and/or protecting existing foraging habitat though putting a conservation covenant on the title of the land. If an impact decreases the nesting success of a listed threatened turtle species due to light pollution, then an appropriate offset may be increasing the birth rate of that same species in a nearby location through threat abatement activities such as reducing feral pig predation on turtle nests.

In some circumstances it may be possible to demonstrate that a better conservation outcome can be achieved for the protected matter by deviating from this rule. If this is the case then the decision-maker may consider this. For instance, in the first example above, if the limiting attribute to the viability of the protected matter in a particular area is not foraging habitat, but nesting habitat, then an offset that produces more nesting habitat may be considered satisfactory for an impact on foraging habitat.

For heritage values, offsetting for the same or similar values in the same property or adjacent to it may be suitable where it can be demonstrated that such an activity will improve the overall integrity and resilience of the property.

In no instances will trading offsets across different protected matters be considered as a suitable offset. That is, where an action impacts on a specific threatened or migratory species, ecological community, Ramsar wetland or heritage property, any offset must relate to that same specific matter which is impacted.

When the protected matter is the whole of the environment (nuclear actions, proposals involving the Commonwealth, actions that affect Commonwealth areas and the Great Barrier Reef Marine Park), offsets must be targeted to the aspect of the environment that is being impacted so as to directly compensate for the impact. For example, where an action has a residual impact that involves the clearing of native vegetation or the degradation of water quality, an offset proposal would need to adequately compensate for these specific residual impacts.

For impacts on habitat for threatened species, migratory species and threatened ecological communities, any direct offset must meet, as a minimum, the quality of the habitat at the impact site. Where a proposed offset site has a lower habitat quality than that of the impact site, the offset must be managed and resourced over a defined period of time so that its habitat quality is improved to meet the quality of habitat originally impacted. Supporting and/or recreating non-endemic vegetation or ecosystems would not be considered a suitable offset.

7.2 Suitable offsets must be built around direct offsets but may include other compensatory measures

Offsets must be built around direct offsets, which should form a minimum of 90 per cent of the total offset requirement. Most proponents will be able to provide a direct offset that will satisfy 100 per cent of the offset requirement. However, other compensatory measures may satisfy up to a maximum of 10 per cent of the total offset requirement.

The circumstances in which deviation from the 90 per cent direct offset requirement may be considered are outlined in section 4.2.1.

Where possible, an offset should address key priority actions outlined for the impacted protected matter in any approved recovery plans, threat abatement plan, conservation advice, ecological character description or approved Commonwealth management plan. Higher priority actions are preferred to lower priority actions. Appendix A outlines what other compensatory measures are considered suitable.

7.2.1 Tenure for direct offsets

For direct offsets, the securing of existing unprotected habitat as an offset only provides a conservation gain if that habitat was under some level of threat of being destroyed or degraded, and as a result of offsetting will instead be protected in an enduring way and actively managed to maintain or improve the viability of the protected matter. In these cases, the tenure of the offset should be secured for at least the same duration as the impact on the protected matter arising from the action, not necessarily the action itself.

As a general guide, the best legal mechanisms for protecting land are intended to be permanent (lasting forever) and are secure (that is, they are difficult to change or alter). These two elements are important because they mean that land set aside as an offset will continue to provide a secure benefit to the impacted protected matter.

Legal mechanisms, such as conservation covenants, exist in each state and territory to enable the protection of land that is set aside for environmental purposes on a permanent or long-term basis. Suitable mechanisms for a particular offset must be built around the principles outlined in Box 3.

In addition to state and territory legal mechanisms for securing offsets, there is also provision under Part 14 of the EPBC Act for the Minister to enter into a conservation agreement with a third party for the conservation of a protected matter. An EPBC Act conservation agreement is a flexible instrument that can be used for implementing a range of management activities to benefit a protected matter, such as fencing off important habitat areas, undertaking weed and feral animal control or the establishment of compensatory habitat. They can also require a landholder to refrain from, control or refuse to permit, activities that may adversely affect the species, ecological communities, habitats or potential habitats covered by the agreement.

Marine areas are predominantly managed by state, territory and/or Commonwealth government agencies. In determining appropriate offset packages in marine environments, proponents should engage with the relevant governing jurisdiction to identify suitable areas of habitat that may be protected and/or improved to achieve a conservation gain. This could include removing pressures, such as dredging, on habitat for a protected matter.

Box 3: Suitable Offset Mechanisms

Offsets on public lands

- should be legally secured for conservation purposes for at least the duration of the impact
- should be statutorily defined and resourced
- any change in management status should require Ministerial or statutory approval.

Offsets on private lands

- should be legally secured for conservation purposes for at least the duration of the impact
- the securing scheme should actively monitor for compliance, with covenant requirements enforced
- any change in legal status should require Ministerial or statutory approval.

Offsets on Indigenous owned lands

- should have customary law protection with Traditional Owners holding a non-transferable interest in the land with a commitment to its long-term protective management
- should include a commitment from Traditional Owners to accept and manage the offset.

Offsets in the marine environment

- should be implemented for the duration of the impact
- should be developed in consultation with governing jurisdiction(s).

In some situations there may be difficulties in permanently securing a site for conservation purposes due to the existing tenure of the land. Such situations will be considered by the department on a case-by-case basis. However, where the security of an offset is diminished, the risk to any protected matters, and subsequently the magnitude of offsets required, will increase. Further discussion of the relationship between risk to the protected matter and the scale of a suitable offset is at section 7.5.

7.2.2 Impacting on existing EPBC Act offsets

Where a proposed action is likely to impact on an existing EPBC Act offset, the person proposing to take the action should refer it to the department to determine whether or not it will require further assessment under the EPBC Act. There is an increased likelihood of significant impacts arising from actions on an existing offset site due to the nature of such sites containing and/or supporting protected matters. Where such actions are determined to be controlled actions, irrespective of the ownership or tenure of the impacted offset, the person proposing to take the action must develop an offsets package to compensate for both the impact of the proposed action, as well as the original action for which the offset was a condition of approval. The subsequent offset conditions would not amount to a variation of the original conditions of approval or excuse non-compliance with those conditions.

7.3 Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter

Due to the higher risk involved with protected matters of greater conservation status, the offsets required for those protected matters with higher conservation status must be greater than those with a lower status. For listed threatened species and ecological communities, this is calculated in the *Offsets assessment guide* by using International Union for Conservation of Nature data on the probability of annual extinction for different categories of threatened species.

Information regarding the conservation status of threatened species and ecological communities is held in the department's Species Profile and Threats Database which can be found at **www.environment.gov.au/cgi-bin/sprat/public/sprat.pl**.

Further information on other matters protected by the EPBC Act can be found at **www.environment.gov.au/epbc/protect/index.html**.

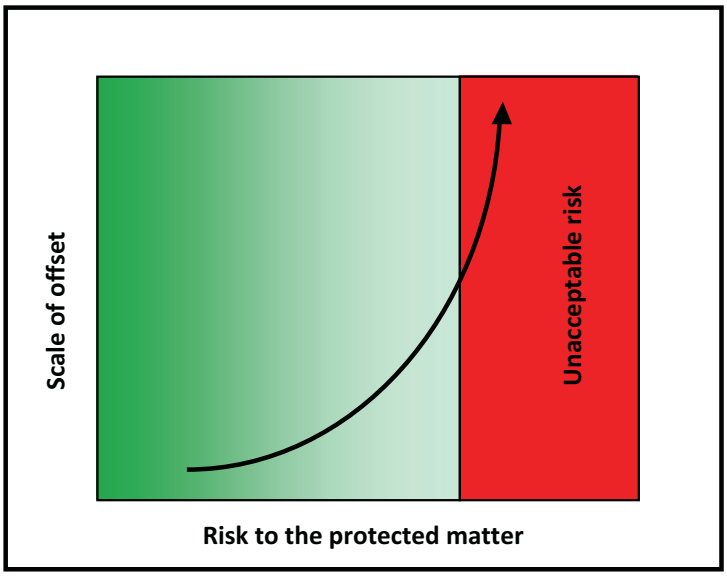
7.4 Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter

Offsets must be proportionate to the size and scale of the residual impacts arising from the action so as to deliver a conservation gain that adequately compensates for the impacted matter. The size and scale of an offset required for each impact is determined by taking account of a number of different considerations that are discussed in this policy, including the:

- level of statutory protection that applies to the protected matter
- specific attributes of the protected matter, or its habitat, being impacted
- quality or importance of the attributes being impacted with regard to the protected matter's ongoing viability
- permanent or temporary nature of the residual impacts
- level of threat (risk of loss) that a proposed offset site is under
- time it will take an offset to yield a conservation gain for the protected matter
- risk of the conservation gain not being realised.

As the time it takes for an offset to deliver an ecological benefit increases, so do the risks to the protected matter. The relationship between risk and scale is represented in Figure 3.

Figure 3 – Relationship between scale of offset requirements and risk



7.5 Suitable offsets must effectively account for and manage the risks of the offset not succeeding

The use of offsets as a compensatory measure through the assessment and approval process involves two levels of risk. The first, and highest, level of risk is that the impact on the protected matter will be too great and that an offset will not be able to compensate for the impact. This risk is addressed through the assessment process.

The second level of risk relates to whether individual offsets are likely to be successful in compensating for the residual impacts of a particular action over a period of time. It is this risk that is considered in determining a suitable offset and has direct bearing on the scale of the offset required. The magnitude of a suitable offset will increase proportionately to the risk posed to the protected matter by the proposed action. The relationship between risk and the scale of offset required is demonstrated in Figure 3 above.

In general terms, direct offsets present a lower risk than other compensatory measures, as they are more likely to result in a conservation gain for a protected matter. The advanced delivery of offsets (that is, those that are in place before the proposed action takes place) also reduce the risk profile of an offset through providing a conservation gain at an earlier point in time (see section 4.2.3 relating to advanced offsets).

Because of these uncertainties, a risk based approach incorporating the precautionary principle is taken when determining whether offsets are a suitable option and whether they can compensate for the residual impacts on a case by case basis. Specifically, risk is taken into account when considering:

- What is the residual impact?
- What type of offset should be provided?
- What size should the proposed offset be?
- Where should the proposed offset be located?

There is also the risk that offsets may result in perverse outcomes, either for the environment as a whole or for other aspects of the community, for instance social and economic factors. To avoid these outcomes, analysis of the possible perverse outcomes will form part of the decision making process in deciding the suitability of an offset package.

7.6 Suitable offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs

Offsets must deliver a conservation gain for the impacted protected matter, and that conservation gain must be new, or additional to what is already required by a duty of care or to any environmental planning laws at any level of government. It is important to note however that this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action (see section 7.6.1).

This requirement would, however, generally prohibit using a piece of land already set aside in the conservation estate or using a site that is already unable to be built upon due to zoning laws (a foreshore reserve for instance) as an offset for a proposed action.

Environmental offsets must also be additional to what has been paid for under other schemes or programs on a *pro rata* basis. For instance, if a landholder is receiving stewardship funding from a program such as *Caring for our Country*, then the conservation gain achieved through fulfilling the program's contract is not eligible to be used as an offset. Similarly, the conservation gain achieved while participating in another scheme (such as the *Carbon Farming Initiative*), would also not be eligible for use as an offset.

However, if the proposed offset is for further activities that achieve additional conservation gain on the same piece of land, then those additional activities may be eligible for use as offsets. For example, if a piece of land is being used as an offset to preserve and manage that land for the protected matter, then it may be permissible to use that piece of land to offset another proposed action where:

- there are no perverse outcomes e.g. there is no conflict between the management of the two offsets, such as the need for conflicting fire regimes; and
- synergies are produced e.g. releasing and actively managing captive bred animals (offset 2) into an already protected and managed area for the same species (offset 1) may increase the survival rate of the released animals and increase the viability of the existing population.

Whether or not an offset is considered to be additional will be assessed on a case by case basis. Where a proponent or offset provider seeks to secure an advanced offset, it must sufficiently document the establishment of that offset, including relevant baseline data, to demonstrate to the department that it is additional.

7.6.1 Links with state and territory approval processes

All of the states and territories have laws that protect the environment. The majority of proposed actions that need approval under the EPBC Act also require environmental approval from the relevant state or territory government before they can proceed.

It is important to note that while there are many similarities between the environmental laws of the states and territories and the EPBC Act, they also differ in a fundamental way. The EPBC Act focuses on protecting matters of national environmental significance and only protects the broader environment in certain circumstances. State and territory laws on the other hand usually protect the environment as a whole (for example air quality, noise pollution, water quality, biodiversity, and heritage values). These differing legislative objectives result in different assessment processes and can result in different offset requirements.

As a consequence, some proponents may need to provide offsets under both state or territory laws and the EPBC Act for the same action. A state or territory offset will count toward an offset under the EPBC Act to the extent that it compensates for the residual impact to the protected matter identified under the EPBC Act.

Making an early referral provides an opportunity to align the impact assessment processes of the relevant state or territory with the EPBC Act to the extent that this is possible.

7.7 Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable

Efficient and effective offsets are those that maintain or improve the viability of a protected matter through the sound allocation of resources. For example, where it is possible under this policy, the Australian Government will work with states and territories to align offset requirements. This alignment will deliver efficient and streamlined assessment processes for project proponents and effective environmental outcomes.

Offsets must also be timely. That is, an offset should be implemented either before, or at the same point in time as, the impact arising from the action. This timing is distinct from the time it will take an offset to yield a conservation gain for the protected matter, which may be a point in the future.

Offsets must be based on both scientifically robust and transparent information that sufficiently analyses and documents the benefit to a protected matter's ecological function or values. This includes undertaking desktop modelling of offset benefits and conducting relevant field work as appropriate.

7.8 Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced

Offsets must be delivered within appropriate and transparent governance arrangements. Proponents, or their contractors, must report on the success of the offsets so that conditions of approval can be varied if the offsets are not delivering the desired outcome.

Offset proposals will need to include clearly articulated measures of success that are linked to the purpose of the offsets and provide clear benchmarks about their success or failure. Annual reports will be required by the department and, where possible, will be made publicly available.

Performance of offsets will be reviewed as part of the monitoring, compliance and audit program for all proposals considered under the EPBC Act. All offsets will be registered and details, such as spatial information (for example GPS data), information on the relevant protected matters and the ongoing management actions required will be recorded. This information will be made publicly available on the department's website where it is appropriate to do so. This registration process will ensure that land that is proposed as an offset is available and suitable for use as an offset in each particular case, allow strategic planning, and streamline processes with state and territory requirements and schemes.

Establishment costs of offsets required as a condition of approval under the EPBC Act must be borne by the proponent and the offset must be designed in a way that is able to be measured, monitored, audited and enforced. The department will not be responsible for the costs of establishing an offset, or any costs associated with the ongoing management of an offset.

Where a proponent elects to have a third party manage or establish an offset area or program, the proponent must make contractual arrangements with the third party to deliver the offset in accordance with their approval conditions.

In determining the success of an offset, proponents will be required to report data that allows for the performance of an offset to be evaluated. Obtaining such data is part of the ongoing management of an offset and the cost therefore lies with the proponent. Conditions will require that data be made readily available to the department and in a format that can be easily integrated into a departmental database.

8. GOVERNMENT DECISION-MAKING RELATING TO OFFSETS

8.1 Decisions will be informed by scientifically robust information

In keeping with the broader environmental impact assessment process under the EPBC Act, the determination of offsets is based on the best available scientific data and evidence. Key sources for determining offset priorities include the relevant Commonwealth approved recovery plan, threat abatement plan, conservation advice, ecological character description, management plan or listing document. Where Commonwealth approved guidance documents are not available or are insufficient in detail, the department will review additional information sources such as state and territory management plans or peer reviewed scientific literature to inform priority offset activities. Data that informs the specific nature and scale of a particular offsets package may include consulting scientists, scientific literature, and data collected by both the department and proponents.

8.2 Conducted in a consistent and transparent manner

The *Offsets assessment guide* (the guide) was designed for the department's use to assist in the determination of suitable offsets for threatened species and ecological communities, based on the nature and extent of the impacts likely to occur at the proposed impact site. The guide helps ensure that the process of determining suitable offsets is consistent across industries and geographical locations. It will increase the transparency of the process because the impacts and offsets are explicitly detailed and calculated.

Although specifically designed for the use of the department, the guide is a public document and as such can be used by proponents to consider offset requirements early in their project planning. It is at the decision maker's discretion to determine how a proposed action and offset proposal is evaluated and how the figures and scores are assigned. The guide provides flexibility to ensure that the most efficient offsets can be determined, while ensuring that offsets improve or maintain the viability of the impacted protected matter. Although informed by the policy, it is important to note that the guide is within the broader context of the policy. Potential offsets generated by the guide may be modified to better conform to the policy. Further, the policy sits beneath, and must conform to, the EPBC Act.

For protected matters not covered by the guide, the department will determine the suitability of any offset proposals based on the principles outlined within this policy and in consultation with project proponents.

9. OFFSET DELIVERY OPTIONS

Offsets can be delivered by a range of mechanisms, including market-based mechanisms and contracting third party providers. Regardless of the offset delivery mechanism, project proponents remain responsible for ensuring that their conditions of approval are met.

9.1 Use of market-based mechanisms to deliver offsets

A well-functioning market for biodiversity offsets creates a clear system through which offsets can be traded by specifying the boundaries and conditions of the market and bringing together potential buyers and sellers. It is anticipated that the financial incentives that are subsequently attained will lead to a greater availability of offsets at any given time by encouraging private sector investment in the protection and restoration of biodiversity. For example, rural landholders may wish to diversify their income streams by investing in conservation activities that benefit specific threatened species with a view to providing these as offsets. Further discussion of the provision of offsets by third parties is at section 9.2.

There are various market-based tools that can be utilised for the delivery of offsets, from land brokering services through to biodiversity banking schemes, whereby credits are generated through conservation activities on a property and subsequently traded within a market framework.

Use of market-based mechanisms for delivering offsets is supported as a means of determining the conservation value of both the proposed action site and the proposed offset, where such mechanisms are based on reproducible and scientifically robust information.

In utilising biodiversity banking schemes, proponents should discuss their plans with the department in order to ensure that the offset delivered through such a scheme will satisfy the requirements of this policy and, in the case of threatened species and ecological communities, the *Offsets assessment guide*.

Two state governments have developed biodiversity banking schemes, BushBroker in Victoria and BioBanking in NSW. Proponents should engage with the department early in the assessment process where they wish to utilise state and territory schemes to allow for streamlining of processes between the different jurisdictions.

9.2 Use of third parties to deliver offsets

Suitable third parties can be used to deliver offsets. In many cases, enhanced environmental, social and economic outcomes can be achieved through the use of third party offset providers such as rural landholders, private conservation organisations, and Indigenous corporations. Contracts with third parties to manage an offset may be through a biodiversity banking scheme, however the use of a third party to deliver an offset must be approved by the decision maker. In all cases, the decision maker must be satisfied that appropriate mechanisms are in place to ensure the successful delivery of the offset and that the offset will meet the compliance requirements of any conditions of approval.

10. FURTHER INFORMATION

EPBC Act policy statements are the department's public policy documents which provide guidance on the practical application of EPBC Act. The policy statements include:

- significant impact guidelines
- EPBC Act practices and procedures
- industry guidelines
- information on listed ecological communities
- significant impact or referral guidelines for nationally listed species
- regional guidelines
- survey guidelines for nationally threatened species.

These are available on the department's website at: **http://www.environment.gov.au/epbc/guidelines-policies.html**

Conservation advices and recovery plans are available at: **http://www.environment.gov.au/cgi-bin/sprat/public/conservationadvice.pl?proc=main**

For further general information about the EPBC Act, including information about the referral, assessment and approval processes, please contact the Department of Sustainability, Environment, Water, Populations and Communities Community Information Unit on 1800 803 772, or access the EPBC Act website at: **www.environment.gov.au/epbc**

Appendix A: Criteria for research and educational programs

A suitable research or education program must:

1. endeavour to improve the viability of the impacted protected matter, for example
   – signage in key areas to educate the public regarding the risks to a threatened animal, or
   – research into effective re-vegetation techniques for a threatened ecological community
2. be targeted toward key research/ education activities as identified in the relevant Commonwealth approved recovery plan, threat abatement plan, conservation advice, ecological character description, management plan or listing document. Where Commonwealth approved guidance documents are not available or are insufficient in detail, the department will consider additional information sources such as state and territory management plans or peer reviewed scientific literature to inform priority offset activities
3. be undertaken in a transparent, scientifically robust and timely manner
4. be undertaken by a suitably qualified individual or organisation in a manner approved by the department
5. consider best practice research approaches.

The proponent is required to:

1. select an institutional or individual host (for the purpose of executing the program) through an internationally available open tender process or provide evidence that the program can be successfully undertaken in-house. The department will not be responsible for processing tenders. Where appropriate, the tender should complement an existing research institution's (e.g. National Environmental Research Program Hub) work program as it relates to the matter of national environmental significance. This will be the responsibility of the proponent; however, the department will require that proponents follow the department's guidelines
2. provide updates on progress and key findings to the department through periodic reporting
3. ensure that funds are managed appropriately and that auditable financial records are kept and maintained
4. apply a 'no-surprises' policy to the publication, whereby research publications and outputs are provided to the department at least 5 working days before release.

Research programs:

1. will be tailored to at least a postgraduate education level; however, there will be scope to engage other educational levels in educational programs (see below)
2. will present findings that can be peer-reviewed
3. will publish findings in an internationally recognised peer-reviewed scientific journal or be of a standard that would be acceptable for publication in such a journal. Publications should be submitted to free open access journals. Data and information collected should have creative commons licensing and be free and accessible
4. research outputs should inform future management decisions on the protected matter and, where possible, be readily applicable to other similar matters (species groupings etc).

Educational programs:

1. will be likely to vary in scope, mode of delivery and duration according to the target audience and the protected matter, (for instance, school or community programs, signage or printed materials)
2. should seek to attain measurable outcomes. Note that it may be difficult to ascertain the scope of influence of educational programs as it can be difficult to link education activities to behavioural change and subsequent improvement in the viability of the protected matter
3. should be targeted toward behavioural change and subsequent improvement in the viability of the protected matter.

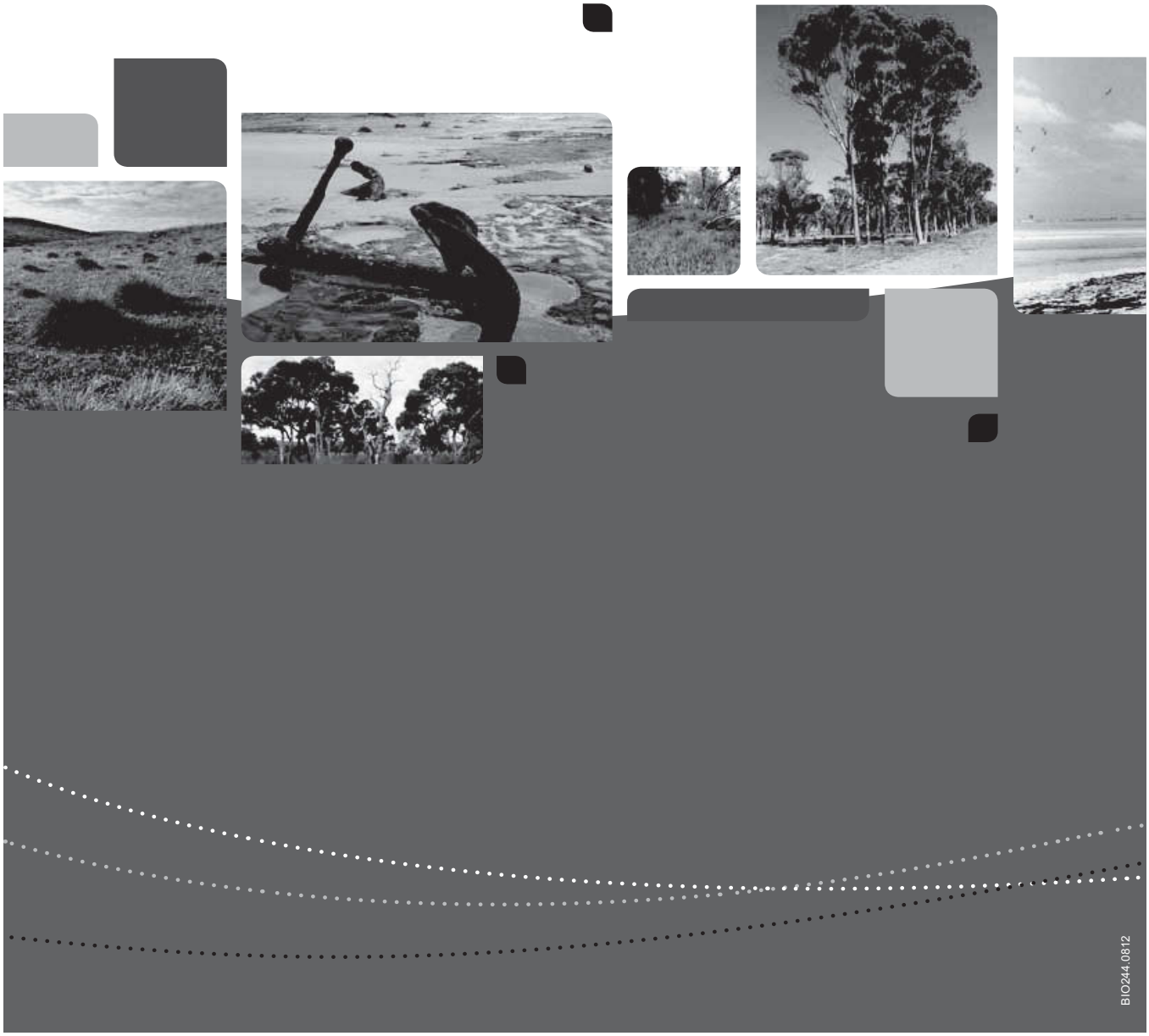
Photo Credits

FRONT COVER IMAGES (left to right)

1 West Islet, Ashmore Reef National Nature Reserve, QLD. Copyright – Australian Heritage Council
2 Avenue of Salmon Gums, WA. Copyright – Leonie McMahon
3 Close-up view of bark texture on a coastal eucalypt, Swansea, NSW. Copyright – John Baker
4 Coral at Osprey Reef in the Coral Sea, QLD. Copyright – Andrew Read
5 Sanderling feeding on beach, California, USA. Copyright – Joyce Gross
6 Green and Golden Bell Frog. Copyright – Frank Lemckert (SFNSW)

BACK COVER IMAGES (left to right, top to bottom)

1 Iron Grass, Kapunda, SA. Copyright – Andrew Tatnell
2 Anchor from the Marie Gabrielle (1869) on Wreck Beach, Apollo Bay, VIC. Copyright – John Baker
3 Bushland alongside modern housing development, Perth, WA. Copyright – Silver Sun Pictures
4 Ground cover of Native Seablite under Casuarinas, Swansea, NSW. Copyright – John Baker
5 Fenced off area of Salmon Gums, Moora, WA. Copyright – Dragi Markovic
6 West Islet, Ashmore Reef National Nature Reserve, QLD. Copyright – Australian Heritage Council



BIO244.0812

Appendix K

Saddlers Creek Restoration: CMA Agreement

RECEIVED
2 0 APR 2012
HCRCMA Muswellbrook

NSW GOVERNMENT Primary Industries

Hunter-Central Rivers CMA CATCHMENT MANAGEMENT AUTHORITY

Collaboration Agreement

Anglo American Property Planning and Land Rehabilitation Programme

This is an agreement between the **Department of Primary Industries, an office of the CMA of Trade and Investment, Regional Infrastructure and Services** representing the Crown in right of the State of New South Wales (ABN 72 189 919 072) located at 161 Kite Street Orange NSW 2800 ("the CMA") and the Collaborator for the Collaborator to collaborate in accordance with the following **Details** and **Terms** and **Schedules** ("**the Agreement**").

