BULLI SEAM OPERATIONS

APPENDIX F
TERRESTRIAL FAUNA ASSESSMENT

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BULLI SEAM OPERATIONS

TERRESTRIAL FAUNA ASSESSMENT

PREPARED BY

BIOSPHERE ENVIRONMENTAL CONSULTANTS PTY LTD

JULY 2009
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1 INTRODUCTION

Illawarra Coal Holdings Pty Ltd (ICHPL) owns and operates the Bulli Seam longwall mining operations at the Appin Mine and West Cliff Colliery approximately 25 kilometres (km) north-west of Wollongong in New South Wales (NSW) (Figure 1). ICHPL is a wholly owned subsidiary of BHP Billiton Pty Limited.

Fauna surveys were conducted by Biosphere Environmental Consultants for the Bulli Seam Operations (the Project) from March/April/May 2008 (autumn), September/October 2008 (spring) and March/April/May 2009 (autumn). Fauna surveys involved a variety of sampling techniques, including systematic and targeted sampling.

The Project would involve the continuation and expansion of underground mining operations at the Appin Mine and West Cliff Colliery and would extend the current mine life by approximately 30 years.

The main activities associated with the development of the Project would include:

- continued development of underground mining operations within existing coal leases and new mining leases to facilitate a total run-of-mine (ROM) coal production rate of up to 10.5 million tonnes per annum (Mtpa);
- ongoing exploration activities within existing exploration tenements;
- upgrade of the existing West Cliff Washery to support the increased ROM coal production;
- continued mine gas drainage and capture for beneficial utilisation at the West Cliff Ventilation Air Methane Project (WestVAMP) and Appin-Tower Power Project;
- continued use of electricity generated by the existing Appin-Tower Power Project (owned and operated by Energy Developments Limited power stations) utilising coal bed methane drained from the Bulli Seam;
- upgrade of existing surface facilities and supporting infrastructure (e.g. service boreholes, gas drainage equipment, waste water treatment and waste water disposal);
- continued and expanded placement of coal wash at the West Cliff Coal Wash Emplacement;
- continued road transport of ROM coal from the Appin East pit top to the West Cliff Wasshery.
- continued road transport of ROM coal from Appin East pit top and West Cliff poit top via the public road network to the Dendrobium Washery at Port Kembla;
- continued road transport of product coal from the West Cliff Washery via the public road network to BlueScope Steelworks, Port Kembla Coal Terminal, Corrimal and Coalcliff Coke Works and other customers;
- ongoing surface monitoring and rehabilitation (including rehabilitation of mine related infrastructure areas that are no longer required) and remediation of subsidence effects; and
- other associated minor infrastructure, plant, equipment and activities.

The main activities associated with the development of the Project are described in detail in Sections 1 and 2 in the Main Report of the Project Environmental Assessment (EA).