Details		
Collaborator *(Clause 15)*	Name: Anglo American Metallurgical Coal Pty Ltd Address: GPO Box 1410, Brisbane QLD, 4001 Australia ABN: 93 076 059 679 Contact Person: Ian Curtis Position: Rural Property Manager Address: GPO Box 1410 Brisbane QLD 4001 Australia Telephone: 07 3834 1216 Fax: 07 3834 1390 E-mail: ian.curtis@angloamerican.com	
CMA Contact Person *(Clause 15)*	Contact Person: Fiona Marshall Position: General Manager Address: Private Bag 2010 Paterson NSW 2421 Telephone: 02 4930 1030 Fax:: 02 4930 1013 E-mail: fiona.marshall@cma.nsw.gov.au	
Commencement Date *(Clause 10)*	05/03/2012	
Completion Date	05/03/2015	
Programme	Saddlers Creek Property Planning and Land Rehabilitation Project	
Programme Steering Committee	The Programme Steering Committee will consist of: 2 members from the CMA and 2 members from the Collaborator	
	Collaborator	**CMA**
	1. Ron Connelly 2. Jason Fittler	1. Adrian J. Brown 2. Steve Eccles

Steering Committee Chairpersons	**Collaborator:** **CMA:**
Special Conditions:	

Terms of Collaboration

1. **Definitions and Interpretation**

2. **Interpretation**

Unless the context requires otherwise, in this Agreement:

(a) the terms set out in the left hand column of the Details have the meaning ascribed to them in the right hand column of the Details;
(b) words in the singular include the plural and vice versa;
(c) where any time limit pursuant to this Agreement falls on a day which is not a Business Day then the time limit will be deemed to have expired on the next Business Day;
(d) a reference to a statute, regulation, ordinance or by-law will be deemed to include a reference to all statutes, regulations, ordinances or by-laws amending, consolidating or replacing same from time to time;
(e) headings are for convenience only and do not affect the interpretation of this Agreement;
(f) the meaning of general words is not limited by specific examples introduced by "including" or "for example" or similar expressions;
(g) references to persons include bodies corporate, government agencies and vice versa;
(h) references to the parties include references to respective directors, officers, employees, agents of the parties;
(i) nothing in this Agreement is to be interpreted against a party solely on the ground that the party put forward this Agreement or any part of it; and
(j) where an expression is defined, any other grammatical form of that expression has a corresponding meaning.

3. **Definitions**

Background IP means Intellectual Property that is made available by a party for the purpose of this Agreement, whether upon commencement of this Agreement or during the Term, and:

a. is in existence prior to the date of this Agreement; or
b. is brought into existence independently of this Project.

Business Day means any day other than a Saturday, Sunday or public holiday in New South Wales.

Claim means any cost, expense, loss, damage, claim, action, proceeding or other liability (whether in contract, tort or otherwise), however arising and includes legal costs on a full indemnity basis.

Confidential Information of a party means all trade secrets, financial information and other commercially or scientifically valuable information of whatever description and in whatever form (whether written or oral, visible or invisible) which:

(a) is by its nature confidential;
(b) has been designated as confidential by a party;
(c) is capable of protection at law or equity as confidential information; or

(d) is derived or produced partly from the Confidential Information.

Intellectual Property includes:

(a) all rights in relation to copyright, inventions, plant varieties, trademarks, designs, patents;
(b) all other rights resulting from intellectual activity in the industrial, scientific, literary or artistic fields including trade secrets and know-how but does not include Moral Rights.

Notice means any approvals, consents, instructions, orders, directions, statements, requests and certificates, or other communication to be given under this Agreement.

Personal Information has the same meaning as in the *Privacy and Personal Information Protection Act 1998 (NSW)*.

Term means the period commencing on the Commencement Date and ending on the Completion Date, unless terminated earlier or extended in accordance with this Agreement.

Project means the individual project under the Programme as set out in Schedule 2 or as determined by the Steering Committee from time to time;

Project Activities means the activities referred to in Schedule 2 for the development and implementation of an individual Project and as varied from time to time by agreement of the parties;

Programme Goals means the goals of the parties in relation to the Programme as set out in Schedule 1 which may be changed from time to time by agreement of the parties;

Project Objectives means the objectives of each Project; and

Non-operational land means that land owned by Collaborator which is outside the area of land covered by a mining lease granted under Part 5 of the *Mining Act 1992*

4. The Collaborator's Obligations

4.1 In consideration of the obligations to be performed by the CMA under clause 5 the Collaborator agrees to:

(a) Provide funding as required under this Agreement;
(b) Undertake the Project Activities with due professional care and skill and in good faith;
(c) Ensure that all approvals and licences necessary to undertake any and all of the Project Activities as described are in place prior to the activities to which those approvals and licences pertain are commenced;
(d) Develop Project plan(s) in collaboration with the CMA;
(e) Engage and direct suitably qualified employees and contractors to undertake the Project Activities;
(f) ensure the occupational health and safety of all people who may be affected by the Collaborator's activities under the Agreement in compliance with the *Work Health and Safety Act 2012* for any works to be undertaken as part of the Project;
(g) avoid damage to property and the environment when carrying out the Project Activities, and make good any such damage at the Collaborator's expense;
(h) prevent nuisance or inconvenience to anyone who may be affected in performing Project Activities.

5. The CMAs obligations:

5.1 The CMA will:

(a) Assist with the development of Project plan(s) in collaboration with the Collaborator;

(b) Provide technical support to the Collaborator to support the implementation of certain works undertaken as part of the Project.

6. **Commitments**

6.1 Each party makes the following commitments:

(a) to positively promote the Programme;

(b) to provide personnel with the appropriate level of expertise to participate in the Programme; and

(c) each party will at all times be just and faithful in the conduct of the Programme and not conduct its affairs in any way that could bring the other party into disrepute, or cause damage to or otherwise diminish the reputation or standing of the other party in any way. This clause will not be used to limit the ability of either party to exercise its rights, responsibilities and obligations under any and all relevant legislation or regulation.

7. **Contributions**

7.1 Financial contributions for any Project Activities will be determined by the Steering Committee in conjunction with and during the development of the commercial arrangements for the joint projects.

7.2 To avoid doubt, any financial contributions determined and recommended by the Steering Committee will be subject to the final approval of each the parties.

7.3 In the event that financial contributions are agreed between the parties, the party responsible for the contribution must make payments 30 days after the receipt of a valid tax invoice.

7.4 Any payment of fees by the CMA does not constitute an admission on the part of the CMA that any services provided for such funding are in conformity with this Agreement and no payment will be deemed to release the Collaborator from its obligations under this Agreement.

8. **GST**

8.1 Unless otherwise defined in this Agreement, words or expressions used in this clause have the same meaning as defined in the *A New Tax System (Goods and Services Tax) Act 1999* ("GST law").

8.2 Unless otherwise indicated all amounts referred to in this Agreement are exclusive of GST.

8.3 If a taxable supply is made to a recipient, the party which makes the taxable supply must provide the recipient with a tax invoice or other document with information required by the GST law to be included in a tax invoice to enable the recipient to claim an input tax credit.

8.4 If the party which makes the taxable supply is not registered for GST it must provide the recipient with a statement with the first invoice in accordance with the GST law, or the recipient will withhold a withholding payment.

8.5 If any GST is payable by the party which makes the taxable supply under this Agreement, any consideration payable for any such taxable supply will be increased by the amount of GST payable (except to the extent that the consideration is already expressed to be GST inclusive).

9. **Steering Committee and Administration**

9.1 The Steering Committee will, wherever applicable:

(i) act as a forum for keeping all parties informed on the progress of the Project;

(ii) develop and approve projects comprising the Project Activities, including details of how, when and by whom such Project Activities will be implemented;

(iii) establish teams to manage Project Activities (Project management teams);

(iv) agree upon contributions to be made in respect of Project Activities (subject to the final approval of the party making such contribution);

(v) develop and approve budgets for Project Activities;

(vi) develop a communications plan for all Project Activities carried out under the Project. At a minimum, such communications plans should include:
  (A) objectives and target audience;
  (B) targeted key messages;
  (C) proposed communications activities including format, timing and responsibilities;
(vii) collaborate at all stages of the Project including, but not limited to, issues relating to Project Activities development and implementation;
(viii) discuss any issues that may arise during the course of the Project that are considered necessary to be discussed in order to effectively carry out the Project;
(ix) make its decisions and actions in accordance with the Programme Goals Objectives and Project Objectives contemplated in Schedule 1.

(b) Decisions of the Steering Committee must be made on:
  (i) on a consensus basis; and
  (ii) ensure that the Programme is conducted in the spirit of the Programme Goals and Project Objectives and.

(c) Specific Project Activities will be carried out on a day-to-day basis by the party nominated by the Steering Committee as having responsibility for such activities.

(d) Such party or committee will manage the Project Activities as directed by the Steering Committee on behalf of the parties and will be responsible for all activities and operations conducted in respect of the Project Activities.

9.2 The Collaborator and CMA agree to report on the following matters at each Steering Committee meeting:

(a) (Partnership Commitments) any specified commitments that arise from Steering Committee or Project Management Team meetings;

(b) (Reporting of expenditure) both cash and in-kind expenditure on Project Activities;

(c) (Communication) communication activities undertaken relating to the Project. Each partner shall report on communication activities as required by the approved communications plans for Project Activities; and

(d) (Project Milestones) an update that summarises outputs achieved for each Project Activity as follows:
  (i) status of Project Activities: Not commenced, Commenced, On-ground works commenced, Complete;
  (ii) landholder engagement: Number of landholders contacted; number of landholders engaged; number of landholders trained; and
  (iii) on-ground works: Summary of State Standard Output and CAP Management Target progress (eg. Km of riparian fencing, hectares revegetated).

10. Aboriginal Material

10.1 Where the material to be used in the Project (pre-existing or new) comprises material reasonably considered by the CMA to be the cultural and/or Intellectual Property of a particular Indigenous/Aboriginal person(s) or community(s), the CMA and Collaborator agree that they will not use or disclose such material unless authorised or required by law, to other persons or bodies without prior written and informed consent of the relevant Indigenous/Aboriginal person(s) or community(s).

10.2 For the purposes of this clause, the cultural and/or intellectual property of a particular Indigenous/ Aboriginal person(s) or community(s) includes the following:

(a) traditional Indigenous/Aboriginal knowledge which in the opinion of these groups or individuals should not be in the public domain; and/or

(b) material which is culturally sensitive to Indigenous/Aboriginal communities.

11. **Intellectual Property**

11.1 Each party retains ownership of any material or Background IP it provides to enable the Project Activities to be carried out.

11.2 The Collaborator acknowledges and agrees that ownership of all Intellectual Property Rights created during the Project will vest on their creation in the CMA and the Collaborator as joint tenants in common except in cases advised by the CMA where the rights are permanent and not capable of being transferred.

11.3 Each party may use any of the joint Intellectual Property and Project Results for its own internal research purposes

11.4 Where either party proposes to publish, register or commercialise any jointly owned Project Intellectual Property the parties will cooperate to facilitate that outcome.

12. **Confidential Information**

12.1 Each party as the recipient of Confidential Information ("Recipient") must in relation to the Confidential Information of the other party ("Discloser"):

(a) keep it confidential;
(b) use it only as permitted under this Agreement;
(c) not disclose it to any person other than to its employees, sub-contractors and agents who have a need to know;
(d) before disclosing it to any of the people described in sub-clause 12.1(c), make sure that those persons are made aware of the confidential nature of the Confidential Information prior to obtaining access and procure an assurance that any such Confidential Information will be kept confidential;
(e) not copy it or any part of it that is in material form other than as strictly necessary and must mark any such copy 'Confidential – ([*Name of Discloser*]);
(f) implement security practices against unauthorised copying, use and disclosure (whether that disclosure is oral, in writing or in any other form);
(g) immediately notify the Discloser if the Recipient becomes aware of any unauthorised copying, use or disclosure in any form or any disclosure required by law;
(h) promptly comply with any request by the Discloser to return or destroy any or all copies of Confidential Information unless required by law to be retained; and
(i) upon expiry or termination of this Agreement, return to the Discloser all Confidential Information provided to it by the Discloser.

12.2 A Recipient's obligations of confidentiality under this Agreement do not apply to information that (whether before or after this Agreement is executed):

(a) was acquired from a source other than the Discloser where such source is entitled to disclose it;
(b) is independently developed or known by the Recipient including because it is in the public domain otherwise than through a breach of this Agreement or other obligation of confidentiality;
(c) the Recipient can prove by contemporaneous written documentation was already known to it at the time of disclosure (unless such knowledge arose from disclosure of information in breach of an obligation of confidentiality); or
(d) is required to be disclosed by law.

12.3 The Recipient bears the onus of showing that any of the above exceptions apply.

12.4 **Disclosure of Information**

(a) In order for the CMA to comply with its obligations under the *Government Information (Public Access) Act 2009*, if this Agreement involves the provision of any services by the Collaborator to the public on behalf of the CMA, the Collaborator must, within seven (7) days

of receiving a written request by the CMA, provide the CMA with immediate access to the following information contained in records held by the Collaborator:

i) information that relates directly to the performance of the Project Activities;
ii) information collected by the Collaborator from members of the public to whom it provides, or offers to undertake Project Activities; and
iii) information received by the Collaborator from the CMA to enable it to undertake the Project Activities.

(b) For the purposes of sub-clause (a), information does not include:

i) information that discloses or would tend to disclose the Collaborator's financing arrangements, financial modelling, cost structure or profit margin;
ii) information that the Collaborator is prohibited from disclosing to the CMA by provision made by or under any Act, whether of any State or Territory, or of the Commonwealth; or
iii) information that, if disclosed to the CMA, could reasonably be expected to place the Collaborator at a substantial commercial disadvantage in relation to the CMA, whether at present or in the future.

(c) The Collaborator will provide copies of any of the information in sub-clause (a), as requested by the CMA, at the Collaborator's own expense.

(d) Any failure by the Collaborator to comply with any request pursuant to sub clause (a) or (c) will be considered a breach of an essential term and will allow the CMA to terminate this Agreement by providing notice in writing of its intention to do so with the termination to take effect seven (7) days after receipt of the notice. Once the Collaborator receives the notice, if it fails to remedy the breach within the seven (7) day period to the satisfaction of the CMA, then the termination will take effect seven (7) days after receipt of the notice.

(e) The Collaborator acknowledges that, under the *Government Information (Public Access) Act* 2009, the CMA may be required to publicly disclose information about this Agreement at https://tenders.nsw.gov.au . None of the disclosure obligations require the disclosure of: the commercial-in-confidence provisions of a contract; any matter that could reasonably be expected to affect public safety or security; or information which would be exempt from disclosure if it were the subject of an application under that Act. The Collaborator may nominate any items it considers are confidential and why, to assist the CMA in determining what items to disclose

(f) The Collaborator authorises the CMA to make personal information concerning the Collaborator, such as its name, address and details of its work performance, available to other State, Commonwealth and local government agencies and funding agencies. The Collaborator does not have to supply this information; however, the CMA may not be able to fulfil its obligations without revealing that information to such agencies. The Collaborator may obtain details of any personal information about it held by the CMA by contacting the CMA's Contact Person.

13. Privacy

13.1 The Collaborator will:

(a) use Personal Information provided by the CMA or collected by the Collaborator under this Agreement, only for the purposes of performing its obligations under this Agreement;
(b) not disclose any Personal Information without the written consent of the CMA;
(c) comply with the Information Protection Principles applying to NSW public sector agencies under the *Privacy and Personal Information Protection Act 1998 (NSW)*; and
(d) include equivalent requirements (including this clause 13.1) in any subcontract entered into for the provision of any of the Project Activities under this Agreement.

14. **Promotional Material**

14.1 Neither party will publish any article relating to the Programme without the prior written consent of the other party, such consent not to be unreasonably withheld. Where appropriate, publications arising out of the performance of this agreement will be jointly authored.

14.2 In the interest of maintaining the good name and reputation of both parties, Collaborator and CMA agree that full details (including artwork) of all proposed advertising or promotional material, press releases and any other publicity material or products making reference to the partnership and the Project Activities will be presented to both parties for approval prior to its production, publication or distribution. Neither party may proceed without the prior written consent of the other party (such consent not to be unreasonably withheld or delayed).

15. **Term and Termination**

15.1 This Agreement will commence on the Commencement Date and shall continue for the Term.

15.2 This Agreement will conclude on the earlier of:

(a) Expiry in accordance with clause15.1;

(b) on the expiration of 90 days following receipt of a notice from one party that it wishes to terminate the agreement; or

(c) except as provided for under clause 12.4(d), termination by either party by giving notice to the other party where the other party has breached any material provision of this Agreement and that other party has not rectified the breach within 30 days of receiving notice requiring it to do so;

(d) termination by the CMA by notice to the Collaborator if the Collaborator becomes insolvent, makes an assignment for the benefit of creditors, is the subject of winding up proceedings whether voluntary or compulsory otherwise than for the purpose of reconstruction and amalgamation or a receiver is appointed to the Collaborator by a court.

15.3 On termination of this Agreement:

(a) Termination of this Agreement will be without prejudice to any accrued rights of the parties;

(b) A party exercising its right to terminate under clause 15.2(b) will not be liable for any loss of profit, consequential loss or indirect loss suffered by the other party in relation to or as a result of the termination.

16. **Insurance**

16.1 The Collaborator must maintain the following insurance policies during the Term of the Agreement:

(a) public liability insurance, in the amount of not less that $10 million in respect of each and every occurrence and unlimited in the aggregate for any period of cover;

(b) worker's compensation insurance which covers all employees;

(c) any insurance which is compulsory under the laws in force for the time being.

16.2 The Collaborator must not do, permit or suffer any act, matter or thing or omission whereby any of the policies referred to in this clause may be vitiated, rendered void or voidable.

16.3 On request by the CMA, the Collaborator must provide a copy of valid and current certificates of currency for each or any of the policies described above.

17. **Dispute Resolution**

17.1 A party must not start an arbitration or court proceedings (except proceedings seeking interlocutory relief) about a dispute arising out of this Agreement unless it has complied with this clause.

17.2 A party claiming that a dispute has arisen must notify the other party to the dispute giving details of the Dispute.

17.3 Each party must negotiate in good faith to resolve a dispute and, if necessary to resolve the dispute, involve the Chief Executive Officers or other senior officers of the parties directly in the negotiations.

17.4 If the dispute involves technical matters and has not been resolved by negotiations under the previous clause within a reasonable time, the parties will refer the dispute for determination by an independent expert agreed by the parties in the technical field of the dispute.

17.5 If the dispute is not resolved under clause 17.3 or 17.4 within 30 days (or longer period agreed between the parties), the parties must refer the dispute for mediation by the Australian Commercial Dispute Centre Limited ("ACDC") for resolution in accordance with the Mediation Rules of the ACDC.

17.6 If the dispute is not resolved under clause 17.5 within 60 days after referral (or longer period agreed between the parties) either party may initiate proceedings in a court.

18. **Notices**

18.1 Unless otherwise stated in this Agreement, all Notices to be given under this Agreement must be in writing, and hand-delivered, posted, faxed or emailed:

(a) for the Collaborator, to the contact details specified in the Details or as otherwise notified in writing; and

(b) for the CMA, to the contact details for the Contact Person specified in the Details or as otherwise notified in writing.

18.2 Any Notice is deemed to be received by the receiving party as follows:

(a) if hand delivered, the day on which it is left at the relevant address;

(b) if sent by regular post within Australia, four [4] Business Days after the day on which it is posted;

(c) if sent by facsimile, the day of transmission, or the date and time the sender received a delivery confirmation report, and

(d) if sent by email, on entering the information system of the recipient party, notices given under the following clauses of the Agreement must not be sent by email: clause 15 (termination), clause 16 (insurance) and clause 18 (dispute resolution).

19. **General**

19.1 **Survival:** The following clauses survive termination or expiration of this Agreement clause 11 (Intellectual Property), clause 12 (Confidential Information), clause 13 (Privacy), clause 15 (Term and Termination), clause 15.3 (Termination consequences) this clause 19.1 and any other clause which by its nature is intended to survive this Agreement.

19.2 **Keeping of records and rights of access to such records:** The Collaborator:

(a) Where funding is received from the CMA the Collaborator authorises the CMA and any State or Commonwealth Government department or agency (the "Auditors") that has provided moneys to the CMA for the purposes of this Agreement, to examine and inspect, at reasonable times and on reasonable notice held by the Collaborator and Records, and allow any such Records to be copied; and

(b) Provide all reasonable assistance in order for auditors to properly carry out such inspections and audits.

19.3 **Independent Research:** Provided such research does not adversely affect that party's ability to carry out its obligations under this Agreement, each party has the right to conduct research independent of the Project free of any obligation to the other Party.

19.4 **Variation:** This Agreement may only be varied by agreement in writing signed by the parties.

19.5 **Inconsistency:** If there is any inconsistency between provisions then the order of precedence will be:

(a) the **Details**; then
(b) the **Special Conditions**; then
(c) these **Terms**; then
(d) any **Schedules**.

19.6 **Negation of employment, partnership or agency:** Notwithstanding that this Agreement is described as a "partnering":

(a) This Agreement does not create a relationship of agency, partnership, joint venture and/or employment between the parties.
(b) the rights, duties, obligations and liabilities of each party to this Agreement are several and not joint or collective;
(c) no party may hold itself out as the agent of, or in any way bind or commit, any other party to any obligation; and
(d) neither party has the authority to pledge or purport to pledge the credit of the other party, or to make or give any representations, warranties or undertakings for or on behalf of the other party.

19.7 **Waiver**

(a) If a party fails to exercise any of its rights under this Agreement, or delays exercising those rights, that failure or delay will not operate as a waiver of those rights or any future rights or in any respect estop a party from relying on the terms of this Agreement to their full force and effect.
(b) Any waiver by a party of a breach of this Agreement must be in writing and will not be construed as a waiver of any further breach of the same or any other provision.

19.8 **Assignment:** The Collaborator must not assign or novate its obligations or interests under this Agreement, without the prior written consent of the CMA.

19.9 **Counterparts:** This Agreement may be signed in any number of counterparts which taken together will constitute one instrument

19.10 **Governing Law:** The laws of New South Wales govern this Agreement and the parties submit to the non-exclusive jurisdiction of the courts in that State.

Executed as an Agreement (company)

Signed for and on behalf of Anglo American Metallurgical Coal Pty Ltd by:	
.....	.....
Signature of Director (1)	Signature of ~~Director (2) or~~ Company Secretary
Dieter Hoogé	Helen Patricia Kelly
Name of Director (1)	Name of ~~Director (2) or~~ Company Secretary
13/4/12	20/3/12.
Date	Date

Signed for and on behalf of the CMA **a part of Department of Primary Industries, an office of the Department of Trade & Investment, Regional Infrastructure & Services for and on behalf of the State of New South Wales** by its authorised signatory:

SUSAN E HOOKE	
Name	Signature
Chair Hunter-Central Rivers CMA	7 March 2012
Title	Date

SCHEDULE 1

Programme Goals

The goals of the Programme have been developed on the basis of the following:

- The Guiding Principles contained within the Hunter-Central Rivers Catchment Action Plan (CAP);
- Sound management of native vegetation including revegetating with locally endemic species;
- Sound management practices relating to riparian rehabilitation, woody weed control, stabilising actively eroding soils and revegetation of saline discharge areas; and
- Appropriate and best practice land management in relation to sustainable farming practices.

SCHEDULE 2

Saddlers Creek Property Planning and Land Rehabilitation Project

Background

Anglo American has approached the Hunter-Central Rivers Catchment Management Authority (CMA) in regards to the opportunities for rehabilitation of their properties in the Saddlers Creek catchment. Based on several site visits to the Saddlers Creek property and subsequent discussions with Anglo American staff, a project to undertake land rehabilitation and associated property planning activities was developed.

Project Scope

The proposed Saddlers Creek Property Planning and Land Rehabilitation Project area encompasses those lands illustrated in Figure 1. These lands are wholly owned by Anglo American. This is an area of non-operational land adjacent to the "Drayton South" open cut coal mine proposal. There is an existing lessee who manages this land and is a willing participant in the proposed property planning and land rehabilitation activities associated with the project.

Activities proposed for rehabilitation of Saddlers Creek have been developed from the land capability classification given to the land. This classification describes the practices that are within the natural limits of the land; dependent on soil type, slope, aspect and rainfall. A project outline with initial cost estimates is outlined below.

Project Activities

Broadly, project activities identified for Saddlers Creek and that form the cornerstones for proposed land rehabilitation include:

- Soil conservation earthworks, such as contour banks, gully control structures, and reshaping of eroded areas;
- Riparian fencing;
- Appropriately located vehicle and stock creek crossings;
- Revegetation, such as buffers, stock shelter belts, native vegetation restoration; and
- Sustainable farm practices, including minimal tillage, selection of appropriate machinery types, off stream watering, strategic fencing and rotational grazing.

Project Roles and Responsibilities

Anglo American will:

- Fund the project from its own funds
- Ensure that all approvals and licences necessary to undertake any and all of the project activities as described are in place prior to the activities to which those approvals and licences pertain are commenced.
- Develop project plan(s) in collaboration with the CMA at a suitable scale for each of the activities to be undertaken
- Engage and direct suitably qualified employees and contractors to undertake the works described in the project plan(s)
- Monitor, evaluate and report on the activities and outcomes according to a Monitoring, Evaluation and Reporting (MER) plan developed in collaboration with the CMA
- Provide the CMA with data pertaining to the outputs from the project, for inclusion in reporting against the targets described in the CAP

The CMA will:

- Assist with the development of project plan(s) in collaboration with Anglo American at a suitable scale for each of the activities to be undertaken
- Provide technical support to Anglo American to support the implementation of certain works undertaken as part of the project (these to be limited to soil conservation works, in-stream structures and riparian works).
- Provide advice to Anglo American on the implementation of strategic grazing activities.

Page 13 of 20

- Collaborate with Anglo American to develop and implement a MER plan for the project.

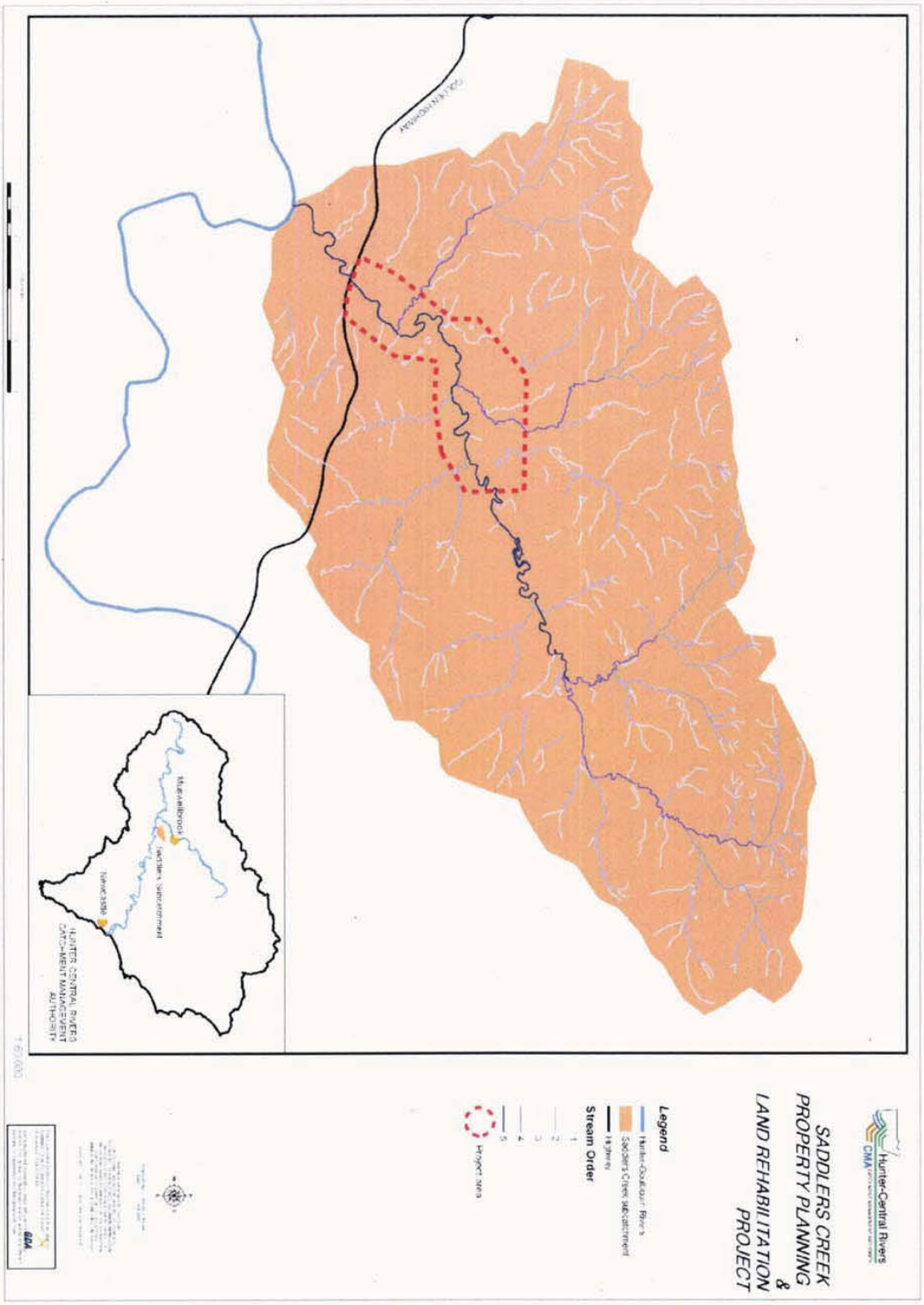


FIGURE 1: Saddlers Creek Property Planning and Land Rehabilitation Project area

Project concept and planning

A concept design layout, preliminary costs and a draft concept project map has been prepared, displaying the recommended activities along Saddlers Creek. The project area has been broken into three work areas. Detailed works are described below along with initial cost estimates. A concept project area is attached (Figure 2).

The concept map is subject to the proposed Edderton Road realignment, which is understood to traverse the project area.

Activities proposed for rehabilitation of Saddlers Creek are developed from the land capability classification given to the land. This classification describes the practices that are within the natural limits of the land; depend on soil type, land management constraints, slope, aspect and climate[1]

Land capability class for the western side of the creek ranges between Class III to Class V. The maps suggest the areas are mainly Class III. However soil limitations and slope provide limits to the land management practices and the area based on these issues is dominated by Class V. This classification relates to arable land with a moderate to high soil erosion hazard. The restricted areas of Class III land, soil erosion can be controlled by using soil conservation earthworks and/or conservation farming practices. Class V land which dominates the terrain is suitable for grazing. There are isolated areas of Class IV which restricts the land to occasional cropping providing soil conservation measures are implemented as per Class III.

The soil conservation earthworks proposed below require stable outlets with either permanently grassed areas or masonry works for water disposal points to ensure long term stability of the systems. Fencing of water disposal areas allows for greater ground cover and restricts domestic grazing in these critical areas. The earthworks generally require maintenance to ensure their continued effectiveness.

Proposed management activities for the Saddlers Creek land rehabilitation project area involve the following:

Soil conservation earthworks

- Construction of contour banks to divert surface flows away from degraded areas to dams to assist in reducing peak run-off and to increase water retention in the catchment.
- Construction of a gully control structure (flume) to stabilise the head-cut in the flow line originating from the property "Loloma" to the west of Saddler's Creek. The 1.5m head-cut is on a main tributary to Saddlers Creek (from the right bank) approximately 100m downstream of the existing vehicle crossing. The gully control structure would consist of angular rock, secured individually into place, with a cut-off wall at the top and bottom of the structure to secure the rock and prevent undercutting of the structure. The shape of the rock flume allows concentrated flows to be directed down the face of the flume and discharged into a stilling pond, before re-entering the gully at existing bed level. Estimated rock volume required to secure the bed of the gully is 220 cubic metres. A concept plan of the proposed structure is attached.
- Reshaping of upper terrace scour areas and smaller lateral head-cuts and application of seed and fertiliser to promote rapid establishment of ground cover
- Reshaping/ extension of existing contour banks to restore their functional use
- Stabilisation of a spillway from an existing dam with shaping and strips of revegetation across the gully to aid sediment retention

[1] Cunningham, GM, Higginson, F.R., Riddler, A.M.H., and Emery, K.A. 1986. *Systems Used to Classify Rural Lands in New South Wales.* Soil Conservation Service and NSW Agriculture.

Riparian fencing

Construction of fencing along Saddlers Creek and main tributaries is recommended to create a riparian corridor and allow regeneration of native plants and establishment of planted vegetation. The minimum buffer widths from the top of bank to the proposed fencing relative to the stream order (3rd order and above) is 40m on each side of the stream.

Tributaries of 3rd order and above or areas that become excessively wet or boggy would also benefit from fencing out. Recommended buffer widths vary for these tributaries, generally a minimum of 10m from the top of the bank to allow for lateral movement of streams, natural regeneration and ease of fencing.

Portions of existing fencing that is within the limits of the buffer area would be removed and new fencing located along the preferred buffer width alignment. (Area 2, Right bank; Figure 2).

Creek crossings

Vehicle and stock crossings are ideally located across a stable, straight stretch of stream to prevent erosion and extensive alteration to the channel. Crossings encountered during the site visits have been well located, with crossing levels matching streambed levels and minimal erosion on entries and exits. Little or no remedial works are required at these locations, but they will require careful management into the future.

Revegetation

Wide, dense, healthy vegetation buffers along the riparian areas provide multiple benefits for the catchment including habitat for aquatic and terrestrial wildlife, stream-bank erosion protection and biodiversity enhancement. Revegetation is recommended along the creek banks and the top of the banks to complement the suite of remnant riparian vegetation that occurs along the streams.

Casuarina glauca. (Swamp oak), is dominant along the riparian area with *Phragmites australis.* (native rush) and *Juncus acutus* (spiny rush an introduced species) intermixed along the creek-line. Areas where *juncus* dominates is generally an indicator of saline flows. A saline discharge area is highlighted on Figure 2. Revegetation with saline tolerant species is recommended across this area to alleviate saline discharge into the creek.

Locally endemic species grown from locally collected seed would be most suitable for revegetation. A plant list specific to the vegetation landscape is also available.[2]

Revegetation of Tributaries

The majority of tributaries to this section of the Saddlers Creek catchment have little or no native tree population. Connectivity to native vegetation outside the property is also low, and so the seed source for natural recruitment of native plants is very limited.

Suitable density of plantings for side gullies with no existing tree vegetation would be;
Minimum 3 rows of plantings along the banks, 3 along the top of the banks, each side of the gully, 4m spacings → 3000 plants / km.

Paddock Revegetation

Consideration may be given to connection of isolated paddock trees to other trees via vegetated corridors. Existing contour banks may provide a suitable medium for planting shelter belts and allow this connection. Integrated with internal paddock fencing (see Grazing section below) these linkages would provide additional stock shade and shelter and improved biodiversity benefits.

[2] Peake, T. 2003. Hunter Bushland Resource Kit: A guide to managing vegetation on private land in the Hunter catchment. Southwood Press, Hunter Catchment Management Trust, Tocal

Shelter belts for the project area have been aligned to suit the land aspect. Eastern facing slopes have greater distance between the corridors, compared to the southern and western facing slope that require greater protection from prevailing winds and therefore closer corridor spaces.

Land management - general

Cropping practices

Farming practices using conservation techniques such as minimal tillage, no kill cropping, direct drilling and pasture cropping are encouraged to maximise the amount of ground cover retained all year round, improving the organic matter in the soil, and improving general soil health.

The type of machinery used is critical in achieving conservation improvements, and existing machinery is often modified to allow this. Suitable machinery may include a "Para Plough", "Agrowplow" or a direct seed drill or machinery with "Baker Boot" fittings that minimise soil disturbance. Machinery such as offset disc ploughs would not form part of a sustainable system as they destroy soil structure.

Particularly in soils that are highly erodible, which is typical across the Bowfield property, conservation tillage techniques are recommended to allow the current enterprise to continue in the long term.

Grazing practices

Adjacent paddocks may benefit from the promotion of rotational grazing techniques, subject to establishment of a suitable stock density and paddock layout. Extensive grass growth in some areas along the western fall of the creek (Areas 1 and 2) may benefit from more intensive grazing over shorter periods, with longer periods of rest to utilise the growth potential of the existing pasture mix.

Subdivisional fencing would allow these strategic rotations to take place and would be easily facilitated through integration with the proposed riparian fencing.

Weed control

There are minimal weeds within the project area. Isolated plants including blackberry and boxthorn occur in Areas 1 and 3, and continued control of these woody weeds is recommended.

Off stream watering

Augmentation of the existing dams via provision of a reticulated system, coupled with a suitable rotational grazing system would allow maximisation of the available pasture and provide further stock benefits through a reticulated system.

A concept rotational plan has been developed for the grazing areas along the right bank of Saddlers Creek.

Initial ~~Cost~~ Work Estimates

The ~~costs associated with~~ the following list of recommended activities are to be considered as an estimate only and are based on the field experience of CMA staff and advice from other external sources. The user of this information is therefore advised to seek further clarification of costs prior to commencing the activities.

1. Rock Flume Design Saddler's Creek

Located on 4th order stream to the west of Saddler's Creek originating from W.R.Wolfgang property "Loloma".

Design Criteria

- 1,007 hectare catchment
- ARI (return period) I in 50 year
- Peak discharge 28 cubic metres.
- Drop of 1.5 meters
- Flume grade 1 in 10.

- 15 metres wide
- Rock Density minimum of 2200
- Minimum Rock diameter 0.6
- Total rock 220 cubic metres
- Cubic metres of the total of 220 to have a diameter of 0.8 metre.
- 2 concrete trenches minimum depth of 1.1 metres

2. Log Structures
- Located on the first flow line west of Saddler's Creek above Golden Highway.
- 3 log structures to control 3 different gully heads each 0.5 metre deep.
- Logs structures to be approximately 6 metres long.

3. Fencing
- Internal fencing including subdivision fencing tree planting area including initial exclusion fencing of Saddler's Creek and Tributaries.
- Based on traditional fence of 3 barbed wire and 2 plains with wooden post strainers and stays
- Total length of fencing is estimated at14 kilometres

4. Tree Planting
- 5.2 kilometres however Saddler's Creek initial area from Golden Highway 1 kilometre needs to have both sides planted
- Hence the total of 6.2 kilometres.
- At 3,000 trees per kilometre
- Total of 18,600 trees allow plants, (associated materials weed, mats, stakes and plastic or cardboard covers, fertiliser tablets).

5. Soil Conservation Works

Diversion Banks
- 2,500 metres to divert water into existing dams and away from eroded areas, including allowing for re-topsoiling due to the erosion hazard and general low fertility soils
- Gully Fill 700 metres
- Gully Shaping 2,000m

Compost
- Highly disturbed areas to be treated with compost from recycled green waste. The total area recommended to be treated for erosion is 9 hectares.

Seeding of eroded areas
- Seeding eroded areas

6. Weed Control
- Control of the existing boxthorns and blackberries using a combination of mechanical and chemical control methods.

7. Rabbit and Hare Control Program

Control by baiting
- Estimated minimum of 10 kilometre lineal length of bait runs.
- May need follow up work such as shooting and or release of virus

Warren ripping (bulldozer)
- Estimated 170 warrens varying in size are to found on the property.
- A minimum of 50 hours machine time is likely.

Seeding the disturbed Areas
- The area disturbed as a result of ripping of rabbit warrens is estimated at 20 hectares.


Hunter-Central Rivers CMA
Saddlers Creek Land Rehabilitation Project: Concept Plan
Area 1
Golden Highway to Main Tributary
Area 2
Main Tributary to next paddock
Area 3
Paddock to Edderton Rd
Prepared by: Linda Russell & Adrian J. Brown
Date: 8/9/11
Legend
Existing Fence
Cattle Yards
Proposed Works
Riparian fencing
Internal fencing
Reshaping
Plume
Diversion bank
Establish vegetation
0 100200 400 Meters
GDA
AREA 1
AREA 2
AREA 3
Edderton Road
Golden Highway
Saline revegetation area

Figure 2.

Appendix L

Survey Data from the Offsite Offset Property

Table L.1 Hollow Dataset from the Offsite Offset Property

		Plot Details	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
		Date	30/01/2012	30/01/2012	30/01/2012	30/01/2012	31/01/2012	27/02/2012	27/02/2012	28/02/2012	28/02/2012	28/02/2012	28/02/2012	29/02/2012	29/02/2012	29/02/2012
		Plot Size	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m
		Waypoint	1 (CP)	2	3	4	5	6	8	9	10	11	12	13	14	16
		Eastings	291584	292486	293527	292573	291548	293265	294798	295034	296212	294906	294831	292548	293941	295479
		Northings	6489601	6489419	6489377	6490566	6489461	6492372	6493817	6490444	6489976	6490081	6489817	6489562	6489567	6489834
<5cm	*E. blakelyi x E tereticornis*															
	E. melliodora															
	E. albens x moluccana									1						
	Stag								1	1						
	E. laevopinea															
	A. floribunda															
	Unidentified															
5-10cm	*E. blakelyi x E tereticornis*		1													
	E. melliodora															
	E. albens x moluccana			1	2											
	Stag									2		1		1		
	E. laevopinea															1
	A. floribunda							2								
	Unidentified															
11-15cm	*E. blakelyi x E tereticornis*															
	E. melliodora															
	E. albens x moluccana															
	Stag								2							
	E. laevopinea															
	A. floribunda															2
	Unidentified															
16-20cm	*E. blakelyi x E tereticornis*															
	E. melliodora															
	E. albens x moluccana			1	2	1										
	Stag															
	E. laevopinea										1					
	A. floribunda															
	Unidentified															
21-25cm	*E. blakelyi x E tereticornis*		1													
	E. melliodora															
	E. albens x moluccana					1										
	Stag															
	E. laevopinea										1					
	A. floribunda															
	Unidentified															
26-30cm	*E. blakelyi x E tereticornis*		2													
	E. melliodora															
	E. albens x moluccana			2		1										
	Stag															
	E. laevopinea															
	A. floribunda															

		Plot Details	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
	Unidentified															
>30cm	*E. blakelyi x E tereticornis*															
	E. melliodora															
	E. albens x moluccana					1										
	Stag															
	E. laevopinea															
	A. floribunda															
	Unidentified															
	Total:		4	4	4	4	0	2	3	4	2	1	0	1	0	3

Table L.1 Hollow Dataset from the Offsite Offset Property

		Plot Details	T15	T16	T17	T18	T19	T20	T21	T22	HT1	HT6	HoC	IR5	No. hollows over 26 x 0.1 ha plot
		Date	29/02/2012	1/03/2012	1/03/2012	1/03/2012	1/03/2012	1/03/2012	1/03/2012	1/03/2012	27/02/2012	28/02/2012	28/02/2012	28/02/2012	
		Plot Size	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	50x20m	
		Waypoint	17	605 (LO)	606	608	18 (CP)	19	20	21	513	583	602	-	
		Eastings	293885	295195	295145	293268	293140	292521	292370	291419	293075	294636	294078	-	
		Northings	6491093	6490963	6490769	6490951	6492996	6492321	6490710	6488824	6493054	6489854	6490149	-	
<5cm	*E. blakelyi x E tereticornis*					2									2
	E. melliodora				1										1
	E. albens x moluccana												6		7
	Stag			1	3					1			1		8
	E. laevopinea			4	4		2					1			11
	A. floribunda														0
	Unidentified										2				2
5-10cm	*E. blakelyi x E tereticornis*					4									5
	E. melliodora				1										1
	E. albens x moluccana							3		2		1	9	3	21
	Stag					1							1		6
	E. laevopinea			1	4		8					1			15
	A. floribunda														2
	Unidentified										1				1
11-15cm	*E. blakelyi x E tereticornis*					1									1
	E. melliodora						2								2
	E. albens x moluccana									1			6		7
	Stag				1	1							3		7
	E. laevopinea				1										1
	A. floribunda														2
	Unidentified														0
16-20cm	*E. blakelyi x E tereticornis*														0
	E. melliodora														0
	E. albens x moluccana								1				2	1	8
	Stag														0
	E. laevopinea						2								3
	A. floribunda														0
	Unidentified														0
21-25cm	*E. blakelyi x E tereticornis*														1
	E. melliodora						2								2
	E. albens x moluccana									1			1	1	4
	Stag														0
	E. laevopinea														1
	A. floribunda														0
	Unidentified														0
26-30cm	*E. blakelyi x E tereticornis*														2
	E. melliodora														0
	E. albens x moluccana													1	4
	Stag														0
	E. laevopinea														0
	A. floribunda														0

		Plot Details	T15	T16	T17	T18	T19	T20	T21	T22	HT1	HT6	HoC	IR5	No. hollows over 26 x 0.1 ha plot
	Unidentified														0
>30cm	*E. blakelyi x E tereticornis*														0
	E. melliodora														0
	E. albens x moluccana														1
	Stag			1 x stag hollow throughout	5 x stags hollow throughout	2 x stags hollow throughout							1 x stag hollow throughout	1 x stag hollow throughout	10
	E. laevopinea														0
	A. floribunda														0
	Unidentified														0
	Total:		0	7	20	11	16	3	1	5	3	3	30	7	138

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
TREES													
Anacardiaceae	exotic	*Schinus areira (small tree)*	Peppercorn Tree	2									
Casuarinaceae	native	*Casuarina cunninghamiana*	River Oak	2									
Cupressaceae	native	*Callitris glaucophylla (small tree)*	White Cypress Pine										
Loranthaceae	native	*Amyema sp.*	a mistletoe										
Myrtaceae	native	*Angophora floribunda*	Rough-barked Apple	2	3				2		1		adj
Myrtaceae	native	*Angophora floribunda (seedling)*	Rough-barked Apple										
Myrtaceae	native	*Angophora floribunda (small tree)*	Rough-barked Apple						3				
Myrtaceae	native	*Eucalyptus albens*	White Box					4		1	2		2
Myrtaceae	native	*Eucalyptus albens (seedling)*	White Box							+	+		
Myrtaceae	native	*Eucalyptus albens (shrub)*	White Box					1					
Myrtaceae	native	*Eucalyptus bridgesiana*	Apple Box			+							
Myrtaceae	native	*Eucalyptus cypellocarpa*	Monkey Grey Gum									2	
Myrtaceae	native	*Eucalyptus laevopinea*	Silvertop Stringybark			3	3		2			3	1
Myrtaceae	native	*Eucalyptus laevopinea (seedling)*	Silver Top Stingybark						+				
Myrtaceae	native	*Eucalyptus melliodora*	Yellow Box			2	2		P	3			
Myrtaceae	native	*Eucalyptus melliodora (seedling)*	Yellow Box							+			
Myrtaceae	native	*Eucalyptus melliodora (shrub)*	Yellow Box							1			
Myrtaceae	native	*Eucalyptus melliodora (small tree)*	Yellow Box						2				
Myrtaceae	native	*Eucalyptus tereticornis x blakelyi*	Forest Red Gum - Blakely's Red Gum intergrade	3	2					2			
Myrtaceae	native	*Eucalyptus tereticornis x blakelyi (shrub)*	Forest Red Gum - Blakely's Red Gum intergrade	P									
Myrtaceae	native	*Eucalyptus tereticornis x blakelyi (small tree)*	Forest Red Gum - Blakely's Red Gum intergrade										
Pittosporaceae	native	*Pittosporum undulatum (seedling)*	Sweet Pittosporum										
Pittosporaceae	native	*Pittosporum undulatum (shrub)*	Sweet Pittosporum			P							
Pittosporaceae	native	*Pittosporum undulatum (small tree)*	Sweet Pittosporum										
Santalaceae	native	*Exocarpos cupressiformis (small tree)*	Cherry Ballart									P	
Simaroubaceae	exotic	*Ailanthus altissima (small tree)*	Tree of Heaven			adj							
Sterculiaceae	native	*Brachychiton populneus*	Kurrajong					P					
Sterculiaceae	native	*Brachychiton populneus (seedling)*	Kurrajong	1									
Sterculiaceae	native	*Brachychiton populneus (shrub)*	Kurrajong										
Sterculiaceae	native	*Brachychiton populneus (small tree)*	Kurrajong										
SHRUBS													
Apocynaceae	exotic	*Gomphocarpus fruiticosus*	Narrow-leaved Cotton Bush						+				
Asteraceae	native	*Cassinia quinquefaria*	Cough Bush					+			P		
Asteraceae	native	*Olearia viscidula*	Wallaby Weed		+	P	1	+	3				
Asteraceae	native	*Senecio hispidulus var. dissectus*	Hill Fireweed				P	+	P	+			+
Asteraceae	exotic	*Senecio madagascariensis*	Fireweed										
Asteraceae	native	*Senecio quadridentatus*	Cotton Fireweed						1		P		+
Asteraceae	native	*Senecio sp. B*	-										
Asteraceae	native	*Sigesbeckia australiensis*	-						1				
Dilleniaceae	native	*Hibbertia obtusifolia*	Hoary Guinea Flower					P					
Dilleniaceae	native	*Hibbertia sp.*	-					P					
Ericaceae - Styphelioideae	native	*Melichrus urceolatus*	Urn-heath										
Fabaceae - Faboideae	native	*Indigofera australis*	Australian Indigo										
Fabaceae - Faboideae	native	*Pultenaea sp.*	-										
Fabaceae - Faboideae	native	*Swainsona galegifolia*	Smooth Darling-pea		+	+	1	1		+	P		+
Fabaceae - Mimosoideae	native	*Acacia implexa*	Hickory Wattle	+	P		1						
Fabaceae - Mimosoideae	native	*Acacia linearifolia*	Narrow-leaved Wattle			P	P	P					+
Fabaceae - Mimosoideae	native	*Acacia paradoxa*	Kangaroo Thorn										P
Oleaceae	native	*Notelaea ?microcarpa*	-										
Oleaceae	native	*Notelaea linearis*	-	2	2	2	2	2	1		1	+	
Oleaceae	native	*Notelaea longifolia forma glabra*	Large Mock-olive				1						
Pittosporaceae	native	*Bursaria spinosa*	Blackthorn								P	+	

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Rosaceae	exotic	*Rosa rubiginosa*	Sweet Briar	+				+		P	2		
Rosaceae	exotic	*Rosa rubiginosa (seedling)*	Sweet Briar				P						
Sapindaceae	native	*Dodonaea viscosa subsp. Angustissima*	Narrow-leaved Hopbush										
Solanaceae	native	*Solanum aviculare*	Kangaroo Apple										
Solanaceae	native	*Solanum cinereum*	Narrawa Burr				+		+				
Solanaceae	exotic	*Solanum pseudocapsicum*	Madeira Winter	1					+			+	
Solanaceae	?	*Solanum sp.*	-										
Ulmaceae	native	*Trema aspera*	Peach-leaf Poison-bush				+						
Violaceae	native	*Melicytus dentatus*	Tree Violet	2	2	3	2	+	+			1	
Xanthorrhoeaceae	native	*Xanthorrhoea johnsonii*	Johnson's Grass Tree						1			+	
DICOTS													
Acanthaceae	native	*Rostellularia adscendens*	-					P					
Amaranthaceae	native	*Alternanthera nana*	Hairy Joyweed	+									
Apiaceae	exotic	*Cyclospermum leptophyllum*	Slender Celery	P				P		P	1	1	+
Apiaceae	native	*Daucus glochidiatus*	Native Carrot										
Apiaceae	native	*Hydrocotyle laxiflora*	Stinking Pennywort			P			+	+	+	+	+
Apiaceae	native	*Hydrocotyle penduncularis*	-										
Apiaceae	native	*Hydrocotyle sp.*	-										
Asteraceae	exotic	*Bidens pilosa*	Cobbler's Pegs						+				+
Asteraceae	?	*Bidens sp.*	-										
Asteraceae	native	*Brachyscome sp.*	-										+
Asteraceae	native	*Calotis cuneifolia*	Purple Burr-daisy									+	
Asteraceae	native	*Calotis lappulacea*	Yellow Burr-daisy					1	+				
Asteraceae	exotic	*Carthamus dentatus*	Toothed Thistle										
Asteraceae	native	*Chrysocephalum apiculatum*	Common Everlasting								+		
Asteraceae	native	*Chrysocephalum semipapposum*	-										
Asteraceae	exotic	*Cirsium vulgare*	Spear Thistle	+			+	R		2	2	+	1
Asteraceae	exotic	*Conyza bonariensis*	Flaxleaf Fleabane	+	+	P	+	+	+	1	1		1
Asteraceae	native	*Cymbonotus lawsonianus*	Bears-ear							P			+
Asteraceae	native	*Euchiton ?sphaericus*	-		+	P				+			
Asteraceae	native	*Euchiton involucratum*	Star Cudweed								1		+
Asteraceae	native	*Euchiton sp.*	-										
Asteraceae	exotic	*Gnaphalium sp.*	-	P									
Asteraceae	exotic	*Hypochaeris radicata*	Catsear	P	1	1	+	+	+	P	+	+	+
Asteraceae	native	*Lagenophora stipitata*	Blue Bottle-daisy								P	+	
Asteraceae	native	*Senecio sp. A*	-										
Asteraceae	exotic	*Silybum marianum*	-								+		
Asteraceae	exotic	*Solvia sessilis (syn. Solvia pterosperma)*	Bindyi	+									
Asteraceae	exotic	*Sonchus oleraceus*	Common Sowthistle		P		+	R	+				
Asteraceae	exotic	*Taraxacum officionale*	Dandelion									P	
Asteraceae	native	*Vittadinia cuneata*	-								+		
Boraginaceae	native	*Cynoglossum australe*	-				P	R					
Cactaceae	exotic	*Opuntia aurantiaca*	Tiger Pear	+			+	P					
Cactaceae	exotic	*Opuntia stricta*	Prickly Pear				+						
Campanulaceae	native	*Wahlenbergia communis*	Tufted Bluebell	1			+		1	P	+		1
Campanulaceae	native	*Wahlenbergia gracilis*	Sprawling Bluebell		P	+		+				P	
Campanulaceae	native	*Wahlenbergia stricta*	Australian Bluebell									+	
Caryophyllaceae	exotic	*Cerastium glomeratum*	Mouse-ear Chickweed	P			+						
Caryophyllaceae	exotic	*Paronychia brasiliana*	Chilean Witlow Wort	+									
Caryophyllaceae	exotic	*Petrorhagia dubia*	-	P		+		+	+	+	+		+
Caryophyllaceae	native	*Stellaria pungens*	Prickly Starwort				1						
Chenopodiaceae	native	*Einadia hastata*	Berry Saltbush				P	P					
Chenopodiaceae	native	*Einadia nutans*	-										

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Chenopodiaceae	native	*Einadia polygonoides*	-						+				
Chenopodiaceae	native	*Einadia trigonos*	Fishweed		P		+						
Clusiaceae	exotic	*Hypericum perforatum*	St John's Wort	+		+		P					
Convolvulaceae	native	*Dichondra repens*	Kidney Weed	1	2	2	1	1	1	2	1	1	
Crassulaceae	native	*Crassula ?sieberiana*	Australian Stonecrop										
Crassulaceae	native	*Crassula sp.*	-										
Euphorbiaceae	native	*Chamaesyce drummondii*	Caustic Weed										
Euphorbiaceae	exotic	*Euphorbia peplus*	Petty Spurge										
Fabaceae - Faboideae	native	*Desmodium brachypodum*	Large Tick-trefoil						1				
Fabaceae - Faboideae	native	*Desmodium varians*	Slender Tick-trefoil		2	+	P	1	+	+	1	1	+
Fabaceae - Faboideae	exotic	*Medicago sativa*	Lucerne				+						
Fabaceae - Faboideae	exotic	*Trifolium arvense*	-			+	P						
Fabaceae - Faboideae	exotic	*Trifolium dubium*	Yellow Suckling Clover		1								
Fabaceae - Faboideae	exotic	*Trifolium repens*	White Clover							1	3		
Fabaceae - Faboideae	exotic	*Trifolium sp.*	-	1								1	
Fabaceae - Faboideae	exotic	*Trifolium subterraneum*	Subterranean Clover										1
Fabaceae - Faboideae	exotic	*Vicia sativa*	Vetch			P							
Fabaceae - Faboideae	exotic	*Vicia sp.*	a Vetch									+	
Gentianaceae	exotic	*Schenkia spicata*	Spike Centaury		+	+			+	+	+		
Geraniaceae	native	*Geranium solanderi*	Native Geranium	1	1	1	1	+	1	2	P	1	1
Haloragaceae	native	*Gonocarpus sp.*	-										
Lamiaceae	native	*Ajuga australis*	Austral Bugle								+		
Lamiaceae	exotic	*Marrubium vulgare*	White Horehound						+	+			
Lamiaceae	native	*Mentha satureoides*	Creeping Mint							3	3		1
Lamiaceae	native	*Scutellaria sp.*	-										
Lobeliaceae	native	*Pratia purpurascens*	Whiteroot								+		1
Malvaceae	exotic	*Modiola caroliniana*	-										
Malvaceae	native	*Sida corrugata*	-	P									
Malvaceae	exotic	*Sida rhombifolia*	Paddy's Lucerne	+		+							
Malvaceae	native	*Sida trichopoda*	Hairy Sida	+									
Menispermaceae	native	*Stephania japonica var. discolor*	Snake Vine				1						
Myrsinaceae	exotic	*Anagallis arvensis*	Scarlet/Blue Pimpernel							P			
Oxalidaceae	native	*Oxalis exilis*	-	+	1	+		1	+	1			+
Phyllanthaceae	native	*Poranthera microphylla*	-		+	+							
Plantaginaceae	native	*Plantago debilis*	-	+							+		+
Plantaginaceae	native	*Plantago gaudichaudii*	Narrow-leaved Plantain			+							
Plantaginaceae	exotic	*Plantago lanceolata*	Lamb's Tongues										
Plantaginaceae	native	*Veronica plebeia*	Creeping Speedwell						P			P	
Polygonaceae	exotic	*Polygonum aviculare*	Wireweed							1			
Polygonaceae	native	*Rumex brownii*	Swamp Dock	+		+	+		P	+	+		
Rosaceae	native	*Acaena anserovina*	-	P		1	1				1		
Rosaceae	native	*Acaena novae-zealandiae*	Biddy Biddy		1	1	2	1		1		P	+
Rubiaceae	native	*Asperula conferta*	Common Woodruff			P				+	2		1
Rubiaceae	native	*Galium ?binifolium*	-			P	+	1				1	+
Rubiaceae	native	*Galium ?leptogonium*	-										
Rubiaceae	native	*Galium gaudichaudii*	Rough Bedstraw										
Scrophulariaceae	exotic	*Verbascum thapsis subsp thapsis*	Common Mullein			+			+				
Solanaceae	exotic	*Solanum nigrum*	Blackberry Nightshade										
Thymelaeaceae	native	*Pimelea curviflora*	-								+		
Thymelaeaceae	native	*Pimelea linifolia*	Slender Rice Flower								+		
Urticaceae	exotic	*Urtica dioica*	Stinging Nettle	1		+	+	+	1	+	1	+	+
Verbenaceae	exotic	*Verbena bonariensis*	Purpletop	P									
Verbenaceae	exotic	*Verbena officinalis*	Common Verbena						+			P	

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Verbenaceae	exotic	*Verbena rigida*	Veined Verbena	P				R					
Verbenaceae	exotic	*Verbena sp.*	-										
MONOCOTS-GRASSES													
Poaceae	native	*Aristida ramosa*	Purple Wiregrass	P				3	2	1	P	+	1
Poaceae	native	*Aristida vagans*	Threeawn Speargrass			1	2	1	1				
Poaceae	native	*Austrodanthonia fulva*	-			1	1	P			P		1
Poaceae	native	*Austrodanthonia racemosa*	-	P	2		2	P				+	
Poaceae	native	*Austrodanthonia richardsonii*	Straw Wallaby-grass										
Poaceae	native	*Austrostipa scabra*	Speargrass				1	1			P		
Poaceae	native	*Bothriochloa decipiens*	Pitted Bluegrass	2		1	2	2	2	2	2		2
Poaceae	exotic	*Briza maxima*	Quaking Grass		1						P		
Poaceae	exotic	*Bromus molliformis*	Soft Broome	P						+			
Poaceae	native	*Chloris truncata*	Windmill Grass							+			
Poaceae	native	*Chloris ventricosa*	Plump Windmill Grass	P				P	+	1			
Poaceae	native	*Cymbopogon refractus*	Barbwire Grass					2	2				
Poaceae	native	*Cynodon dactylon*	Couch Grass										
Poaceae	exotic	*Cynosurus echinatus*	Rough Dog's Tail			P							
Poaceae	native	*Deyeuxia quadriseta*	-		1					1			
Poaceae	native	*Dichanthium sericeum*	Queensland Bluegrass					4			2		P
Poaceae	native	*Dichelachne crinita*	Longhair Plumegrass								1		2
Poaceae	native	*Dichelachne micrantha*	Shorthair Plumegrass			1							
Poaceae	native	*Dichelachne sp.*	-										
Poaceae	native	*Echinopogon caespitosus*	Bushy Hedgehog-grass	2	2	2		P	P		1	1	
Poaceae	native	*Echinopogon ovatus*	Forest Hedgehog Grass		1		1					2	
Poaceae	native	*Echinopogon sp.*	-										
Poaceae	exotic	*Eleusine tristachya*	Goose Grass										
Poaceae	native	*Elymus scaber*	Common Wheatgrass				P				1		1
Poaceae	native	*Eragrostis leptostachya*	Paddock Lovegrass	2			P	1	2				
Poaceae	native	*Eragrostis sp.*	-										
Poaceae	native	*Lachnagrostis filiformis*	-										
Poaceae	exotic	*Lolium perenne*	Perennial Ryegrass								P		
Poaceae	native	*Microlaena stipoides*	Weeping Meadow Grass	4	4	3	2	2	1	2	P	1	
Poaceae	native	*Panicum effusum*	Hairy Panic		P					P			
Poaceae	native	*Panicum simile*	Two-colour Panic										
Poaceae	exotic	*Paspalum dilatatum*	Paspalum							P			
Poaceae	native	*Poa labillardierei*	Tussock Grass	3	2	3	2	2			P	3	2
Poaceae	native	*Poa sieberiana*	-						1	2	2		
Poaceae	native	*Poa sp.*	-										
Poaceae	native	*Sporobolus creber*	Slender Rat's Tail Grass	P		+		2		1			
Poaceae	native	*Sporobulus sp.*	-										
Poaceae	native	*Themeda australis*	Kangaroo Grass				P						adj
MONOCOTS-OTHER													
Anthericaceae	native	*Arthropodium milleflorum*	Pale Vanilla-lily										
Anthericaceae	native	*Arthropodium sp.*	-					+			+	+	+
Anthericaceae	native	*Tricoryne ?elatior*	Yellow Autumn-lily										
Cyperaceae	native	*Carex ?incomitata*	-	1	1	2	+	+	1				
Cyperaceae	native	*Carex inversa*	-		P		P			+	1		+
Cyperaceae	native	*Cyperus gracilis*	Slender Flat-sedge	1			P	1	P	+			
Cyperaceae	native	*Cyperus sp. A*	-	+									
Cyperaceae	native	*Cyperus sp. B*	-										
Cyperaceae	native	*Lepidosperma laterale*	-										
Cyperaceae	native	*Shoenus ?imberbis*	Beardless Bog-rush								1		
Juncaceae	native	*Juncus subsecundus*	-	1							1		

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Juncaceae	native	*Juncus usitatus*	-										
Lomandraceae	native	*Lomandra confertifolia*	Mat-rush										
Lomandraceae	native	*Lomandra filiformis*	Wattle Mat-rush										+
Lomandraceae	native	*Lomandra glauca*	-					+					
Lomandraceae	native	*Lomandra longifolia*	Spiny-headed Mat-rush										
Lomandraceae	native	*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush	1					1		+		
Orchidaceae	native	*Pterostylis sp.*	-										
Phormiaceae	native	*Dianella ?revoluta*	Blueberry Lily										
FERNS AND ALLIES													
Adiantaceae	native	*Adianthum aethiopicum*	Common Maidenhair	P	P	2						P	
Adiantaceae	native	*Cheilanthes distans*	Bristly Cloak Fern										
Adiantaceae	native	*Cheilanthes sieberi*	Poison Rock Fern	P		1	P	1	+				
Aspleniaceae	native	*Asplenium flabellifolium*	Necklace Fern		P	2	1					1	
Davalliaceae	exotic	*Nephrolepis cordifolia*	Fishbone Fern										
Dennstaedtiaceae	native	*Pteridium esculentum*	Common Bracken			2						P	
CLIMBERS AND VINES													
Apocynaceae	native	*Parsonsia straminea*	Common Silkpod										
Bigoniaceae	native	*Pandorea pandorana*	Wonga Wonga Vine										
Caprifoliaceae	exotic	*Lonicera japonica*	Honeysuckle			adj							
Commelinaceae	native	*Commelina cyanea*	Native Wandering Jew	P									
Fabaceae - Faboideae	native	*Glycine ?tomentella*	Woolly Glycine										+
Fabaceae - Faboideae	native	*Glycine clandestina*	-		1							+	
Fabaceae - Faboideae	native	*Glycine microphylla*	Small-leaf glycine			+							
Fabaceae - Faboideae	native	*Glycine sp.*	-										
Fabaceae - Faboideae	native	*Glycine tabacina*	-	1	1	1	1	2	1	1	P	+	+
Luzuriagaceae	native	*Eustrephus latifolius*	Wombat Berry									+	
Pittosporaceae	native	*Billardiera scandens*	Hairy Apple Berry			P							
Ranunculaceae	native	*Clematis glycinoides*	Headache Vine			P						+	
Rosaceae	exotic	*Rubus fruticosus*	Blackberry complex							P			

Class	Cover-abundance
R	Rare (less than 0.1% cover)
+	Few Individuals (less than 1% cover)
1	Many Individuals (less than 5% cover)
2	5 - less than 25% cover
3	25 - less than 50% cover
4	50 - less than 75% cover
5	75 - 100% cover
adj	incidental (adjacent but not within plot)
P	present; outside 20 x 20 plot but within 20 x 50

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	T11	T12	T13	T14	T15	T16	T17	T18	TA	TB
TREES													
Anacardiaceae	exotic	*Schinus areira (small tree)*	Peppercorn Tree										
Casuarinaceae	native	*Casuarina cunninghamiana*	River Oak										
Cupressaceae	native	*Callitris glaucophylla (small tree)*	White Cypress Pine					2			3		
Loranthaceae	native	*Amyema sp.*	a mistletoe		P								
Myrtaceae	native	*Angophora floribunda*	Rough-barked Apple		P	P	P	3			2	2	P
Myrtaceae	native	*Angophora floribunda (seedling)*	Rough-barked Apple				P	+					P
Myrtaceae	native	*Angophora floribunda (small tree)*	Rough-barked Apple										
Myrtaceae	native	*Eucalyptus albens*	White Box	3	3								+
Myrtaceae	native	*Eucalyptus albens (seedling)*	White Box	+									
Myrtaceae	native	*Eucalyptus albens (shrub)*	White Box		1								P
Myrtaceae	native	*Eucalyptus bridgesiana*	Apple Box										
Myrtaceae	native	*Eucalyptus cypellocarpa*	Monkey Grey Gum				P						
Myrtaceae	native	*Eucalyptus laevopinea*	Silvertop Stringybark	2	2	P	3	P	3	2	P	2	2
Myrtaceae	native	*Eucalyptus laevopinea (seedling)*	Silver Top Stingybark		1								P
Myrtaceae	native	*Eucalyptus melliodora*	Yellow Box			3			P	1		P	
Myrtaceae	native	*Eucalyptus melliodora (seedling)*	Yellow Box										
Myrtaceae	native	*Eucalyptus melliodora (shrub)*	Yellow Box										
Myrtaceae	native	*Eucalyptus melliodora (small tree)*	Yellow Box										
Myrtaceae	native	*Eucalyptus tereticornis x blakelyi*	Forest Red Gum - Blakely's Red Gum intergrade		P	P		adj			2		
Myrtaceae	native	*Eucalyptus tereticornis x blakelyi (shrub)*	Forest Red Gum - Blakely's Red Gum intergrade										
Myrtaceae	native	*Eucalyptus tereticornis x blakelyi (small tree)*	Forest Red Gum - Blakely's Red Gum intergrade					P					
Pittosporaceae	native	*Pittosporum undulatum (seedling)*	Sweet Pittosporum				P						
Pittosporaceae	native	*Pittosporum undulatum (shrub)*	Sweet Pittosporum										
Pittosporaceae	native	*Pittosporum undulatum (small tree)*	Sweet Pittosporum		P	P	P						
Santalaceae	native	*Exocarpos cupressiformis (small tree)*	Cherry Ballart										
Simaroubaceae	exotic	*Ailanthus altissima (small tree)*	Tree of Heaven										
Sterculiaceae	native	*Brachychiton populneus*	Kurrajong										
Sterculiaceae	native	*Brachychiton populneus (seedling)*	Kurrajong										
Sterculiaceae	native	*Brachychiton populneus (shrub)*	Kurrajong									+	
Sterculiaceae	native	*Brachychiton populneus (small tree)*	Kurrajong					P			P		
SHRUBS													
Apocynaceae	exotic	*Gomphocarpus fruiticosus*	Narrow-leaved Cotton Bush			P							
Asteraceae	native	*Cassinia quinquefaria*	Cough Bush	+				P			+		+
Asteraceae	native	*Olearia viscidula*	Wallaby Weed	2	1	3		1				3	2
Asteraceae	native	*Senecio hispidulus var. dissectus*	Hill Fireweed	1			+						+
Asteraceae	exotic	*Senecio madagascariensis*	Fireweed									+	+
Asteraceae	native	*Senecio quadridentatus*	Cotton Fireweed	1				P				+	+
Asteraceae	native	*Senecio sp. B*	-										+
Asteraceae	native	*Sigesbeckia australiensis*	-									+	1
Dilleniaceae	native	*Hibbertia obtusifolia*	Hoary Guinea Flower										
Dilleniaceae	native	*Hibbertia sp.*	-					+					
Ericaceae - Styphelioideae	native	*Melichrus urceolatus*	Urn-heath		+								
Fabaceae - Faboideae	native	*Indigofera australis*	Australian Indigo	+		+							
Fabaceae - Faboideae	native	*Pultenaea sp.*	-		+	+		+					
Fabaceae - Faboideae	native	*Swainsona galegifolia*	Smooth Darling-pea	P	+	1	+	+	P			1	+
Fabaceae - Mimosoideae	native	*Acacia implexa*	Hickory Wattle					P			+		
Fabaceae - Mimosoideae	native	*Acacia linearifolia*	Narrow-leaved Wattle	P									
Fabaceae - Mimosoideae	native	*Acacia paradoxa*	Kangaroo Thorn	+									
Oleaceae	native	*Notelaea ?microcarpa*	-									+	
Oleaceae	native	*Notelaea linearis*	-	1	+	1	1	2			1	1	+
Oleaceae	native	*Notelaea longifolia forma glabra*	Large Mock-olive		+		P				+	+	2
Pittosporaceae	native	*Bursaria spinosa*	Blackthorn					1					

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	T11	T12	T13	T14	T15	T16	T17	T18	TA	TB
Rosaceae	exotic	*Rosa rubiginosa*	Sweet Briar	+				+			+		+
Rosaceae	exotic	*Rosa rubiginosa (seedling)*	Sweet Briar										
Sapindaceae	native	*Dodonaea viscosa subsp. Angustissima*	Narrow-leaved Hopbush					+					
Solanaceae	native	*Solanum aviculare*	Kangaroo Apple							+			
Solanaceae	native	*Solanum cinereum*	Narrawa Burr						P				
Solanaceae	exotic	*Solanum pseudocapsicum*	Madeira Winter					+			+		
Solanaceae	?	*Solanum sp.*	-										
Ulmaceae	native	*Trema aspera*	Peach-leaf Poison-bush										
Violaceae	native	*Melicytus dentatus*	Tree Violet		P	1	2		2		1	+	+
Xanthorrhoeaceae	native	*Xanthorrhoea johnsonii*	Johnson's Grass Tree					2					
DICOTS													
Acanthaceae	native	*Rostellularia adscendens*	-					+			P	P	
Amaranthaceae	native	*Alternanthera nana*	Hairy Joyweed										
Apiaceae	exotic	*Cyclospermum leptophyllum*	Slender Celery										
Apiaceae	native	*Daucus glochidiatus*	Native Carrot						+				
Apiaceae	native	*Hydrocotyle laxiflora*	Stinking Pennywort		1	+	1	1	+				
Apiaceae	native	*Hydrocotyle penduncularis*	-					+					
Apiaceae	native	*Hydrocotyle sp.*	-										+
Asteraceae	exotic	*Bidens pilosa*	Cobbler's Pegs					+			+		
Asteraceae	?	*Bidens sp.*	-										
Asteraceae	native	*Brachyscome sp.*	-	P									
Asteraceae	native	*Calotis cuneifolia*	Purple Burr-daisy									+	
Asteraceae	native	*Calotis lappulacea*	Yellow Burr-daisy					+		+	P		
Asteraceae	exotic	*Carthamus dentatus*	Toothed Thistle							+			
Asteraceae	native	*Chrysocephalum apiculatum*	Common Everlasting										
Asteraceae	native	*Chrysocephalum semipapposum*	-				P						
Asteraceae	exotic	*Cirsium vulgare*	Spear Thistle	P					+	+		+	P
Asteraceae	exotic	*Conyza bonariensis*	Flaxleaf Fleabane	+	+	+	P	+		+	1	+	1
Asteraceae	native	*Cymbonotus lawsonianus*	Bears-ear	+			P		+				+
Asteraceae	native	*Euchiton ?sphaericus*	-				+	+	P	+	+		P
Asteraceae	native	*Euchiton involucratum*	Star Cudweed	P									
Asteraceae	native	*Euchiton sp.*	-										
Asteraceae	exotic	*Gnaphalium sp.*	-										
Asteraceae	exotic	*Hypochaeris radicata*	Catsear		+	P	1		+	+	1		
Asteraceae	native	*Lagenophora stipitata*	Blue Bottle-daisy		+				P		+		
Asteraceae	native	*Senecio sp. A*	-								+		
Asteraceae	exotic	*Silybum marianum*	-										
Asteraceae	exotic	*Solvia sessilis (syn. Solvia pterosperma)*	Bindyi										
Asteraceae	exotic	*Sonchus oleraceus*	Common Sowthistle	P					+	+		+	+
Asteraceae	exotic	*Taraxacum officionale*	Dandelion	P					+	+		+	+
Asteraceae	native	*Vittadinia cuneata*	-		+								
Boraginaceae	native	*Cynoglossum australe*	-										
Cactaceae	exotic	*Opuntia aurantiaca*	Tiger Pear										
Cactaceae	exotic	*Opuntia stricta*	Prickly Pear		P	+					+		
Campanulaceae	native	*Wahlenbergia communis*	Tufted Bluebell	+	+	+	+	+	+		+	1	+
Campanulaceae	native	*Wahlenbergia gracilis*	Sprawling Bluebell	1			+				P		
Campanulaceae	native	*Wahlenbergia stricta*	Australian Bluebell									+	1
Caryophyllaceae	exotic	*Cerastium glomeratum*	Mouse-ear Chickweed										
Caryophyllaceae	exotic	*Paronychia brasiliana*	Chilean Witlow Wort										
Caryophyllaceae	exotic	*Petrorhagia dubia*	-	P			P	+			+		
Caryophyllaceae	native	*Stellaria pungens*	Prickly Starwort						+				
Chenopodiaceae	native	*Einadia hastata*	Berry Saltbush									+	
Chenopodiaceae	native	*Einadia nutans*	-	+			+	+		+	1		

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	T11	T12	T13	T14	T15	T16	T17	T18	TA	TB
Chenopodiaceae	native	*Einadia polygonoides*	-	+							+		
Chenopodiaceae	native	*Einadia trigonos*	Fishweed							+		+	+
Clusiaceae	exotic	*Hypericum perforatum*	St John's Wort		1								+
Convolvulaceae	native	*Dichondra repens*	Kidney Weed	P	1	+	+	1	1		1	1	1
Crassulaceae	native	*Crassula ?sieberiana*	Australian Stonecrop										+
Crassulaceae	native	*Crassula sp.*	-	+									
Euphorbiaceae	native	*Chamaesyce drummondii*	Caustic Weed	P									
Euphorbiaceae	exotic	*Euphorbia peplus*	Petty Spurge				P						
Fabaceae - Faboideae	native	*Desmodium brachypodum*	Large Tick-trefoil			P						+	+
Fabaceae - Faboideae	native	*Desmodium varians*	Slender Tick-trefoil		1	1	1	+	1			+	+
Fabaceae - Faboideae	exotic	*Medicago sativa*	Lucerne										
Fabaceae - Faboideae	exotic	*Trifolium arvense*	-										
Fabaceae - Faboideae	exotic	*Trifolium dubium*	Yellow Suckling Clover										
Fabaceae - Faboideae	exotic	*Trifolium repens*	White Clover	+	1		1		+	1		P	
Fabaceae - Faboideae	exotic	*Trifolium sp.*	-						1				
Fabaceae - Faboideae	exotic	*Trifolium subterraneum*	Subterranean Clover										
Fabaceae - Faboideae	exotic	*Vicia sativa*	Vetch										
Fabaceae - Faboideae	exotic	*Vicia sp.*	a Vetch					+					
Gentianaceae	exotic	*Schenkia spicata*	Spike Centaury		+						+		P
Geraniaceae	native	*Geranium solanderi*	Native Geranium	1	1	+	1	1	1	+	1	+	+
Haloragaceae	native	*Gonocarpus sp.*	-									+	
Lamiaceae	native	*Ajuga australis*	Austral Bugle	P					P				
Lamiaceae	exotic	*Marrubium vulgare*	White Horehound						P	+			
Lamiaceae	native	*Mentha satureoides*	Creeping Mint										
Lamiaceae	native	*Scutellaria sp.*	-					+		+			
Lobeliaceae	native	*Pratia purpurascens*	Whiteroot	P			+						
Malvaceae	exotic	*Modiola caroliniana*	-							+			
Malvaceae	native	*Sida corrugata*	-										
Malvaceae	exotic	*Sida rhombifolia*	Paddy's Lucerne										
Malvaceae	native	*Sida trichopoda*	Hairy Sida										
Menispermaceae	native	*Stephania japonica var. discolor*	Snake Vine										
Myrsinaceae	exotic	*Anagallis arvensis*	Scarlet/Blue Pimpernel						+				+
Oxalidaceae	native	*Oxalis exilis*	-		+			+	P	+			+
Phyllanthaceae	native	*Poranthera microphylla*	-		1	P				+			
Plantaginaceae	native	*Plantago debilis*	-									+	P
Plantaginaceae	native	*Plantago gaudichaudii*	Narrow-leaved Plantain										
Plantaginaceae	exotic	*Plantago lanceolata*	Lamb's Tongues						P				
Plantaginaceae	native	*Veronica plebeia*	Creeping Speedwell	+		+			P				
Polygonaceae	exotic	*Polygonum aviculare*	Wireweed							+			
Polygonaceae	native	*Rumex brownii*	Swamp Dock	+			P	+	+	+	P		
Rosaceae	native	*Acaena anserovina*	-				1			+	P		
Rosaceae	native	*Acaena novae-zealandiae*	Biddy Biddy	P	+				+		+	P	+
Rubiaceae	native	*Asperula conferta*	Common Woodruff	1	1	+	1					P	
Rubiaceae	native	*Galium ?binifolium*	-	1	+		+		1		1	1	1
Rubiaceae	native	*Galium ?leptogonium*	-				P		+				
Rubiaceae	native	*Galium gaudichaudii*	Rough Bedstraw					+					
Scrophulariaceae	exotic	*Verbascum thapsis subsp thapsis*	Common Mullein					+	P		+	+	P
Solanaceae	exotic	*Solanum nigrum*	Blackberry Nightshade									+	
Thymelaeaceae	native	*Pimelea curviflora*	-										
Thymelaeaceae	native	*Pimelea linifolia*	Slender Rice Flower					1				+	
Urticaceae	exotic	*Urtica dioica*	Stinging Nettle		+				+	1	+		
Verbenaceae	exotic	*Verbena bonariensis*	Purpletop										
Verbenaceae	exotic	*Verbena officinalis*	Common Verbena						P				

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	T11	T12	T13	T14	T15	T16	T17	T18	TA	TB
Verbenaceae	exotic	*Verbena rigida*	Veined Verbena										
Verbenaceae	exotic	*Verbena sp.*	-										+
MONOCOTS-GRASSES													
Poaceae	native	*Aristida ramosa*	Purple Wiregrass	1	1		1				1	2	1
Poaceae	native	*Aristida vagans*	Threeawn Speargrass			2		1				1	
Poaceae	native	*Austrodanthonia fulva*	-			P	+	1		+			
Poaceae	native	*Austrodanthonia racemosa*	-		+						P		
Poaceae	native	*Austrodanthonia richardsonii*	Straw Wallaby-grass						2	1			
Poaceae	native	*Austrostipa scabra*	Speargrass	1							+		
Poaceae	native	*Bothriochloa decipiens*	Pitted Bluegrass	P	1		+	1			1		+
Poaceae	exotic	*Briza maxima*	Quaking Grass		+								
Poaceae	exotic	*Bromus molliformis*	Soft Broome										
Poaceae	native	*Chloris truncata*	Windmill Grass										
Poaceae	native	*Chloris ventricosa*	Plump Windmill Grass		P						P		
Poaceae	native	*Cymbopogon refractus*	Barbwire Grass		3	1		1				+	P
Poaceae	native	*Cynodon dactylon*	Couch Grass			P							
Poaceae	exotic	*Cynosurus echinatus*	Rough Dog's Tail										
Poaceae	native	*Deyeuxia quadriseta*	-										
Poaceae	native	*Dichanthium sericeum*	Queensland Bluegrass										P
Poaceae	native	*Dichelachne crinita*	Longhair Plumegrass	P		+					1		
Poaceae	native	*Dichelachne micrantha*	Shorthair Plumegrass										
Poaceae	native	*Dichelachne sp.*	-									+	
Poaceae	native	*Echinopogon caespitosus*	Bushy Hedgehog-grass		+		1				2		
Poaceae	native	*Echinopogon ovatus*	Forest Hedgehog Grass	P	P		1		2				
Poaceae	native	*Echinopogon sp.*	-										+
Poaceae	exotic	*Eleusine tristachya*	Goose Grass							1			
Poaceae	native	*Elymus scaber*	Common Wheatgrass	P	+		P		P		+	2	2
Poaceae	native	*Eragrostis leptostachya*	Paddock Lovegrass		1			1			1		
Poaceae	native	*Eragrostis sp.*	-										+
Poaceae	native	*Lachnagrostis filiformis*	-					+					
Poaceae	exotic	*Lolium perenne*	Perennial Ryegrass										
Poaceae	native	*Microlaena stipoides*	Weeping Meadow Grass		+		+	2	2	1	3	+	
Poaceae	native	*Panicum effusum*	Hairy Panic								+	P	1
Poaceae	native	*Panicum simile*	Two-colour Panic					+					
Poaceae	exotic	*Paspalum dilatatum*	Paspalum										
Poaceae	native	*Poa labillardierei*	Tussock Grass	3		2	2		2		1		
Poaceae	native	*Poa sieberiana*	-		+			1					
Poaceae	native	*Poa sp.*	-									2	1
Poaceae	native	*Sporobolus creber*	Slender Rat's Tail Grass		+		+	P			P		
Poaceae	native	*Sporobulus sp.*	-										+
Poaceae	native	*Themeda australis*	Kangaroo Grass		2			2			P	+	P
MONOCOTS-OTHER													
Anthericaceae	native	*Arthropodium milleflorum*	Pale Vanilla-lily		P								
Anthericaceae	native	*Arthropodium sp.*	-	+					+			+	P
Anthericaceae	native	*Tricoryne ?elatior*	Yellow Autumn-lily				+						
Cyperaceae	native	*Carex ?incomitata*	-		+		+		P				
Cyperaceae	native	*Carex inversa*	-	P	+		+	+	P		+		P
Cyperaceae	native	*Cyperus gracilis*	Slender Flat-sedge			P		+			+		
Cyperaceae	native	*Cyperus sp. A*	-										
Cyperaceae	native	*Cyperus sp. B*	-									+	+
Cyperaceae	native	*Lepidosperma laterale*	-									+	1
Cyperaceae	native	*Shoenus ?imberbis*	Beardless Bog-rush			+		+					
Juncaceae	native	*Juncus subsecundus*	-										

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	T11	T12	T13	T14	T15	T16	T17	T18	TA	TB
Juncaceae	native	*Juncus usitatus*	-				+						
Lomandraceae	native	*Lomandra confertifolia*	Mat-rush			+		+					
Lomandraceae	native	*Lomandra filiformis*	Wattle Mat-rush	+		1		+					+
Lomandraceae	native	*Lomandra glauca*	-		P			+					+
Lomandraceae	native	*Lomandra longifolia*	Spiny-headed Mat-rush					+				2	1
Lomandraceae	native	*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush	P	+						+		P
Orchidaceae	native	*Pterostylis sp.*	-								P		
Phormiaceae	native	*Dianella ?revoluta*	Blueberry Lily									P	P
FERNS AND ALLIES													
Adiantaceae	native	*Adianthum aethiopicum*	Common Maidenhair				P		1		+		
Adiantaceae	native	*Cheilanthes distans*	Bristly Cloak Fern					+					
Adiantaceae	native	*Cheilanthes sieberi*	Poison Rock Fern		1	P	+	+			+	+	+
Aspleniaceae	native	*Asplenium flabellifolium*	Necklace Fern				+		+		1	+	+
Davalliaceae	exotic	*Nephrolepis cordifolia*	Fishbone Fern					+	+		+		+
Dennstaedtiaceae	native	*Pteridium esculentum*	Common Bracken						+				
CLIMBERS AND VINES													
Apocynaceae	native	*Parsonsia straminea*	Common Silkpod								+		
Bigoniaceae	native	*Pandorea pandorana*	Wonga Wonga Vine										
Caprifoliaceae	exotic	*Lonicera japonica*	Honeysuckle										
Commelinaceae	native	*Commelina cyanea*	Native Wandering Jew								+		
Fabaceae - Faboideae	native	*Glycine ?tomentella*	Woolly Glycine										
Fabaceae - Faboideae	native	*Glycine clandestina*	-			1			1				1
Fabaceae - Faboideae	native	*Glycine microphylla*	Small-leaf glycine		+	+	+	1					
Fabaceae - Faboideae	native	*Glycine sp.*	-									+	
Fabaceae - Faboideae	native	*Glycine tabacina*	-	P	+		+	1			1	1	P
Luzuriagaceae	native	*Eustrephus latifolius*	Wombat Berry			P							
Pittosporaceae	native	*Billardiera scandens*	Hairy Apple Berry										
Ranunculaceae	native	*Clematis glycinoides*	Headache Vine	P		1	+	1	P		+	+	1
Rosaceae	exotic	*Rubus fruticosus*	Blackberry complex						P		+		

Class	Cover-abundance
R	Rare (less than 0.1% cover)
+	Few Individuals (less than 1% cover)
1	Many Individuals (less than 5% cover)
2	5 - less than 25% cover
3	25 - less than 50% cover
4	50 - less than 75% cover
5	75 - 100% cover
adj	incidental (adjacent but not within plot)
P	present; outside 20 x 20 plot but within 20 x 50

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	TC	TD
TREES					
Anacardiaceae	exotic	*Schinus areira (small tree)*	Peppercorn Tree		
Casuarinaceae	native	*Casuarina cunninghamiana*	River Oak		
Cupressaceae	native	*Callitris glaucophylla (small tree)*	White Cypress Pine		1
Loranthaceae	native	*Amyema sp.*	a mistletoe		
Myrtaceae	native	*Angophora floribunda*	Rough-barked Apple	P	P
Myrtaceae	native	*Angophora floribunda (seedling)*	Rough-barked Apple	+	P
Myrtaceae	native	*Angophora floribunda (small tree)*	Rough-barked Apple		
Myrtaceae	native	*Eucalyptus albens*	White Box	+	2
Myrtaceae	native	*Eucalyptus albens (seedling)*	White Box	+	P
Myrtaceae	native	*Eucalyptus albens (shrub)*	White Box		
Myrtaceae	native	*Eucalyptus bridgesiana*	Apple Box		
Myrtaceae	native	*Eucalyptus cypellocarpa*	Monkey Grey Gum		
Myrtaceae	native	*Eucalyptus laevopinea*	Silvertop Stringybark	2	
Myrtaceae	native	*Eucalyptus laevopinea (seedling)*	Silver Top Stingybark		
Myrtaceae	native	*Eucalyptus melliodora*	Yellow Box		
Myrtaceae	native	*Eucalyptus melliodora (seedling)*	Yellow Box		
Myrtaceae	native	*Eucalyptus melliodora (shrub)*	Yellow Box		
Myrtaceae	native	*Eucalyptus melliodora (small tree)*	Yellow Box		
Myrtaceae	native	*Eucalyptus tereticornis x blakelyi*	Forest Red Gum - Blakely's Red Gum intergrade		
Myrtaceae	native	*Eucalyptus tereticornis x blakelyi (shrub)*	Forest Red Gum - Blakely's Red Gum intergrade		
Myrtaceae	native	*Eucalyptus tereticornis x blakelyi (small tree)*	Forest Red Gum - Blakely's Red Gum intergrade		
Pittosporaceae	native	*Pittosporum undulatum (seedling)*	Sweet Pittosporum		
Pittosporaceae	native	*Pittosporum undulatum (shrub)*	Sweet Pittosporum		
Pittosporaceae	native	*Pittosporum undulatum (small tree)*	Sweet Pittosporum		
Santalaceae	native	*Exocarpos cupressiformis (small tree)*	Cherry Ballart		
Simaroubaceae	exotic	*Ailanthus altissima (small tree)*	Tree of Heaven		
Sterculiaceae	native	*Brachychiton populneus*	Kurrajong		
Sterculiaceae	native	*Brachychiton populneus (seedling)*	Kurrajong		
Sterculiaceae	native	*Brachychiton populneus (shrub)*	Kurrajong		
Sterculiaceae	native	*Brachychiton populneus (small tree)*	Kurrajong		
SHRUBS					
Apocynaceae	exotic	*Gomphocarpus fruiticosus*	Narrow-leaved Cotton Bush	+	+
Asteraceae	native	*Cassinia quinquefaria*	Cough Bush		
Asteraceae	native	*Olearia viscidula*	Wallaby Weed	P	+
Asteraceae	native	*Senecio hispidulus var. dissectus*	Hill Fireweed		
Asteraceae	exotic	*Senecio madagascariensis*	Fireweed		
Asteraceae	native	*Senecio quadridentatus*	Cotton Fireweed	P	
Asteraceae	native	*Senecio sp. B*	-		
Asteraceae	native	*Sigesbeckia australiensis*	-		+
Dilleniaceae	native	*Hibbertia obtusifolia*	Hoary Guinea Flower		1
Dilleniaceae	native	*Hibbertia sp.*	-		
Ericaceae - Styphelioideae	native	*Melichrus urceolatus*	Urn-heath		
Fabaceae - Faboideae	native	*Indigofera australis*	Australian Indigo		
Fabaceae - Faboideae	native	*Pultenaea sp.*	-		
Fabaceae - Faboideae	native	*Swainsona galegifolia*	Smooth Darling-pea	1	+
Fabaceae - Mimosoideae	native	*Acacia implexa*	Hickory Wattle		
Fabaceae - Mimosoideae	native	*Acacia linearifolia*	Narrow-leaved Wattle		P
Fabaceae - Mimosoideae	native	*Acacia paradoxa*	Kangaroo Thorn		
Oleaceae	native	*Notelaea ?microcarpa*	-		
Oleaceae	native	*Notelaea linearis*	-	P	
Oleaceae	native	*Notelaea longifolia forma glabra*	Large Mock-olive	1	1
Pittosporaceae	native	*Bursaria spinosa*	Blackthorn		

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	TC	TD
Rosaceae	exotic	*Rosa rubiginosa*	Sweet Briar		P
Rosaceae	exotic	*Rosa rubiginosa (seedling)*	Sweet Briar		
Sapindaceae	native	*Dodonaea viscosa subsp. Angustissima*	Narrow-leaved Hopbush		
Solanaceae	native	*Solanum aviculare*	Kangaroo Apple		
Solanaceae	native	*Solanum cinereum*	Narrawa Burr		
Solanaceae	exotic	*Solanum pseudocapsicum*	Madeira Winter		
Solanaceae	?	*Solanum sp.*	-		P
Ulmaceae	native	*Trema aspera*	Peach-leaf Poison-bush		
Violaceae	native	*Melicytus dentatus*	Tree Violet	+	1
Xanthorrhoeaceae	native	*Xanthorrhoea johnsonii*	Johnson's Grass Tree		
DICOTS					
Acanthaceae	native	*Rostellularia adscendens*	-		+
Amaranthaceae	native	*Alternanthera nana*	Hairy Joyweed		
Apiaceae	exotic	*Cyclospermum leptophyllum*	Slender Celery		
Apiaceae	native	*Daucus glochidiatus*	Native Carrot		
Apiaceae	native	*Hydrocotyle laxiflora*	Stinking Pennywort		
Apiaceae	native	*Hydrocotyle peduncularis*	-		
Apiaceae	native	*Hydrocotyle sp.*	-	+	+
Asteraceae	exotic	*Bidens pilosa*	Cobbler's Pegs		
Asteraceae	?	*Bidens sp.*	-	P	
Asteraceae	native	*Brachyscome sp.*	-		+
Asteraceae	native	*Calotis cuneifolia*	Purple Burr-daisy		P
Asteraceae	native	*Calotis lappulacea*	Yellow Burr-daisy	1	1
Asteraceae	exotic	*Carthamus dentatus*	Toothed Thistle		
Asteraceae	native	*Chrysocephalum apiculatum*	Common Everlasting		
Asteraceae	native	*Chrysocephalum semipapposum*	-		
Asteraceae	exotic	*Cirsium vulgare*	Spear Thistle	+	+
Asteraceae	exotic	*Conyza bonariensis*	Flaxleaf Fleabane	1	+
Asteraceae	native	*Cymbonotus lawsonianus*	Bears-ear		
Asteraceae	native	*Euchiton ?sphaericus*	-	P	
Asteraceae	native	*Euchiton involucratum*	Star Cudweed	P	
Asteraceae	native	*Euchiton sp.*	-		+
Asteraceae	exotic	*Gnaphalium sp.*	-		
Asteraceae	exotic	*Hypochaeris radicata*	Catsear		
Asteraceae	native	*Lagenophora stipitata*	Blue Bottle-daisy	P	
Asteraceae	native	*Senecio sp. A*	-		
Asteraceae	exotic	*Silybum marianum*	-		
Asteraceae	exotic	*Solvia sessilis (syn. Solvia pterosperma)*	Bindyi		
Asteraceae	exotic	*Sonchus oleraceus*	Common Sowthistle		+
Asteraceae	exotic	*Taraxacum officionale*	Dandelion	+	+
Asteraceae	native	*Vittadinia cuneata*	-	P	
Boraginaceae	native	*Cynoglossum australe*	-		
Cactaceae	exotic	*Opuntia aurantiaca*	Tiger Pear	+	+
Cactaceae	exotic	*Opuntia stricta*	Prickly Pear	+	+
Campanulaceae	native	*Wahlenbergia communis*	Tufted Bluebell	1	1
Campanulaceae	native	*Wahlenbergia gracilis*	Sprawling Bluebell	+	
Campanulaceae	native	*Wahlenbergia stricta*	Australian Bluebell	+	
Caryophyllaceae	exotic	*Cerastium glomeratum*	Mouse-ear Chickweed		
Caryophyllaceae	exotic	*Paronychia brasiliana*	Chilean Witlow Wort		
Caryophyllaceae	exotic	*Petrorhagia dubia*	-		+
Caryophyllaceae	native	*Stellaria pungens*	Prickly Starwort		
Chenopodiaceae	native	*Einadia hastata*	Berry Saltbush		
Chenopodiaceae	native	*Einadia nutans*	-		

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	TC	TD
Chenopodiaceae	native	*Einadia polygonoides*	-		
Chenopodiaceae	native	*Einadia trigonos*	Fishweed		+
Clusiaceae	exotic	*Hypericum perforatum*	St John's Wort	+	
Convolvulaceae	native	*Dichondra repens*	Kidney Weed	1	1
Crassulaceae	native	*Crassula ?sieberiana*	Australian Stonecrop	P	
Crassulaceae	native	*Crassula sp.*	-		
Euphorbiaceae	native	*Chamaesyce drummondii*	Caustic Weed	+	
Euphorbiaceae	exotic	*Euphorbia peplus*	Petty Spurge		
Fabaceae - Faboideae	native	*Desmodium brachypodum*	Large Tick-trefoil	+	+
Fabaceae - Faboideae	native	*Desmodium varians*	Slender Tick-trefoil	+	P
Fabaceae - Faboideae	exotic	*Medicago sativa*	Lucerne		
Fabaceae - Faboideae	exotic	*Trifolium arvense*	-		
Fabaceae - Faboideae	exotic	*Trifolium dubium*	Yellow Suckling Clover		
Fabaceae - Faboideae	exotic	*Trifolium repens*	White Clover	+	+
Fabaceae - Faboideae	exotic	*Trifolium sp.*	-		
Fabaceae - Faboideae	exotic	*Trifolium subterraneum*	Subterranean Clover		
Fabaceae - Faboideae	exotic	*Vicia sativa*	Vetch		
Fabaceae - Faboideae	exotic	*Vicia sp.*	a Vetch		
Gentianaceae	exotic	*Schenkia spicata*	Spike Centaury	P	P
Geraniaceae	native	*Geranium solanderi*	Native Geranium	1	1
Haloragaceae	native	*Gonocarpus sp.*	-		
Lamiaceae	native	*Ajuga australis*	Austral Bugle		
Lamiaceae	exotic	*Marrubium vulgare*	White Horehound		
Lamiaceae	native	*Mentha satureoides*	Creeping Mint		
Lamiaceae	native	*Scutellaria sp.*	-		
Lobeliaceae	native	*Pratia purpurascens*	Whiteroot		
Malvaceae	exotic	*Modiola caroliniana*	-		
Malvaceae	native	*Sida corrugata*	-		
Malvaceae	exotic	*Sida rhombifolia*	Paddy's Lucerne		
Malvaceae	native	*Sida trichopoda*	Hairy Sida		
Menispermaceae	native	*Stephania japonica var. discolor*	Snake Vine		
Myrsinaceae	exotic	*Anagallis arvensis*	Scarlet/Blue Pimpernel		
Oxalidaceae	native	*Oxalis exilis*	-	+	+
Phyllanthaceae	native	*Poranthera microphylla*	-		
Plantaginaceae	native	*Plantago debilis*	-	P	+
Plantaginaceae	native	*Plantago gaudichaudii*	Narrow-leaved Plantain		
Plantaginaceae	exotic	*Plantago lanceolata*	Lamb's Tongues		
Plantaginaceae	native	*Veronica plebeia*	Creeping Speedwell		
Polygonaceae	exotic	*Polygonum aviculare*	Wireweed		
Polygonaceae	native	*Rumex brownii*	Swamp Dock	+	+
Rosaceae	native	*Acaena anserovina*	-		
Rosaceae	native	*Acaena novae-zealandiae*	Biddy Biddy	+	+
Rubiaceae	native	*Asperula conferta*	Common Woodruff		
Rubiaceae	native	*Galium ?binifolium*	-	+	+
Rubiaceae	native	*Galium ?leptogonium*	-		
Rubiaceae	native	*Galium gaudichaudii*	Rough Bedstraw		
Scrophulariaceae	exotic	*Verbascum thapsis subsp thapsis*	Common Mullein		P
Solanaceae	exotic	*Solanum nigrum*	Blackberry Nightshade		+
Thymelaeaceae	native	*Pimelea curviflora*	-		
Thymelaeaceae	native	*Pimelea linifolia*	Slender Rice Flower		
Urticaceae	exotic	*Urtica dioica*	Stinging Nettle	+	+
Verbenaceae	exotic	*Verbena bonariensis*	Purpletop		
Verbenaceae	exotic	*Verbena officinalis*	Common Verbena		

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	TC	TD
Verbenaceae	exotic	*Verbena rigida*	Veined Verbena		
Verbenaceae	exotic	*Verbena sp.*	-	+	+
MONOCOTS-GRASSES					
Poaceae	native	*Aristida ramosa*	Purple Wiregrass	3	2
Poaceae	native	*Aristida vagans*	Threeawn Speargrass		
Poaceae	native	*Austrodanthonia fulva*	-		
Poaceae	native	*Austrodanthonia racemosa*	-		
Poaceae	native	*Austrodanthonia richardsonii*	Straw Wallaby-grass		
Poaceae	native	*Austrostipa scabra*	Speargrass		
Poaceae	native	*Bothriochloa decipiens*	Pitted Bluegrass	1	2
Poaceae	exotic	*Briza maxima*	Quaking Grass		
Poaceae	exotic	*Bromus molliformis*	Soft Broome		
Poaceae	native	*Chloris truncata*	Windmill Grass		
Poaceae	native	*Chloris ventricosa*	Plump Windmill Grass	+	2
Poaceae	native	*Cymbopogon refractus*	Barbwire Grass	+	
Poaceae	native	*Cynodon dactylon*	Couch Grass		
Poaceae	exotic	*Cynosurus echinatus*	Rough Dog's Tail		
Poaceae	native	*Deyeuxia quadriseta*	-		
Poaceae	native	*Dichanthium sericeum*	Queensland Bluegrass	+	+
Poaceae	native	*Dichelachne crinita*	Longhair Plumegrass		
Poaceae	native	*Dichelachne micrantha*	Shorthair Plumegrass	+	+
Poaceae	native	*Dichelachne sp.*	-	+	
Poaceae	native	*Echinopogon caespitosus*	Bushy Hedgehog-grass		
Poaceae	native	*Echinopogon ovatus*	Forest Hedgehog Grass		
Poaceae	native	*Echinopogon sp.*	-		+
Poaceae	exotic	*Eleusine tristachya*	Goose Grass		+
Poaceae	native	*Elymus scaber*	Common Wheatgrass	2	2
Poaceae	native	*Eragrostis leptostachya*	Paddock Lovegrass		
Poaceae	native	*Eragrostis sp.*	-	+	+
Poaceae	native	*Lachnagrostis filiformis*	-		
Poaceae	exotic	*Lolium perenne*	Perennial Ryegrass		
Poaceae	native	*Microlaena stipoides*	Weeping Meadow Grass	+	
Poaceae	native	*Panicum effusum*	Hairy Panic		+
Poaceae	native	*Panicum simile*	Two-colour Panic		
Poaceae	exotic	*Paspalum dilatatum*	Paspalum		
Poaceae	native	*Poa labillardierei*	Tussock Grass		
Poaceae	native	*Poa sieberiana*	-		
Poaceae	native	*Poa sp.*	-	+	+
Poaceae	native	*Sporobolus creber*	Slender Rat's Tail Grass		
Poaceae	native	*Sporobulus sp.*	-	+	+
Poaceae	native	*Themeda australis*	Kangaroo Grass	+	P
MONOCOTS-OTHER					
Anthericaceae	native	*Arthropodium milleflorum*	Pale Vanilla-lily		
Anthericaceae	native	*Arthropodium sp.*	-		
Anthericaceae	native	*Tricoryne ?elatior*	Yellow Autumn-lily		
Cyperaceae	native	*Carex ?incomitata*	-	P	+
Cyperaceae	native	*Carex inversa*	-	+	+
Cyperaceae	native	*Cyperus gracilis*	Slender Flat-sedge		
Cyperaceae	native	*Cyperus sp. A*	-		
Cyperaceae	native	*Cyperus sp. B*	-	+	2
Cyperaceae	native	*Lepidosperma laterale*	-	P	
Cyperaceae	native	*Shoenus ?imberbis*	Beardless Bog-rush	+	+
Juncaceae	native	*Juncus subsecundus*	-		

Table L.2 Quadrat Dataset from the Offsite Offset Property

Family	Native / Exotic	Species	Common Name	TC	TD
Juncaceae	native	*Juncus usitatus*	-	+	
Lomandraceae	native	*Lomandra confertifolia*	Mat-rush		
Lomandraceae	native	*Lomandra filiformis*	Wattle Mat-rush	+	+
Lomandraceae	native	*Lomandra glauca*	-		
Lomandraceae	native	*Lomandra longifolia*	Spiny-headed Mat-rush		
Lomandraceae	native	*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush		+
Orchidaceae	native	*Pterostylis sp.*	-		
Phormiaceae	native	*Dianella ?revoluta*	Blueberry Lily		
FERNS AND ALLIES					
Adiantaceae	native	*Adianthum aethiopicum*	Common Maidenhair	P	P
Adiantaceae	native	*Cheilanthes distans*	Bristly Cloak Fern	P	
Adiantaceae	native	*Cheilanthes sieberi*	Poison Rock Fern	+	+
Aspleniaceae	native	*Asplenium flabellifolium*	Necklace Fern		
Davalliaceae	exotic	*Nephrolepis cordifolia*	Fishbone Fern	P	
Dennstaedtiaceae	native	*Pteridium esculentum*	Common Bracken		
CLIMBERS AND VINES					
Apocynaceae	native	*Parsonsia straminea*	Common Silkpod		
Bigoniaceae	native	*Pandorea pandorana*	Wonga Wonga Vine	+	
Caprifoliaceae	exotic	*Lonicera japonica*	Honeysuckle		
Commelinaceae	native	*Commelina cyanea*	Native Wandering Jew		
Fabaceae - Faboideae	native	*Glycine ?tomentella*	Woolly Glycine	P	
Fabaceae - Faboideae	native	*Glycine clandestina*	-		
Fabaceae - Faboideae	native	*Glycine microphylla*	Small-leaf glycine		
Fabaceae - Faboideae	native	*Glycine sp.*	-	P	
Fabaceae - Faboideae	native	*Glycine tabacina*	-	1	+
Luzuriagaceae	native	*Eustrephus latifolius*	Wombat Berry		
Pittosporaceae	native	*Billardiera scandens*	Hairy Apple Berry		
Ranunculaceae	native	*Clematis glycinoides*	Headache Vine	+	
Rosaceae	exotic	*Rubus fruticosus*	Blackberry complex		

Class	Cover-abundance
R	Rare (less than 0.1% cover)
+	Few Individuals (less than 1% cover)
1	Many Individuals (less than 5% cover)
2	5 - less than 25% cover
3	25 - less than 50% cover
4	50 - less than 75% cover
5	75 - 100% cover
adj	incidental (adjacent but not within plot)
P	present; outside 20 x 20 plot but within 20 x 50

Table L.3 Flora Species List from the Offsite Offset Property

Family	Exotic/Native	Species	Common Name
TREES			
Anacardiaceae	exotic	*Schinus areira*	Peppercorn Tree
Casuarinaceae	native	*Casuarina cunninghamiana*	River Oak
Cupressaceae	native	*Callitris glaucophylla*	White Cypress Pine
Loranthaceae	native	*Amyema sp.*	a mistletoe
Myrtaceae	native	*Angophora floribunda*	Rough-barked Apple
Myrtaceae	native	*Eucalyptus albens*	White Box
Myrtaceae	native	*Eucalyptus blakelyi x tereticornis*	Blakely's Red Gum-Forest Red Gum intergrade
Myrtaceae	native	*Eucalyptus bridgesiana*	Apple Box
Myrtaceae	native	*Eucalyptus cypellocarpa*	Monkey Grey Gum
Myrtaceae	native	*Eucalyptus dalrympleana*	Mountain Gum
Myrtaceae	native	*Eucalyptus laevopinea*	Silvertop Stringybark
Myrtaceae	native	*Eucalyptus melliodora*	Yellow Box
Myrtaceae	native	*Eucalyptus nortonii*	Large-flowered Bundy
Myrtaceae	native	*Eucalyptus viminalis*	Ribbon Gum
Pittosporaceae	native	*Pittosporum undulatum*	Sweet Pittosporum
Santalaceae	native	*Exocarpos cupressiformis*	Cherry Ballart
Simaroubaceae	exotic	*Ailanthus altissimum*	Tree of Heaven
SHRUBS			
Apocynaceae	exotic	*Gomphocarpus fruiticosus*	Narrow-leaved Cotton Bush
Asteraceae	native	*Cassinia quinquefaria*	Cough Bush
Asteraceae	native	*Olearia viscidula*	Wallaby Weed
Ericaceae-Styphelioideae	native	*Melichrus urceolatus*	Urn-heath
Fabaceae - Faboideae	native	*Indigofera australis*	Australian Indigo
Fabaceae - Faboideae	native	*Pultenaea sp.*	-
Fabaceae - Faboideae	native	*Swainsona galegifolia*	Smooth Darling-pea
Fabaceae - Mimosoideae	native	*Acacia implexa*	Hickory Wattle
Fabaceae - Mimosoideae	native	*Acacia linearifolia*	Narrow-leaved Wattle
Fabaceae - Mimosoideae	native	*Acacia paradoxa*	Kangaroo Thorn
Oleaceae	native	*Notelaea ?microcarpa*	-
Oleaceae	native	*Notelaea linearis*	-
Oleaceae	native	*Notelaea longifolia forma glabra*	Large Mock-olive
Pittosporaceae	native	*Bursaria spinosa*	Blackthorn
Rosaceae	exotic	*Rosa rubiginosa*	Sweet Briar
Rosaceae	exotic	*Rubus fruiticosus*	Blackberry
Sapindaceae	native	*Dodonaea viscosa subsp. angustissima*	Narrow-leaved Hopbush
Solanaceae	native	*Solanum aviculare*	Kangaroo Apple
Solanaceae	native	*Solanum cinereum*	Narrawa Burr
Solanaceae	exotic	*Solanum pseudocapsicum*	Madeira Winter
Sterculiaceae	native	*Brachychiton populneus*	Kurrajong
Thymelaeaceae	native	*Pimelea curviflora*	-
Thymelaeaceae	native	*Pimelea linifolia*	Slender Rice Flower
Ulmaceae	native	*Trema aspera*	Peach-leaf Poison-bush
Violaceae	native	*Melicytus dentatus*	Tree Violet
Xanthorrhoeaceae	native	*Xanthorrhoea johnsonii*	Johnson's Grass Tree
DICOTS			
Acanthaceae	native	*Rostellularia adscendens*	-
Amaranthaceae	native	*Alternanthera nana*	Hairy Joyweed
Apiaceae	exotic	*Cyclospermum leptophyllum*	Slender Celery
Apiaceae	native	*Daucus glochidiatus*	Native Carrot
Apiaceae	native	*Hydrocotyle laxiflora*	Stinking Pennywort
Apiaceae	native	*Hydrocotyle penduncularis*	-
Apiaceae	native	*Hydrocotyle sp.*	-
Asteraceae	exotic	*Bidens pilosa*	Cobbler's Pegs
Asteraceae	?	*Bidens sp.*	-
Asteraceae	native	*Brachyscome sp.*	-
Asteraceae	native	*Calotis cuneifolia*	Purple Burr-daisy
Asteraceae	native	*Calotis lappulacea*	Yellow Burr-daisy
Asteraceae	exotic	*Carthamus dentatus*	Toothed Thistle
Asteraceae	native	*Chrysocephalum apiculatum*	Common Everlasting
Asteraceae	native	*Chrysocephalum semipapposum*	-
Asteraceae	exotic	*Cirsium vulgare*	Spear Thistle
Asteraceae	exotic	*Conyza bonariensis*	Flaxleaf Fleabane
Asteraceae	native	*Cymbonotus lawsonianus*	Bears-ear
Asteraceae	native	*Euchiton ?sphaericus*	-
Asteraceae	native	*Euchiton involucratum*	Star Cudweed
Asteraceae	native	*Euchiton sp.*	-
Asteraceae	exotic	*Gnaphalium sp.*	-
Asteraceae	exotic	*Hypochaeris radicata*	Catsear
Asteraceae	native	*Lagenophora stipitata*	Blue Bottle-daisy
Asteraceae	native	*Senecio hispidulus var. dissectus*	Hill Fireweed
Asteraceae	exotic	*Senecio madagascariensis*	Fireweed
Asteraceae	native	*Senecio quadridentatus*	Cotton Fireweed
Asteraceae	native	*Senecio sp.*	-
Asteraceae	native	*Senecio sp. A*	-
Asteraceae	native	*Sigesbeckia australiensis*	-
Asteraceae	exotic	*Silybum marianum*	-
Asteraceae	exotic	*Solvia sessilis (syn. Solvia pterosperma)*	Bindyi
Asteraceae	exotic	*Sonchus oleraceus*	Common Sowthistle
Asteraceae	exotic	*Taraxacum officionale*	Dandelion
Asteraceae	native	*Vittadinia cuneata*	-
Boraginaceae	native	*Cynoglossum australe*	-

Table L.3 Flora Species List from the Offsite Offset Property

Family	Exotic/Native	Species	Common Name
Cactaceae	exotic	*Opuntia aurantiaca*	Tiger Pear
Cactaceae	exotic	*Opuntia stricta*	Prickly Pear
Campanulaceae	native	*Wahlenbergia communis*	Tufted Bluebell
Campanulaceae	native	*Wahlenbergia gracilis*	Sprawling Bluebell
Campanulaceae	native	*Wahlenbergia stricta*	Australian Bluebell
Caryophyllaceae	exotic	*Cerastium glomeratum*	Mouse-ear Chickweed
Caryophyllaceae	exotic	*Paronychia brasiliana*	Chilean Witlow Wort
Caryophyllaceae	exotic	*Petrorhagia dubia*	-
Caryophyllaceae	native	*Stellaria pungens*	Prickly Starwort
Chenopodiaceae	native	*Einadia hastata*	Berry Saltbush
Chenopodiaceae	native	*Einadia nutans*	-
Chenopodiaceae	native	*Einadia polygonoides*	-
Chenopodiaceae	native	*Einadia trigonos*	Fishweed
Clusiaceae	exotic	*Hypericum perforatum*	St John's Wort
Convolvulaceae	native	*Dichondra repens*	Kidney Weed
Crassulaceae	native	*Crassula ?sieberiana*	Australian Stonecrop
Crassulaceae	native	*Crassula sp.*	-
Dilleniaceae	native	*Hibbertia obtusifolia*	Hoary Guinea Flower
Dilleniaceae	native	*Hibbertia sp.*	-
Euphorbiaceae	native	*Chamaesyce drummondii*	Caustic Weed
Euphorbiaceae	exotic	*Euphorbia peplus*	Petty Spurge
Fabaceae - Faboideae	native	*Desmodium brachypodum*	Large Tick-trefoil
Fabaceae - Faboideae	native	*Desmodium varians*	Slender Tick-trefoil
Fabaceae - Faboideae	native	*Glycine ?tomentella*	Woolly Glycine
Fabaceae - Faboideae	native	*Glycine clandestina*	-
Fabaceae - Faboideae	native	*Glycine sp.*	-
Fabaceae - Faboideae	native	*Glycine tabacina*	-
Fabaceae - Faboideae	exotic	*Medicago sativa*	Lucerne
Fabaceae - Faboideae	exotic	*Trifolium arvense*	-
Fabaceae - Faboideae	exotic	*Trifolium dubium*	Yellow Suckling Clover
Fabaceae - Faboideae	exotic	*Trifolium repens*	White Clover
Fabaceae - Faboideae	exotic	*Trifolium sp.*	-
Fabaceae - Faboideae	exotic	*Trifolium subterraneum*	Subterranean Clover
Fabaceae - Faboideae	exotic	*Vicia sp.*	a Vetch
Gentianaceae	exotic	*Centaurium spicatum*	-
Geraniaceae	native	*Geranium solanderi*	Native Geranium
Haloragaceae	native	*Gonocarpus sp.*	-
Lamiaceae	native	*Ajuga australis*	Austral Bugle
Lamiaceae	exotic	*Marrubium vulgare*	White Horehound
Lamiaceae	native	*Mentha satureoides*	Creeping Mint
Lamiaceae	native	*Scutellaria sp.*	-
Lobeliaceae	native	*Pratia purpurascens*	Whiteroot
Malvaceae	exotic	*Modiola caroliniana*	-
Malvaceae	native	*Sida corrugata*	-
Malvaceae	exotic	*Sida rhombifolia*	Paddy's Lucerne
Malvaceae	native	*Sida trichopoda*	Hairy Sida
Myrsinaceae	exotic	*Anagallis arvensis*	Scarlet/Blue Pimpernel
Oxalidaceae	native	*Oxalis exilis*	-
Phyllanthaceae	native	*Poranthera microphylla*	-
Plantaginaceae	native	*Plantago debilis*	-
Plantaginaceae	native	*Plantago gaudichaudii*	Narrow-leaved Plantain
Plantaginaceae	exotic	*Plantago lanceolata*	Lamb's Tongues
Plantaginaceae	native	*Veronica plebeia*	Creeping Speedwell
Polygonaceae	exotic	*Polygonum aviculare*	Wireweed
Polygonaceae	native	*Rumex brownii*	Swamp Dock
Rosaceae	native	*Acaena anserovina*	-
Rosaceae	native	*Acaena novae-zealandiae*	Biddy Biddy
Rubiaceae	native	*Asperula conferta*	Common Woodruff
Rubiaceae	native	*Galium ?binifolium*	-
Rubiaceae	native	*Galium ?leptogonium*	-
Rubiaceae	native	*Galium gaudichaudii*	Rough Bedstraw
Scrophulariaceae	exotic	*Verbascum thapsis subsp thapsis*	Common Mullein
Solanaceae	exotic	*Solanum nigrum*	Blackberry Nightshade
Solanaceae	?	*Solanum sp.*	-
Urticaceae	exotic	*Urtica dioica*	Stinging Nettle
Verbenaceae	exotic	*Verbena bonariensis*	Purpletop
Verbenaceae	exotic	*Verbena officinalis*	Common Verbena
Verbenaceae	exotic	*Verbena rigida*	Veined Verbena
Verbenaceae	exotic	*Verbena sp.*	-
MONOCOT-GRASSES			
Poaceae	native	*Aristida ramosa*	Purple Wiregrass
Poaceae	native	*Aristida vagans*	Threeawn Speargrass
Poaceae	native	*Austrodanthonia fulva*	-
Poaceae	native	*Austrodanthonia racemosa*	-
Poaceae	native	*Austrodanthonia richardsonii*	Straw Wallaby-grass
Poaceae	native	*Austrostipa scabra*	Speargrass
Poaceae	native	*Bothriochloa decipiens*	Pitted Bluegrass
Poaceae	exotic	*Briza maxima*	Quaking Grass
Poaceae	exotic	*Bromus molliformis*	Soft Broome
Poaceae	native	*Chloris truncata*	Windmill Grass
Poaceae	native	*Chloris ventricosa*	Plump Windmill Grass
Poaceae	native	*Cymbopogon refractus*	Barbwire Grass
Poaceae	native	*Cynodon dactylon*	Couch Grass

Table L.3 Flora Species List from the Offsite Offset Property

Family	Exotic/Native	Species	Common Name
Poaceae	exotic	*Cynosurus echinatus*	Rough Dog's Tail
Poaceae	native	*Deyeuxia quadriseta*	-
Poaceae	native	*Dichanthium sericeum*	Queensland Bluegrass
Poaceae	native	*Dichelachne crinita*	Longhair Plumegrass
Poaceae	native	*Dichelachne micrantha*	Shorthair Plumegrass
Poaceae	native	*Dichelachne sp.*	-
Poaceae	native	*Echinopogon caespitosus*	Bushy Hedgehog-grass
Poaceae	native	*Echinopogon ovatus*	Forest Hedgehog Grass
Poaceae	native	*Echinopogon sp.*	-
Poaceae	exotic	*Eleusine tristachya*	Goose Grass
Poaceae	native	*Elymus scaber*	Common Wheatgrass
Poaceae	native	*Eragrostis leptostachya*	Paddock Lovegrass
Poaceae	native	*Eragrostis sp.*	-
Poaceae	native	*Lachnagrostis filiformis*	-
Poaceae	exotic	*Lolium perenne*	Perennial Ryegrass
Poaceae	native	*Microlaena stipoides*	Weeping Meadow Grass
Poaceae	native	*Panicum effusum*	Hairy Panic
Poaceae	native	*Panicum simile*	Two-colour Panic
Poaceae	exotic	*Paspalum dilatatum*	Paspalum
Poaceae	native	*Poa labillardierei*	Tussock Grass
Poaceae	native	*Poa sieberiana*	-
Poaceae	native	*Poa sp.*	-
Poaceae	native	*Sporobulus creber*	Western Rat-tail Grass
Poaceae	native	*Sporobulus sp.*	-
Poaceae	native	*Themeda australis*	Kangaroo Grass
MONOCOT-OTHER			
Anthericaceae	native	*Arthropodium milleflorum*	Pale Vanilla-lily
Anthericaceae	native	*Arthropodium sp.*	-
Anthericaceae	native	*Tricoryne ?elatior*	Yellow Autumn-lily
Cyperaceae	native	*Carex ?incomitata*	-
Cyperaceae	native	*Carex inversa*	-
Cyperaceae	native	*Cyperus gracilis*	Slender Flat-sedge
Cyperaceae	native	*Cyperus sp.*	-
Cyperaceae	native	*Lepidosperma laterale*	-
Cyperaceae	native	*Shoenus ?imberbis*	Beardless Bog-rush
Juncaceae	native	*Juncus subsecundus*	-
Juncaceae	native	*Juncus usitatus*	-
Lomandraceae	native	*Lomandra confertifolia*	Mat-rush
Lomandraceae	native	*Lomandra filiformis*	Wattle Mat-rush
Lomandraceae	native	*Lomandra glauca*	-
Lomandraceae	native	*Lomandra longifolia*	Spiny-headed Mat-rush
Lomandraceae	native	*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush
Orchidaceae	native	*Cymbidium canaliculatum*	Tiger Orchid
Orchidaceae	native	*Dipodium punctatum*	-
Orchidaceae	native	*Pterostylis sp.*	-
Phormiaceae	native	*Dianella ?revoluta*	Blueberry Lily
FERNS AND ALLIES			
Adiantaceae	native	*Adianthum aethiopicum*	Common Maidenhair
Adiantaceae	native	*Cheilanthes distans*	Bristly Cloak Fern
Adiantaceae	native	*Cheilanthes sieberi*	Poison Rock Fern
Aspleniaceae	native	*Asplenium flabellifolium*	Necklace Fern
Bigoniaceae	native	*Pandorea pandorana*	Wonga Wonga Vine
Davalliaceae	exotic	*Nephrolepis cordifolia*	Fishbone Fern
Dennstaedtiaceae	native	*Pteridium esculentum*	Common Bracken
CLIMBERS AND VINES			
Apocynaceae	native	*Parsonsia straminea*	Common Silkpod
Caprifoliaceae	exotic	*Lonicera japonica*	Honeysuckle
Commelinaceae	native	*Commelina cyanea*	Native Wandering Jew
Fabaceae - Faboideae	native	*Glycine microphylla*	Small-leaf glycine
Fabaceae - Faboideae	exotic	*Vicia sativa*	Vetch
Luzuriagaceae	native	*Eustrephus latifolius*	Wombat Berry
Menispermaceae	native	*Stephania japonica var. discolor*	Snake Vine
Pittosporaceae	native	*Billardiera scandens*	Hairy Apple Berry
Ranunculaceae	native	*Clematis glycinoides*	Headache Vine

Table L.4 Fauna Species Recorded on the Offsite Offset Property Compared with the Study Area

Family	Scientific Name	Common Name	Status		Study Area			Offsite Offset Property
			TSC Act Status	EPBC Act Status	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)	Cumberland Ecology (2012)
Amphibia								
Hylidae	*Litoria caerulea*	Green Tree Frog			X			
Hylidae	*Litoria fallax*	Eastern Dwarf Tree Frog			X			
Hylidae	*Litoria latopalmata*	Broad-palmed Frog			X			
Hylidae	*Litoria peronii*	Peron's Tree Frog			X			
Myobatrachidae	*Crinia signifera*	Common Eastern Froglet				X	X	
Myobatrachidae	*Limnodynastes ornatus*	Ornate Burrowing Frog			X			
Myobatrachidae	*Limnodynastes tasmaniensis*	Spotted Grass Frog			X			
Myobatrachidae	*Uperoleia tyleri*	Tyler's Toadlet			X			
Aves								
Acanthizidae	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill			X	X	X	X
Acanthizidae	*Acanthiza lineata*	Striated Thornbill					X	X
Acanthizidae	*Acanthiza nana*	Yellow Thornbill			X	X	X	X
Acanthizidae	*Acanthiza Pusilla*	Brown Thornbill						X
Acanthizidae	*Acanthiza reguloides*	Buff-rumped Thornbill			X	X	X	X
Acanthizidae	*Gerygone fusca*	Western Gerygone			X	X		
Acanthizidae	*Gerygone mouki*	Brown Gerygone					X	
Acanthizidae	*Gerygone olivacea*	White-throated Gerygone				X		X
Acanthizidae	***Pyrrholaemus saggitatus***	**Speckled Warbler**	V		X	X	X	X
Acanthizidae	*Sericornis frontalis*	White-browed Scrubwren						X
Acanthizidae	*Smicrornis brevirostris*	Weebill			X	X	X	X
Accipitridae	*Accipiter fasciatus*	Brown Goshawk			X	X	X	
Accipitridae	*Accipiter novaehollandiae*	Grey Goshawk						X
Accipitridae	*Aquila audax*	Wedge-tailed Eagle			X	X	X	X
Accipitridae	***Circus assimilis***	**Spotted Harrier**	V			X		
Accipitridae	*Elanus axillaris*	Black-shouldered Kite			X	X		
Accipitridae	***Hieraaetus morphinoides***	**Little Eagle**	V				X	X
Accipitridae	*Milvus sphenurus*	Whistling Kite				X		
Aegothelidae	*Aegotheles cristatus*	Australian Owlet-nightjar			X		X	
Anatidae	*Anas gracilis*	Grey Teal			X	X		
Anatidae	*Anas superciliosa*	Pacific Black Duck			X		X	
Anatidae	*Aythya australis*	Hardhead				X		
Anatidae	*Chenonetta jubata*	Australian Wood Duck			X		X	X
Anatidae	*Cygnus atratus*	Black Swan					X	
Anatidae	*Dendrocygna eytoni*	Plumed Whistling-Duck			X			
Apodidae	***Hirundapus caudacutus***	**White-throated Needletail**		Mi	X			
Ardeidae	*Egretta novaehollandiae*	White-faced Heron			X			
Artamidae	*Artamus cyanopterus*	Dusky Woodswallow			X	X		X
Artamidae	*Artamus personatus*	Masked Woodswallow				X		
Artamidae	*Artamus superciliosus*	White-browed Woodswallow				X		
Artamidae	*Cracticus nigrogularis*	Pied Butcherbird			X	X	X	X
Artamidae	*Cracticus torquatus*	Grey Butcherbird			X		X	X
Artamidae	*Gymnorhina tibicen*	Australian Magpie			X	X	X	X
Artamidae	*Strepera graculina*	Pied Currawong			X	X	X	X
Cacatuidae	*Cacatua galerita*	Sulphur-crested Cockatoo			X	X	X	X
Cacatuidae	*Cacatua sanguinea*	Little Corella						
Cacatuidae	*Calyptorhynchus funereus*	Yellow-tailed Black-Cockatoo						X
Cacatuidae	*Eolophus roseicapillus*	Galah			X	X	X	X
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike			X	X	X	X

Table L.4 Fauna Species Recorded on the Offsite Offset Property Compared with the Study Area

Family	Scientific Name	Common Name	Status		Study Area			Offsite Offset Property
			TSC Act Status	EPBC Act Status	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)	Cumberland Ecology (2012)
Campephagidae	*Coracina tenuirostris*	Cicadabird						X
Charadriidae	*Vanellus miles*	Masked Lapwing				X	X	
Cisticolidae	*Cisticola exilis*	Golden-headed Cisticola				X		
Climacteridae	*Cormobates leucophaea*	White-throated Treecreeper				X		X
Climacteridae	***Climacteris picumnus victoriae***	**Brown Treecreeper (eastern subspecies)**	V		X		X	
Columbidae	*Ocyphaps lophotes*	Crested Pigeon			X	X	X	X
Columbidae	*Phaps chalcoptera*	Common Bronzewing			X		X	X
Coraciidae	*Eurystomus orientalis*	Dollarbird				X		X
Corcoracidae	*Corcorax melanorhamphos*	White-winged Chough			X	X	X	X
Corvidae	*Corvus coronoides*	Australian Raven			X	X	X	X
Corvidae	*Corvus mellori*	Little Raven				X		
Corvidae	*Corvus orru*	Torresian Crow						
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed Cuckoo			X	X		X
Cuculidae	*Chalcites basalis*	Horsfield's Bronze-Cuckoo			X	X		
Cuculidae	*Chalcites lucidus*	Shining Bronze-Cuckoo				X		
Cuculidae	*Chalcites osculans*	Black-eared Cuckoo			X			
Cuculidae	*Cuculus pallidus*	Pallid Cuckoo				X		
Cuculidae	*Eudynamys orientalis*	Pacific Koel				X		
Cuculidae	*Scythrops novaehollandiae*	Channel-billed Cuckoo						X
Dicaeidae	*Dicaeum hirundinaceum*	Mistletoebird			X		X	X
Monarchidae	*Grallina cyanoleuca*	Magpie-lark			X	X	X	X
Monarchidae	*Myiagra inquieta*	Restless Flycatcher			X			
Monarchidae	*Myiagra rubecula*	Leaden Flycatcher						X
Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail			X	X	X	X
Rhipiduridae	*Rhipidura leucophrys*	Willie Wagtail			X	X	X	X
Rhipiduridae	*Rhipidura rufifrons*	Rufous Fantail			X			
Estrildidae	*Neochmia temporalis*	Red-browed Finch			X		X	X
Estrildidae	***Stagonopleura guttata***	**Diamond Firetail**	V		X		X	
Estrildidae	*Taeniopygia bichenovii*	Double-barred Finch			X	X	X	
Estrildidae	*Taeniopygia guttata*	Zebra Finch			X			
Falconidae	*Falco berigora*	Brown Falcon			X	X	X	X
Falconidae	*Falco cenchroides*	Nankeen Kestrel			X	X	X	X
Falconidae	*Falco longipennis*	Australian Hobby			X		X	
Falconidae	*Falco subniger*	Black Falcon			X			
Halcyonidae	*Dacelo novaeguineae*	Laughing Kookaburra			X	X	X	X
Halcyonidae	*Todiramphus sanctus*	Sacred Kingfisher			X	X		
Hirundinidae	*Hirundo neoxena*	Welcome Swallow				X	X	X
Hirundinidae	*Hirundo nigricans*	Tree Martin					X	
Hirundinidae	*Petrochelidon ariel*	Fairy Martin			X	X		
Maluridae	*Malurus cyaneus*	Superb Fairy-wren			X	X	X	X
Maluridae	*Malurus lamberti*	Variegated Fairy-wren			X			
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater						X
Meliphagidae	*Acanthorhynchus tenuirostris*	Eastern Spinebill						X
Meliphagidae	*Anthochaera carunculata*	Red Wattlebird				X		X
Meliphagidae	*Lichenostomus chrysops*	Yellow-faced Honeyeater				X	X	X
Meliphagidae	*Lichenostomus leucotis*	White-eared Honeyeater						X
Meliphagidae	*Lichenostomus penicillatus*	White-plumed Honeyeater			X		X	X
Meliphagidae	*Lichenostomus virescens*	Singing Honeyeater						
Meliphagidae	*Manorina melanocephala*	Noisy Miner			X	X	X	X
Meliphagidae	*Melithreptus brevirostris*	Brown-headed Honeyeater					X	X

Table L.4 Fauna Species Recorded on the Offsite Offset Property Compared with the Study Area

Family	Scientific Name	Common Name	Status		Study Area			Offsite Offset Property
			TSC Act Status	EPBC Act Status	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)	Cumberland Ecology (2012)
Meliphagidae	***Melithreptus gularis gularis***	**Black-chinned Honeyeater (eastern subspecies)**	V		X			
Meliphagidae	*Melithreptus lunatus*	White-naped Honeyeater						X
Meliphagidae	*Myzomela sanguinolenta*	Scarlet Honeyeater					X	
Meliphagidae	*Philemon citreogularis*	Little Friarbird			X			
Meliphagidae	*Philemon corniculatus*	Noisy Friarbird				X	X	X
Meliphagidae	*Plectorhyncha lanceolata*	Striped Honeyeater					X	
Meropidae	***Merops ornatus***	**Rainbow Bee-eater**		Mi	X	X		X
Motacillidae	*Anthus australis*	Australian Pipit			X	X	X	
Neosittidae	***Daphoenositta chrysoptera***	**Varied Sittella**	v					X
Oriolidae	*Oriolus sagittatus*	Olive-backed Oriole				X		X
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush			X		X	X
Pachycephalidae	*Pachycephala pectoralis*	Golden Whistler					X	
Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler			X	X	X	X
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote				X	X	X
Pardalotidae	*Pardalotus striatus*	Striated Pardalote			X	X	X	X
Petroicidae	*Eopsaltria australis*	Eastern Yellow Robin			X			X
Petroicidae	***Melanodryas cucullata***	**Hooded Robin**	V		X			
Petroicidae	*Microeca fascinans*	Jacky Winter			X		X	
Petroicidae	***Petroica boodang***	**Scarlet Robin**	V			X	X	
Petroicidae	*Petroica rosea*	Rose Robin					X	
Petroicidae	*Petroica goodenovii*	Red-capped Robin			X	X	X	
Phasianidae	*Coturnix pectoralis*	Stubble Quail			X			
Phasianidae	*Coturnix ypsilophora*	Brown Quail			X		X	
Podargidae	*Podargus strigoides*	Tawny Frogmouth			X			X
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe			X	X	X	
Pomatostomidae	***Pomatostomus temporalis temporalis***	**Grey-crowned Babbler (eastern subspecies)**	V		X	X	X	
Psittacidae	*Alisterus scapularis*	Australian King-Parrot					X	X
Psittacidae	*Glossopsitta cocinna*	Musk Lorikeet					X	X
Psittacidae	*Glossopsitta spp.*				X			
Psittacidae	***Lathamus discolor***	**Swift Parrot**	E	E; Ma			X	
Psittacidae	*Platycercus adscitus eximius*	Eastern Rosella			X	X	X	X
Psittacidae	*Platycercus ELEGANS*	Crimson Rosella						X
Psittacidae	*Psephotus haematonotus*	Red-rumped Parrot					X	
Psittacidae	*Psephotus varius*	Mulga Parrot			X			
Psittacidae	*Trichoglossus haematodus*	Rainbow Lorikeet						
Ptilonorhynchidae	*Ptilonorhynchus violaceus*	Satin Bowerbird						
Strigidae	*Ninox boobook*	Southern Boobook					X	
Strigidae	***Ninox connivens***	**Barking Owl**	V		X			
Sturnidae	*Acridotheres tristis**	Common Myna				X		
Sturnidae	*Sturnus vulgaris**	Common Starling			X	X	X	
Sylviidae	*Cincloramphus cruralis*	Brown Songlark				X		
Threskiornithidae	*Threskiornis spinicollis*	Straw-necked Ibis						
Turnicidae	*Turnix varia*	Painted Button-quail			X			
Tytonidae	*Tyto alba*	Barn Owl				X		
Zosteropidae	*Zosterops lateralis*	Silvereye			X		X	X
Mammalia								
Bovidae	*Bos taurus**	European cattle				X	X	X
Bovidae	*Ovis aries**	Sheep				X		
Canidae	*Canis lupus familiaris**	Dog			X			

Table L.4 Fauna Species Recorded on the Offsite Offset Property Compared with the Study Area

Family	Scientific Name	Common Name	Status		Study Area			Offsite Offset Property
			TSC Act Status	EPBC Act Status	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)	Cumberland Ecology (2012)
Canidae	*Vulpes vulpes**	Fox			X		X	
Dasyuridae	***Dasyurus maculatus***	**Spotted-tailed Quoll**	V	E1				X
Dasyuridae	*Sminthopsis murina*	Slender-tailed Dunnart/ Common Dunnart					X	
Emballonuridae	***Saccolaimus flaviventris***	**Yellow-bellied Sheathtail-bat**	V				X	X
Equidae	*Equus caballus**	Horse				X		
Leporidae	*Lepus capensis**	Brown Hare			X	X	X	
Macropodidae	*Macropus robustus*	Common Wallaroo			X			X
Macropodidae	*Macropus rufogriseus*	Red-necked Wallaby				X	X	X
Molossidae	*Austronomus australis (Tadarida australis)*	White-striped Freetail-bat			X		X	X
Molossidae	*Mormopterus* ("Species 1")	A Freetail-bat			X			
Molossidae	***Mormopterus norfolkensis***	**Eastern Freetail-bat**	V		X		X	
Molossidae	*Mormopterus planiceps*	Little Mastiff-bat			X			
Molossidae	*Mormopterus ridei* ("Species 2")	Eastern Freetail-bat					X	
Molossidae	*Mormopterus* ("Species 4")	Eastern Freetail-bat					X	X
Muridae	*Mus musculus**	House Mouse			X		X	
Muridae	*Rattus rattus**	Black Rat			X			
Phalangeridae	*Trichosurus vulpecula*	Common Brushtail Possum			X		X	X
Phascolarctidae	***Phascolarctos cinereus***	**Koala**	V	V	X			
Suidae	*Sus scrofa**	Pig						X
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna			X			
Vespertilionidae	***Chalinolobus dwyeri***	**Large-eared Pied Bat**	V	V			X	?
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat			X		X	X
Vespertilionidae	*Chalinolobus morio*	Chocolate Wattled Bat			X		X	X
Vespertilionidae	***Miniopterus australis***	**Little Bent-wing Bat**	V					X
Vespertilionidae	***Miniopterus orianae oceanensis (M.schreibersii oceane***	**Eastern Bentwing-bat**	V		X		X	X
Vespertilionidae	***Myotis macropus***	**Southern Myotis**	V		X		?	
Vespertilionidae	*Nyctophilus geoffroyi*	Lesser Long-eared Bat			X			X
Vespertilionidae	*Nyctophilus spp.*	Long-eared bat					?	X
Vespertilionidae	***Nyctophilus corbeni***	**Greater Long-eared Bat**	V	V	X			
Vespertilionidae	***Scoteanax rueppellii***	**Greater Broad-nosed Bat**	V		X			
Vespertilionidae	*Scotorepens balstoni*	Inland Broad-nosed Bat			X		?	
Vespertilionidae	*Scotorepens greyii*	Little Broad-nosed Bat					?	
Vespertilionidae	*Vespadelus darlingtoni*	Large Forest Bat			X		X	
Vespertilionidae	*Vespadelus sp.*	Forest Bat					?	X
Vespertilionidae	***Vespadelus troughtoni***	**Eastern Cave Bat**	V				?	
Vespertilionidae	*Vespadelus vulturnus*	Little Forest Bat			X		?	X
Vombatidae	*Vombatus ursinus*	Common Wombat			X			
Reptilia								
Agamidae	*Amphibolurus muricatus*	Jacky Lizard						X
Agamidae	*Pogona barbata*	Bearded Dragon			X	X		X
Chelidae	*Chelodina longicollis*	Eastern Snake-necked Turtle			X			
Elapidae	*Pseudechis porphyriacus*	Red-bellied Black Snake			X		X	
Elapidae	*Pseudonaja textilis*	Eastern Brown Snake			X			
Gekkonidae	*Diplodactylus vittatus*	Wood Gecko			X		X	
Gekkonidae	*Oedura robusta*	Robust Velvet Gecko			X			
Scincidae	*Carlia tetradactyla*	Southern Rainbow-skink			X			
Scincidae	*Cryptoblepharus virgatus*	Cream-striped Shinning-skink			X			
Scincidae	*Ctenotus robustus*	Robust Ctenotus			X			
Scincidae	*Egernia modesta*	Eastern Ranges Rock-skink			X			

Table L.4 Fauna Species Recorded on the Offsite Offset Property Compared with the Study Area

Family	Scientific Name	Common Name	Status		Study Area			Offsite Offset Property
			TSC Act Status	EPBC Act Status	Ecotone (2000)	Cumberland Ecology (2009)	Cumberland Ecology (2011)	Cumberland Ecology (2012)
Varanidae	*Varanus varius*	Lace Monitor			X	X	X	
Crustaceae								
Parastacidae	*Cherax destructor*	Common Yabby						X

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

Appendix M

Summary of Assessment of MNES

M.1 Introduction

The purpose of this Appendix is to provide a summary of the assessment of Matters of National Environmental Significance (MNES) that are relevant to the Project. The relevant MNES are listed in **Table M.1** below.

Table M.1 MNES Relevant to the Study Area

Common Species Name	Scientific Name	EPBC Status
Box-Gum Woodland	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	CE
Weeping Myall Woodlands	Weeping Myall Woodlands	E
Regent Honeyeater	*Anthochaera phrygia*	E, Mi
Swift Parrot	*Lathamus discolor*	E, Ma
Spotted-tail Quoll	*Dasyurus maculatus maculatus*	E
Koala	*Phascolarctos cinereus*	V
Greater Long-eared Bat	*Nyctophilus corbeni* (syn. *N. timoriensis*)	V
Green and Golden Bell Frog	*Litoria aurea*	E
Lobed Blue Grass	*Bothriochloa biloba*	V
Finger Panic Grass	*Digitaria porrecta*	E
Leek-orchid	*Prasophyllum* sp. Wybong (C. Phelps ORG 5269)	CE
Illawarra Greenhood	*Pterostylis gibbosa*	E
Austral Toadflax	*Thesium australe*	V

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

This Appendix is structured as follows:

- **Section M.2** Methods;
- **Section M.3** Species Profiles and Likely Occurrence in the Study Area;
- **Section M.4** Impact Assesssment;
- **Section M.5** Avoidance, Mitigation and Offset Measures; and
- **Section M.6** Conclusions.

M.2 Methods

Field and desktop studies for relevant MNES were conducted concurrently with state studies and are described in **Chapter 4** of the ecology impact assessment. The field studies were completed in a number of different seasons to address seasonal differences in detectability of different species.

M.3 Species Profiles and Likely Occurrence in the Study Area

M.3.1 Box-Gum Woodland

Box-Gum Woodland is an ecological community that is, or was historically dominated by one or more of the following canopy trees: *Eucalyptus albens* (White Box), *Eucalyptus melliodora* (Yellow Box) and *Eucalyptus blakelyi* (Blakely's Red Gum). Associated and occasionally co-dominant tree species include *Eucalyptus conica* (Fuzzy Box), *Eucalyptus bridgesiana* (Apple Box), *Eucalyptus polyanthemos* (Red Box), *Eucalyptus goniocalyx* (Long-leaved Box) and *Brachychiton populneus* (Kurrajong). It has a predominantly native grassy understorey and can include open woodland areas as well as native grassland derived from the clearance of the canopy trees (DECCW (NSW) 2010b).

Box-Gum Woodland was once a geographically wide-spread community spanning three different states and covering an estimated pre-European area of several million hectares. Most of the distributional range of Box-Gum Woodland occurs within NSW. Approximately 10% of its pre-European extent is estimated to remain today and occurs largely on fertile, arable land in prime agricultural areas (DECCW (NSW) 2010b).

A patch of Box-Gum Woodland must conform to the following criteria to be recognised as the EPBC listed ecological community:

- Tree canopy comprising, or historically comprising *Eucalyptus albens* (White Box), *Eucalyptus melliodora* (Yellow Box) and *Eucalyptus blakelyi* (Blakely's Red Gum);
- Predominantly native understorey containing at least 12 native, non-grass understorey species;
- At least one native understorey species being an important species that represents a grazing sensitive, regionally significant or uncommon/rare species (e.g. Kangaroo Grass, orchids or rock ferns); and
- Patch size being at least 0.1 hectares in size.

Box-Gum Woodland is known to occur in the Muswellbrook area but generally does not extend as far south as Singleton. It is associated with intergrades of *Eucalyptus albens* (White Box) and *Eucalyptus moluccana* (Grey Box).

Box-Gum Woodland was recorded in the Study Area as remnant woodland and derived native grassland. It is represented by the following vegetation units:

- 94 ha Upper Hunter White Box-Ironbark Grassy Woodland;
- 40 ha Hunter Floodplain Red Gum Woodland; and
- 169 ha of Derived Native Grassland associated with the historical clearance of canopy trees from the above communities.

The floristics and condition of the above vegetation units are described in further detail in **Chapter 5**. The distribution of Box-Gum Woodland is largely concentrated in the eastern undulating hills and steep gullies of the Study Area. Fragmented patches of Box-Gum Woodland occur intermittently along Saddlers Creek. **Figure M.1** below provides a map of the occurrence of Box-Gum Woodland in the Study Area.

Figure M.2 below provides a map of the condition of Box-Gum Woodland as defined in the Commonwealth Listing Advice for Box-Gum Woodland. The Listing Advice for Box-Gum Woodland describes the following Condition Classes:

Condition Class 'A' = where an overstorey of eucalypt trees exists, but there is no substantial native understorey

Condition Class 'B' = where native understorey exists, but the trees have been cleared; and

Condition Class 'C' = where both a native understorey and an overstorey of eucalypts exists in conjunction.

There are approximately 134 ha of Box-Gum Woodland of Condition Class C and 169 ha of Box-Gum Woodland of Condition Class B. There are no Condition Class A Box-Gum Woodland areas present in the Study Area.

M.3.2 Weeping Myall Woodland

Weeping Myall Woodlands ecological community generally occurs on heavy soils of flats, floodplains and undulating, arable landscapes as a mosaic of sparse to open woodlands and treeless shrublands and grasslands where *Acacia pendula* (Weeping Myall) trees are the sole or dominant overstorey species in these landscapes (SEWPaC 2011g). 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).

The Weeping Myall Woodlands occurs on the inland alluvial plains west of the Great Dividing Range in NSW and Queensland, with one small outlying patch in northern Victoria. It occurs in the Riverina, NSW South Western Slopes, Darling Riverine Plains, Brigalow Belt South, Brigalow Belt North, Murray-Darling Depression, Nandewar and Cobar Peneplain IBRA Bioregions. The core distribution of the ecological community in NSW is thought to have been the Riverina bioregion.

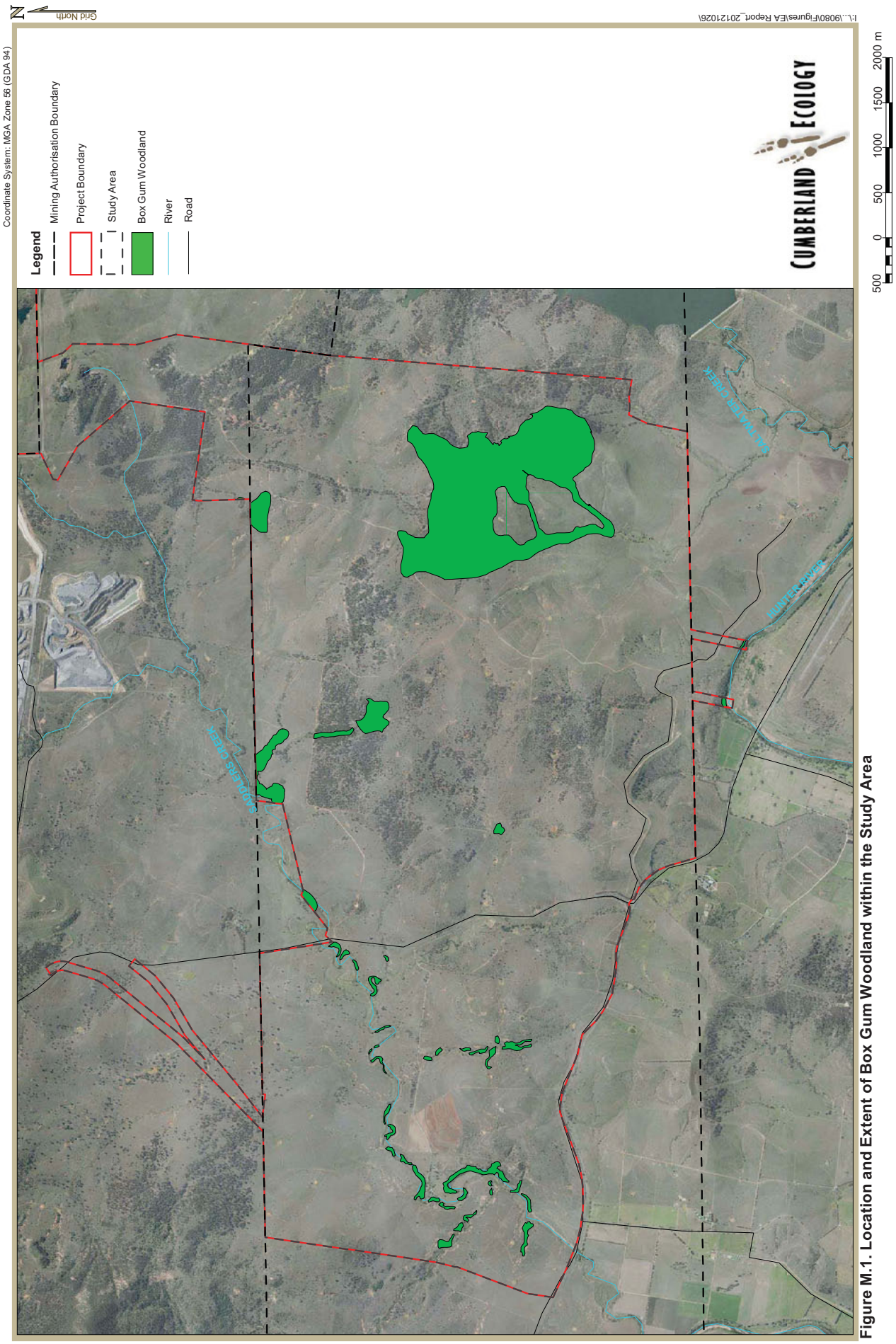


Figure M.1. Location and Extent of Box Gum Woodland within the Study Area

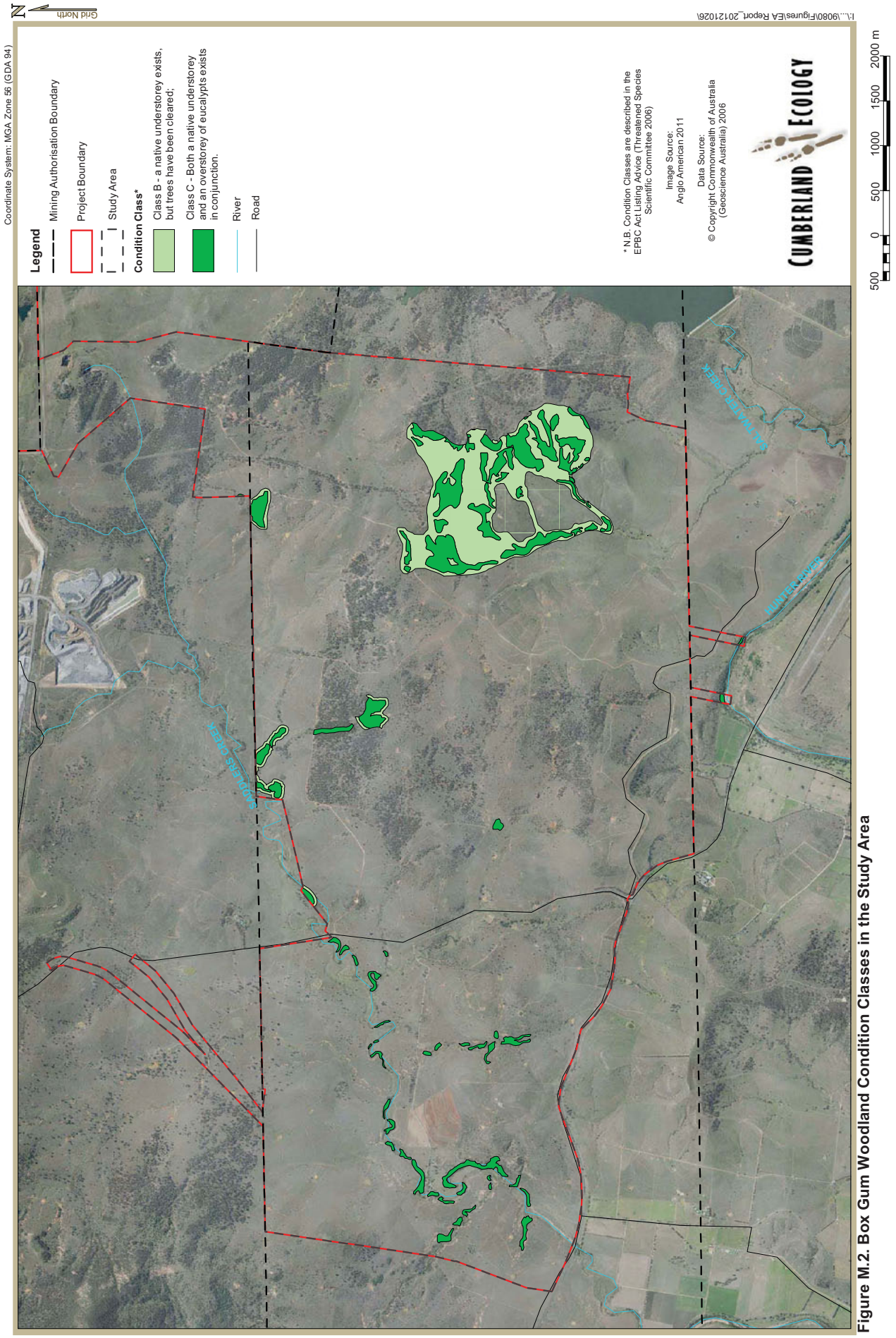


Figure M.2. Box Gum Woodland Condition Classes in the Study Area

A patch of *Acacia pendula* (Weeping Myall) must conform to the following criteria to be recognised as the EPBC listed ecological community:

- 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.

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 2011g). The Hunter population of *Acacia pendula* (Weeping Myall) 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.

No area of Weeping Myall Woodland has been recorded in the Study Area. Small patches of regrowth (less than 3 m tall) *Acacia pendula* (Weeping Myall) has been recorded at two locations in grassland. No *Acacia pendula* (Weeping Myall) trees were present. The understorey at one of these patches was eroded and almost absent of understorey species, including grasses. As a result of the erosion, there was an absence of leaf litter, cryptograms or soil crust.

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.

M.3.3 Regent Honeyeater and Swift Parrot

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 2000). 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, Menkhorst et al. 1989; NSW Scientific Committee 2004p). The species uses patches of vegetation as ‘stepping stones’ to travel across landscapes.

The Swift Parrot is a predominantly nectarivorous, migratory parrot endemic to south eastern Australia (Birds Australia 2011). 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 2000). 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) 2005o; Saunders and Heinsohn 2008).

There are 15 records for the Regent Honeyeater in Muswellbrook LGA and they have been recorded consistently in Wollemi National Park and on the timbered slopes around Manobalai Nature Reserve (**Figure M.3**) since 1980. Regent Honeyeaters have not been recorded in the Study Area but have been detected in the adjacent Mt Arthur Coal Mine lease in the past.

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 6.14** in **Chapter 6**). No previous sightings for the Swift Parrot have been recorded in the Muswellbrook LGA since 1980.

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. 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 2004p; Kennedy and Tzaros 2005).

M.3.4 Spotted-tail Quoll

The Spotted-tailed Quoll (*Dasyurus maculatus*) is a solitary and carnivorous marsupial with a reddish brown to dark chocolate brown coat with white spots on the body and tail. It occurs on the east coast of mainland Australia from Queensland through Victoria, and in Tasmania. The mainland population occurs in very low densities and is considered to be rare.

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. Females breed once a year and typically establish grass-lined dens in burrows or hollow logs. The species usually traverse their ranges along densely vegetated creeklines (DEC (NSW) 2005m).

The Spotted-tailed Quoll (*Dasyurus maculatus*) has been recorded within the Muswellbrook LGA. At least 24 sightings have been recorded since 1980 with the most recent recorded in May 2008 just east of the Muswellbrook Township. The four closest sightings are about six to eight years old and were recorded along Edderton Road, Denman Road, Golden Highway, and near Lake Liddell (**Figure M.3**).

The Spotted-tailed Quoll (*Dasyurus maculatus*) has not been recorded within the Study Area. One individual was recorded during surveys of the Mt Arthur Coal Mine lease. The species has potential to occur within the Study Area from time to time and is likely to utilise vegetation corridors and habitat in the Study Area for movement and foraging. 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, although it is unlikely that there is a breeding den on site. It is also unlikely that the Spotted-tail Quoll occurs in the area in significant densities.

M.3.5 Koala

The Koala (*Phascolarctos cinereus*) is an arboreal marsupial with large furry ears and a vestigial tail. The species is found throughout eastern Australia, from north eastern Queensland to south eastern South Australia and to the west of the Great Dividing Range. In NSW, the Koala population is largely concentrated on the North Coast and in the Pilliga and Gunnedah areas (DECC (NSW) 2008).

The Koala inhabits a range of eucalypt forests and woodland communities, including coastal forests and woodlands and riparian communities of the western plains. Koalas have very low metabolic rates and are not very active. However, they are known to move considerable distances when necessary, and can use isolated paddock trees when moving from one area to another. The Koala lives in breeding aggregations comprising a dominant male and a small number of mature females, as well as juveniles of various ages. Home ranges for individual Koalas can vary between 0.2-500 ha, depending on the quality and availability of habitat in a locality. The Koala primarily feeds on eucalypt leaves (DECC (NSW) 2008).

There are 17 sightings of the Koala in the Muswellbrook LGA that were recorded since 1980 (**Figure M.3**). The Koala (*Phascolarctos cinereus*) 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 they have been recorded within the Muswellbrook and Singleton LGAs, with 21 and 77 species records respectively. 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 species is unlikely to occur within the Study Area. The Study Area is also not considered to be core koala habitat as defined under SEPP 44. The forest and woodland within the Study Area currently does not connect to significant areas of habitat and does not represent good movement corridors.

The Koala is discussed in further detail under **Section 7.2.2** in **Chapter 7**.

M.3.6 Greater Long-eared Bat

The Greater Long-eared Bat is an insectivorous microchiropteran bat with rare distribution around south eastern Australia, including the Hunter Valley (Churchill 2008). 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 parches of trees (DEC (NSW) 2005h).

There are 16 records for the species in Muswellbrook LGA. The species occurs in low densities within the Wollemi National Park and on the timbered slopes around Manobalai Nature Reserve (**Figure M.3**).

The Greater Long-eared Bat (south eastern form) (*Nyctophilus corbeni*) was recorded within the Study Area in 2000 (Ecotone 2000). Hollow-dependent microbat species are highly mobile but as they 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 their home ranges.

M.3.7 Green and Golden Bell Frog

The Green and Golden Bell Frog is a large bell frog that that preys upon other frogs, actively locating them by their advertisement calls. The adults are bright emerald to dull olive green with or without brown and gold blotches and stripes. The tadpoles are pinkish-grey with yellowish fins (OEH 2012). The species inhabits disturbed sites including abandoned mines, grassy habitats and fringing aquatic vegetation and breeds in still, shallow, ephemeral ponds. Marshes, dams and stream sides, particularly those containing bullrushes or spikerushes and /or rocks, comprise suitable aquatic habitat with adequate sheltering sites. Unshaded water bodies free of *Gambusia holbrooki* (Mosquito Fish) form optimum habitat.

The Green and Golden Bell Frog was once very common across south eastern Australia. The species is now restricted across much of its former distribution along the NSW coast to approximately 40 widely separated and isolated populations that are scattered across the coastal parts of NSW, including Koorangang Island and Kurnell Peninsula (DECC (NSW) 2008a). In the Hunter Valley, the Green and Golden Bell Frog was historically widespread and was commonly found associated with the various floodplain wetlands of the Hunter River and its tributaries during the 1950s, 60s and 70s. The species is now believed restricted to four meta-populations in the Hunter Valley: Sandgate on the margins of Hexham Swamp;

Kooragang Island in the delta of the Hunter River; Gillieston Heights/East Maitland, Ravensdale areas including Wentworth Swamp; and Ravensworth/Liddell/Bayswater area. These observations support the notion that the species is present across this area of the Hunter Valley but that it occurs as a diffuse population (Department of Environment and Conservation NSW 2005).

The Ravensworth/Liddell/Bayswater area meta-population includes several sightings recorded since 1995. However, the Green and Golden Bell Frog (*Litoria aurea*) has not been recorded within the Study Area. The aquatic habitat provided by Saddlers Creek is sub-optimal and there is no suitable winter shelter habitat. Elements such as bullrushes or spikerushes, rocks and other sheltering vegetation are generally lacking. *Gambusia holbrooki* is the dominant fish in Saddlers Creek and is generally known to occur in the Hunter River system (see **Section 6.4.3** in **Chapter 6**). Thus, the Green and Golden Bell Frog is unlikely to be present in the Study Area.

M.3.8 Lobed Blue Grass

Bothriochloa biloba (Lobed Blue-grass), is an erect or decumbent grass to 1 m high (Harden 1993). It has a lobed upper lemma (bract enclosing the flower) which remains attached to the base of the awn when the awn is pulled out of the spikelet. Flowering occurs from November to June (Threatened Species Scientific Committee 2008b).

Lobed Blue-grass grows in cleared eucalypt forests and relict grassland, often dominated by Purple Wiregrass (*Aristida ramosa*), Red-leg Grass (*Bothriochloa macra*), Red Grass (*Bothriochcloa decipiens*), Queensland Bluegrass (*Dicanthium sericeum*) or *Austrostipa aristiglumis* (Threatened Species Scientific Committee 2008b). The species tends to prefer heavier-textured soils such as brown or black clay soils (Quinn et al. 1995, NSW Scientific Committee 2004x) but it has been recorded consistently in the Muswellbrook area on sandstone soils (**Figure M.4**).

Lobed Blue-grass is distributed from the Darling Downs district in Queensland, south along the western slopes of the Great Dividing Range to the Merriwa region in NSW, west to Dubbo and around the Hunter Valley (Quinn et al. 1995, NSW Scientific Committee 2004x).

Lobed Blue Grass has been consistently recorded in the locality (**Figure M.4**) and is known from Mt Arthur Coal mine lease just north of Saddlers Creek (Cumberland Ecology 2009). Lobed Blue Grass was recorded within Box-Gum Woodland in the Study Area during the 2009 surveys of the Study Area by Cumberland Ecology and the 2000 surveys by Ecotone.

Lobed Blue Grass is fairly tolerant of grazing and grows in partially cleared eucalypt forests and grassland derived from the clearing of such forests (NSW Scientific Committee 2004c). Proximate off site distribution and the fact that the species is more widespread than previously thought make it highly likely that the species occurs in other grassland and woodland areas elsewhere within the Study Area.

M.3.9 Finger Panic Grass

Digitaria porrecta (Finger Panic Grass), is a loosely tufted perennial grass growing to 60 cm tall. The species occurs on heavy floodplain soils, typically on black clay or basaltic soils. It has grey leaves, 2–3 mm wide, with sharp hairs along the middle. Flowers appear in late summer in a cylindrical cluster along a stalk and spread stiffly from the flowering stem, with the lower clusters arranged in a whorl of four to six, each up to 30 cm long. It seeds from March to April but also reproduces vegetatively by dying back to the tussock base, from which it resprouts in summer. As the tussock ages the central portion dies and the resultant ring of plantlets eventually separate and become independent tussocks (DECCW (NSW) 2005, Threatened Species Scientific Committee 2008a).

This species is known from four disjunct areas extending over 1000km, two of which are known from NSW. In NSW, Finger Panic Grass occurs from Graman and Croppa Creek (near Inverell); south to the Liverpool Plains near Coonabarabran and Werris Creek where there are 33 known sites (Threatened Species Scientific Committee 2008a). No previous sightings for Finger Panic Grass have been recorded in the Muswellbrook LGA since 1980.

Digitaria porrecta (Finger Panic Grass) has not been recorded in the Study Area during surveys. The Study Area is outside the known range for the species and does not support the species.

M.3.10 Leek-orchid

Prasophyllum sp. Wybong (Leek-orchid) is a terrestrial orchid that grows to approximately 30 cm high. It has a single, tubular, fleshy, dull-green leaf and a single flower spike with numerous fragrant flowers. Leek orchids are generally found in shrubby and grassy habitats in dry to wet soil (Threatened Species Scientific Committee 2009). *Prasophyllum* sp. Wybong (Leek-orchid) is known to occur in open eucalypt woodland and grassland. Its distributional range overlaps with that of Box-Gum Woodland.

The species is known from seven populations in eastern NSW near Ilford, Premer, Muswellbrook, Wybong, Yeoval, Inverell and Tenterfield, with an area of occupancy estimated at 1.5 km². The populations are separated by large areas of cleared land (SEWPaC 2011h).

No records for *Prasophyllum* sp. Wybong (Leek-orchid) in the Muswellbrook LGA are available from the Atlas of NSW Wildlife Records. However, the population near Muswellbrook has been monitored from 1999-2005 and fluctuations in the number of individuals visible (ranging from zero to 10 plants) were observed. This population does not occur in the Study Area.

Prasophyllum sp. Wybong (Leek-orchid) has not been recorded in 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 records.

M.3.11 Illawarra Greenhood

Pterostylis gibbosa (Illawarra Greenhood) is a perennial terrestrial orchid and is characterised by green, hood-shaped flowers. The leaves of this species are elliptic to ovate in shape, 1.5 to 3.5 cm long, entire and arranged in a small basal rosette (NSW National Parks and Wildlife Service 2002). The orchid flowers from August to November (NSW DECCW 2005).

The habitat of the Illawarra Greenhood varies in composition and vegetation types. It is known to occur in a range of habitats, but particularly in grassland in sclerophyll forest.

The current distribution of the species is known from five locations in NSW. These include three sites in the Illawarra, a disjunct population in the Hunter Valley at Milbrodale, and one site near Nowra in the Shoalhaven (NSW National Parks and Wildlife Service 2002).

No records for Illawarra Greenhood in the Muswellbrook LGA are available from the Atlas of NSW Wildlife Records. The only known occurrence of this species in the Hunter Valley is on private property in the Milbrodale area, comprised of an estimated 1000 to 2000 plants (NSW National Parks and Wildlife Service 2002). No other occurrences of the species are known in the Hunter region.

Pterostylis gibbosa (Illawarra Greenhood) was not recorded in the Study Area. Despite the availability of suitable habitat, the species is unlikely to occur as it is outside of the known range in the Hunter (private property near Milbrodale).

M.3.12 Austral Toadflax

Thesium australe (Australe 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 flowers are five-lobed, have both male and female parts and are approximately 2 mm long, cylindrical in shape and greenish-yellow in colour. Flowering is predominantly in spring and summer. The fruit is an oval or spherical nut that is between 2-2.5 mm long with 8-10 longitudinal ribs and a network of veins that run over the surface (Tas. DPIPWE 2003). The species occurs in grassland and grassy woodlands, with strong associations with Kangaroo Grass.

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 Muswellbrook LGA. *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, such that the species only has a very low potential to occur in the Study Area.

A summary of the likely occurrence of the discussed MNES is presented in **Table M.2**.

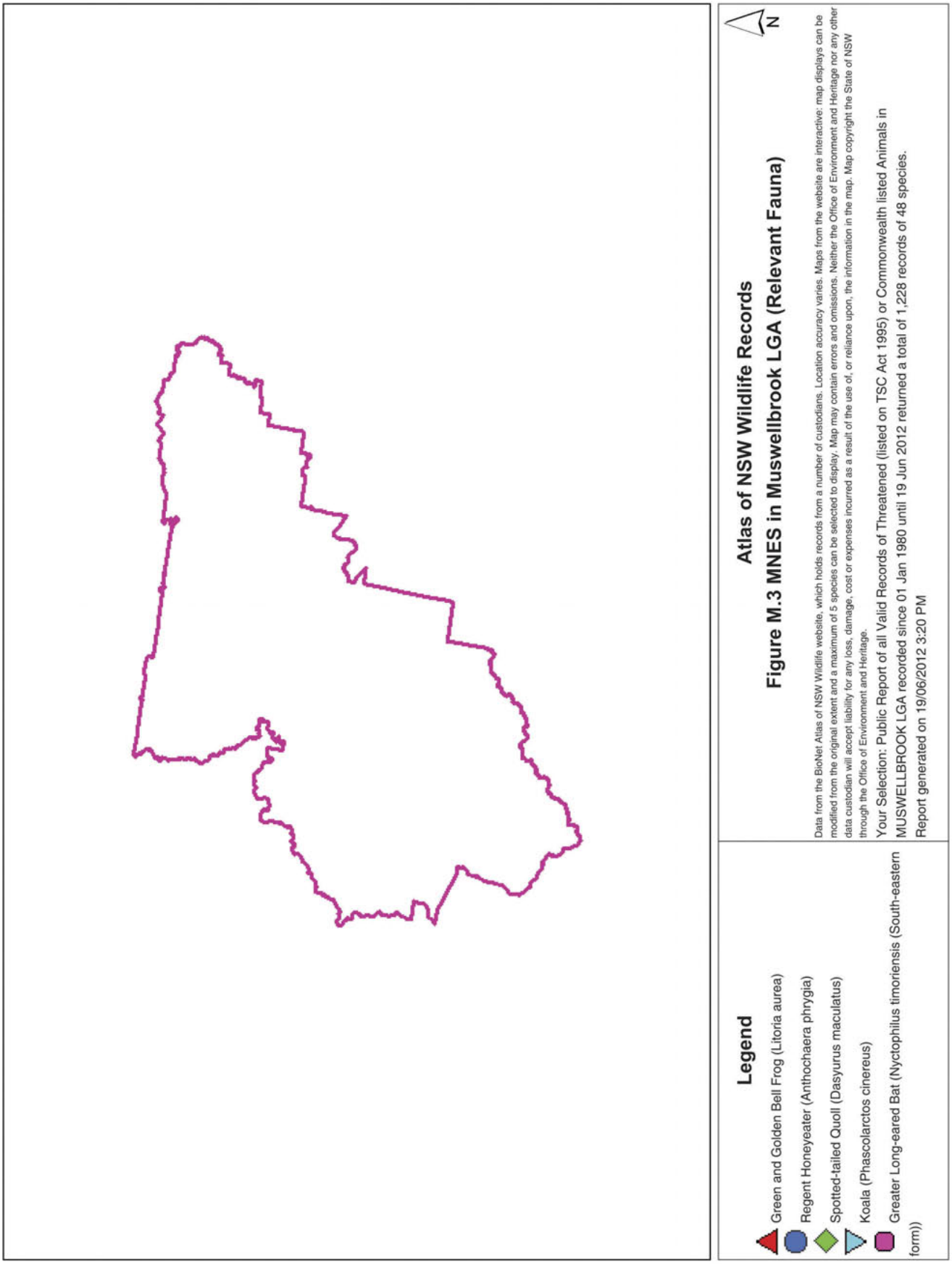
Table M.2 Summary of Likely Occurrence of Relevant MNES in Study Area

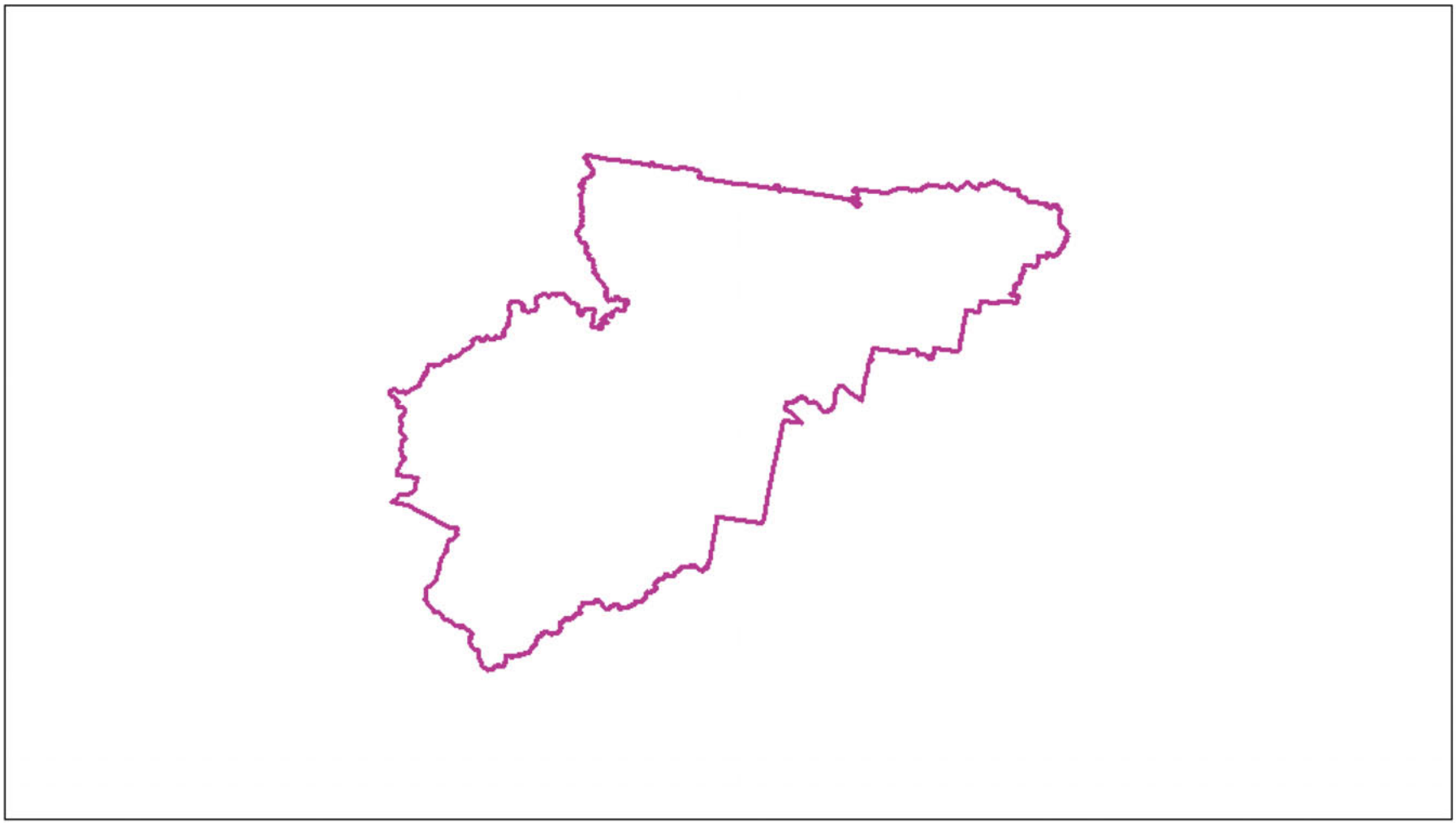
Common Name	Scientific Name	EPBC Status	Occurrence in Study Area
Box-Gum Woodland	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	CE	Present. 303 ha (grassland and woodland) mapped.
Weeping Myall Woodlands	Weeping Myall Woodlands	E	Not present. Unlikely to occur with current land practices.
Regent Honeyeater	*Anthochaera phrygia (syn. Xanthomyza phrygia)*	E, Mi	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.
Swift Parrot	*Lathamus discolor*	E, Ma	Recorded in the Study Area. Likely to occur occasionally and in very low numbers but unlikely to visit regularly every year.
Spotted-tail Quoll	*Dasyurus maculatus maculatus*	E	Not recorded. Potential to visit occasionally and in low numbers but unlikely to visit regularly every year.
Koala	*Phascolarctos cinereus*	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 to significant areas of habitat offsite.
Greater Long-eared Bat	*Nyctophilus corbeni* (syn. *N. timoriensis*)	V	Recorded in the Study Area. Suitable roosting and foraging habitat available.
Green and Golden Bell Frog	*Litoria aurea*	E	Not recorded. Unlikely to occur. Some suitable summer habitat is available along sections of Saddlers Creek; however there is no suitable

Table M.2 Summary of Likely Occurrence of Relevant MNES in Study Area

Common Name	Scientific Name	EPBC Status	Occurrence in Study Area
			winter shelter habitat.
Lobed Blue Grass	*Bothriochloa biloba*	V	Present. Most likely to occur in open woodland or diverse grassland areas.
Finger Panic Grass	*Digitaria porrecta*	E	Not recorded. Unlikely to occur. Not previously known from the Muswellbrook LGA.
Leek-orchid	*Prasophyllum* sp. Wybong (C. Phelps ORG 5269)	CE	Not recorded. Low potential to occur. Suitable habitat available but outside of the 7 known populations.
Illawarra Greenhood	*Pterostylis gibbosa*	E	Not recorded. Unlikely to occur. Not detected in flora surveys, and outside of known range in the Hunter.
Austral Toadflax	*Thesium australe*	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.

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


Atlas of NSW Wildlife Records
Figure M.3 MNES in Muswellbrook LGA (Relevant Fauna)
N
Data from the BioNet Atlas of NSW Wildlife website, which holds records from a number of custodians. Location accuracy varies. Maps from the website are interactive: map displays can be modified from the original extent and a maximum of 5 species can be selected to display. Map may contain errors and omissions. Neither the Office of Environment and Heritage nor any other data custodian will accept liability for any loss, damage, cost or expenses incurred as a result of the use of, or reliance upon, the information in the map. Map copyright the State of NSW through the Office of Environment and Heritage.
Your Selection: Public Report of all Valid Records of Threatened (listed on TSC Act 1995) or Commonwealth listed Animals in MUSWELLBROOK LGA recorded since 01 Jan 1980 until 19 Jun 2012 returned a total of 1,228 records of 48 species.
Report generated on 19/06/2012 3:20 PM
Legend
Green and Golden Bell Frog (Litoria aurea)
Regent Honeyeater (Anthochaera phrygia)
Spotted-tailed Quoll (Dasyurus maculatus)
Koala (Phascolarctos cinereus)
Greater Long-eared Bat (Nyctophilus timoriensis (South-eastern form))



Legend	Atlas of NSW Wildlife Records Figure M.4 MNES in Muswellbrook LGA (Relevant Flora)
Lobed Bluegrass (Bothriochloa biloba)	Data from the BioNet Atlas of NSW Wildlife website, which holds records from a number of custodians. Location accuracy varies. Maps from the website are interactive: map displays can be modified from the original extent and a maximum of 5 species can be selected to display. Map may contain errors and omissions. Neither the Office of Environment and Heritage nor any other data custodian will accept liability for any loss, damage, cost or expenses incurred as a result of the use of, or reliance upon, the information in the map. Map copyright the State of NSW through the Office of Environment and Heritage. Your Selection: Public Report of all Valid Records of Threatened (listed on TSC Act 1995) or Commonwealth listed Plants in MUSWELLBROOK LGA recorded since 01 Jan 1980 until 20 Jun 2012 returned a total of 369 records of 29 species. Report generated on 20/06/2012 9:26 AM

N

M.4 Impact Assessment

As described in **Chapter 5** and **Chapter 6**, the environment within the Study Area has been greatly modified from its original character by a long history of agriculture and is now dominated by extensive areas of native perennial grassland of various diversity and floristic composition. The landscape is generally fragmented and simplified, as is typical of much of the landscape in the Hunter Valley. Despite this, the Study Area features considerable areas of native forest and woodland that, although much altered from their original condition, still provide value for native species in the locality.

The key impact on MNES in the Study Area is likely to arise from direct removal of native vegetation and threatened species habitat. As discussed in **Section 7.1** of **Chapter 7**, the total areas of vegetation removal from the Study Area are estimated to be:

- 389 ha of forest, woodland and shrubland; and
- 1539 ha of grassland of varying diversity and condition.

The area of direct removal of native vegetation and habitat for MNES has been estimated and summarised in **Table M.3** below and is shown in **Figure 7.1** within **Chapter 7**. The predicted direct impact on Box-Gum Woodland is shown in **Figure M.5** below.

Table M.3 Direct Loss of Native Vegetation and Habitat for MNES in the Study Area

Common Name	Preferred Habitat	Used For	Present or Likely to be Present	Area of Direct Impact (ha)
Box-Gum Woodland	-	-	Y	181
Weeping Myall Woodland	-	-	N	0
Regent Honeyeater	F, W	Infrequent Foraging; low numbers	Y (low)	389
Swift Parrot	F, W	Infrequent Foraging; low numbers	Y (low)	389
Spotted-tailed Quoll	F, W	Foraging; low density	Y (low)	389
Koala	F, W	Foraging or movement	N	389
Greater Long-eared Bat	F, W	Foraging and roosting	Y	389
Green and Golden Bell Frog	Wetland	Foraging and breeding	N	0

Table M.3 Direct Loss of Native Vegetation and Habitat for MNES in the Study Area

Common Name	Preferred Habitat	Used For	Present or Likely to be Present	Area of Direct Impact (ha)
Lobed Blue-grass	F, W, G	-	Y	1928
Finger Panic Grass	F, W, G on basalt	-	N	0
Leek-orchid	F, W, G	-	Y (low)	1928
Illawarra Greenhood	F, W, G	-	N	0
Austral Toadflax	F, W, G	-	Y (low)	0

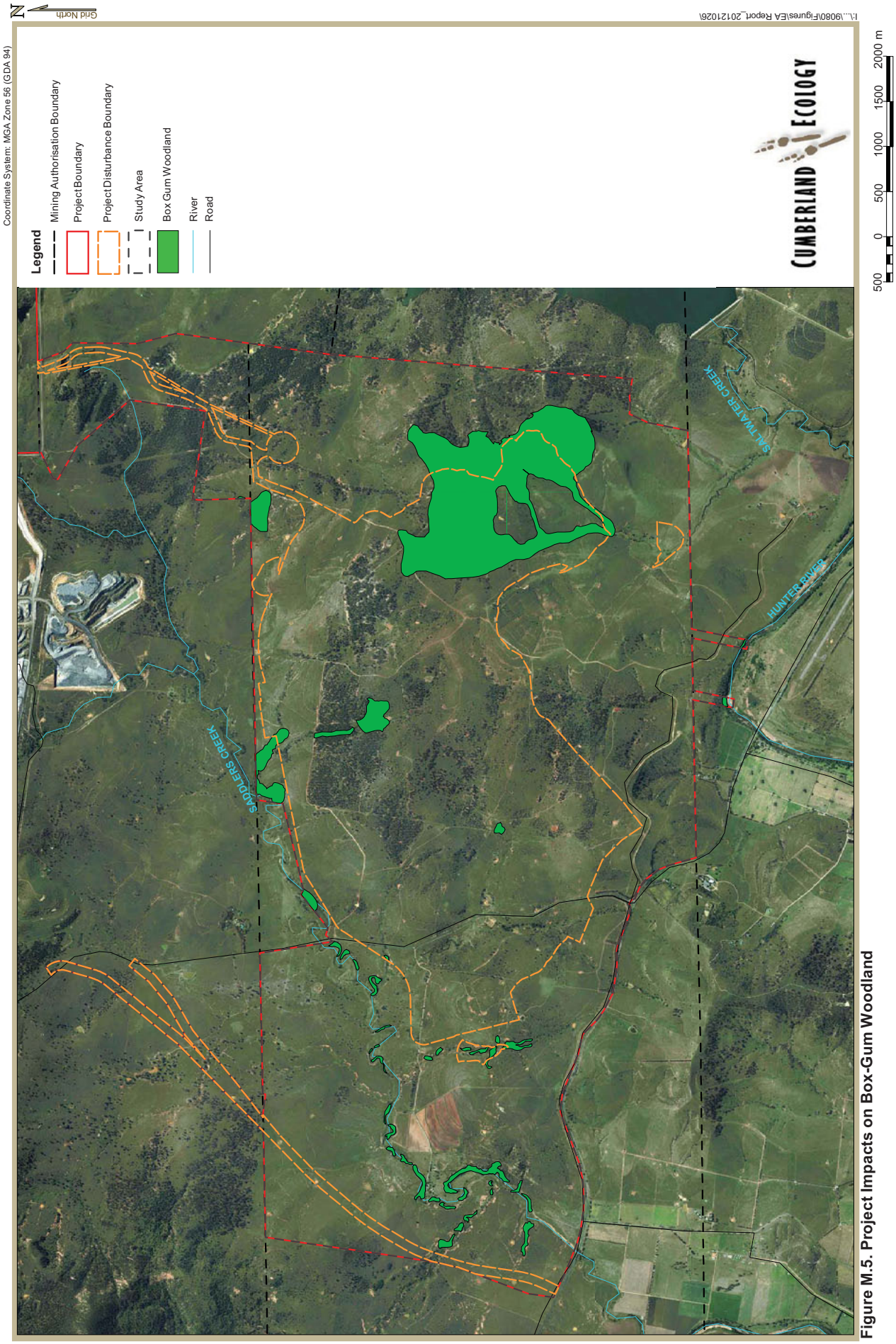


Figure M.5. Project Impacts on Box-Gum Woodland

The potential indirect and facilitative impacts of the Project on MNES that are known or likely to occur in the Study Area are described and discussed in detail in **Section 7.1** and **Section 7.3** of **Chapter 7**. It includes the following:

- Stress on residual vegetation from:
  - Increased fragmentation;
  - Increased isolation between patches;
  - Reduced patch sizes; and
  - Increased edge effects, including potential for facilitation of nutrient movement through remaining vegetation, transport of weed propagules via plant equipment, increased access for feral fauna and inclreased competition from overabundant native fauna;
- Increased light impacts;
- Increased noise impacts;
- Increased erosion, particular in proximity of the length Saddlers Creek;
- Increased dust levels; and
- Native fauna mortaility from vehicle strikes.

The following tables (**Table M.4** to **Table M.6**) assess the Project against EPBC significant impact criteria (Commonwealth of Australia 2009) and considers whether there is a real chance or possibility that the Project will result in the impacts listed in the tables. It shows that without implementing mitigation and offset measures, the potential impacts of the Project on MNES are likely to be significant for some species.

Table M.4 Significant Impact Criteria for Critically Endangered and Endangered Ecological Communities

Significant Impact Criteria	Box-Gum Woodland	Weeping Myall Woodland
Reduce the extent of an ecological community	Y	N
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	Y	N
Adversely affect habitat critical to the survival of an ecological community	N	N
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including	Y	N

Table M.4 Significant Impact Criteria for Critically Endangered and Endangered Ecological Communities

Significant Impact Criteria	Box-Gum Woodland	Weeping Myall Woodland
reduction of groundwater levels, or substantial alteration of surface water drainage patterns		
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	N	N
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: - assisting invasive species, that are harmful to the listed ecological community, to become established, or - causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or	Y	N
Interfere with the recovery of an ecological community	Y	N
Significant Impact? Y/N	**Y**	**N**

Table M.5 Significant Impact Criteria for Critically Endangered and Endangered Species

Significant Impact Criteria	Regent Honeyeater	Swift Parrot	Spotted-tail Quoll	Green and Golden Bell Frog	Finger Panic Grass	Leek-orchid	Illawarra Greenhood
Lead to a long-term decrease in the size of a population	N	N	N	N	N	N	N
Reduce the area of occupancy of the species	N	N	N	N	N	N	N
Fragment an existing population into two or more populations	N	N	N	N	N	N	N
Adversely affect habitat critical to the survival of a species	N	N	N	N	N	N	N
Disrupt the breeding cycle of a population	N	N	N	N	N	N	N
Modify, destroy, remove, isolate or	N	N	N	N	N	N	N

Table M.5 Significant Impact Criteria for Critically Endangered and Endangered Species

Significant Impact Criteria	Regent Honeyeater	Swift Parrot	Spotted-tail Quoll	Green and Golden Bell Frog	Finger Panic Grass	Leek-orchid	Illawarra Greenhood
decrease the availability or quality of habitat to the extent that the species is likely to decline							
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	N	N	N	N	N	N	N
Introduce disease that may cause the species to decline	Y	Y	N	N	N	N	N
Interfere with the recovery of the species	Y	Y	N	N	N	N	N
Significant Impact? Y/N	**Y**	**Y**	**N**	**N**	**N**	**N**	**N**

Table M.6 Significant Impact Criteria for Vulnerable Species

Significant Impact Criteria	Koala	Greater Long-eared Bat	Lobed Blue Grass	Austral Toadflax
Lead to a long-term decrease in the size of an important population of a species	N	N	N	N
Reduce the area of occupancy of an important population	N	N	N	N
Fragment an existing important population into two or more populations	N	N	N	N
Adversely affect habitat critical to the survival of a species	N	N	N	N
Disrupt the breeding cycle of an important population	N	N	N	N
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	N	N	N	N
Result in invasive species that are harmful to a vulnerable species becoming established in the	N	Y	Y	N

Table M.6 Significant Impact Criteria for Vulnerable Species

Significant Impact Criteria	Koala	Greater Long-eared Bat	Lobed Blue Grass	Austral Toadflax
vulnerable species' habitat				
Introduce disease that may cause the species to decline	N	N	N	N
Interfere substantially with the recovery of the species	N	N	N	N
Significant Impact? Y/N	**N**	**Y**	**Y**	**N**

M.5 Avoidance, Mitigation and Offset Measures

Avoidance and mitigation measures have been discussed in **Chapter 8**. Avoidance measures include design considerations where possible to minimise the Project Disturbance Footprint or to configure the Project Disturbance Footprint to avoid sensitive areas. However, due to the nature of the Project, it is not possible to completely avoid impacts on native vegetation and habitat for MNES.

Mitigation measures have been proposed that will include pre-clearance and clearance protocols to minimise vegetation loss and collateral damage to surrounding vegetation. It also includes rehabilitation and on site restoration measures to address some of the impacts and to minimise impacts by retaining and salvaging habitat features on site. Management of biodiversity over the life of the Project will be coordinated via the implementation of a Biodiversity Action Plan (see **Section 8.4**) which will guide all facets of biodiversity management and mitigation for the Project.

Residual impacts that cannot be avoided or mitigated are proposed to be addressed through onsite and offsite offsetting that will include: permanent protection and management of residual remnant vegetation on site; restoration and permanent protection of the length of Saddlers Creek within the Study Area; rehabilitation of the Project Disturbance Footprint; and purchase of an offsite offset property for permanent conservation and management. The management of the onsite offsets will be intergrated with the management of other areas of the Study Area through implementation of the BAP. The offsite offset property iwll be managed via a site-specific biodiversity management plan to ensure that conservation objectives are met. The rationale and merits of this Biodiversity Offset Package (BOP) is discussed in detail in **Chapter 9** and is illustrated in **Figure 9.2**. Detailed information on the offsite offset property is provided in **Chapter 10** and **Appendix L**.

A summary of the habitat areas that will be made available through the conservation and management of the BOP is provided in **Table M.7** overpage. It demonstrates that the offsets can provide habitat for all the MNES known or likely to occur in the Study Area, as well as

some MNES that are unlikely to occur in the Study Area but may be present in the locality. It also demonstrates that there will be a net gain in habitat for MNES in the long term.

M.6 Conclusion

The Project is likely to have a significant impact on the following MNES if mitigation and offsetting measures are not implemented:

- Box-Gum Woodland;
- Regent Honeyeater;
- Swift Parrot;
- Greater Long-eared Bat; and
- Lobed Blue Grass.

However, the impact mitigation and compensation measures to be implemented over the life of the Project are likely to sufficiently ameliorate the potential impacts to the above MNES. Moreover, they are expected to deliver a net benefit to flora and fauna within the locality by substantially increasing the proportion of native forest and woodland in conservation tenure. When the mitigation and compensation measures are considered, the Project will have a major ecological benefit in the medium to long term.

Table M.7 Habitat Provided by the Biodiversity Offset Package for MNES

Common Name	Preferred Habitat	Used For	Study Area		Offsite Offset Property		Onsite Offset Areas	
			Present or Likely to be Present	Area of Direct Impact (ha)	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)
Box-Gum Woodland	-	-	Y	181	774	1672	20	82
Weeping Myall Woodland	-	-	N	0	-	-	-	-
Regent Honeyeater	F, W	Infrequent Foraging; low numbers	Y (low)	389	1181	2079	109	1574
Swift Parrot	F, W	Infrequent Foraging; low numbers	Y (low)	389	1181	2079	109	1574
Spotted-tailed Quoll	F, W	Foraging; low density	Y (low)	389	1181	2079	109	1574
Koala	F, W	Foraging or movement	N	389	1181	2079	109	1574
Greater Long-eared Bat	F, W	Foraging and roosting	Y	389	1181	2079	109	1574
Green and Golden Bell Frog	Wetland	Foraging and breeding	N	0	-	-	24	86

Table M.7 Habitat Provided by the Biodiversity Offset Package for MNES

Common Name	Preferred Habitat	Used For	Study Area		Offsite Offset Property		Onsite Offset Areas	
			Present or Likely to be Present	Area of Direct Impact (ha)	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)	Available Habitat (without restoration of grassland areas)	Available Habitat (with restoration of grassland areas)
Lobed Blue-grass	F, W, G	-	Y	1928	2079	2079	171	1574
Finger Panic Grass	F, W, G on basalt	-	N	0	1181	2079	-	-
Leek-orchid	F, W, G	-	Y (low)	1928	2079	2079	171	1574
Illawarra Greenhood	F, W, G	-	N	0	2079	2079	171	1574
Austral Toadflax	F, W, G	-	Y (low)	0	2079	2079	171	1574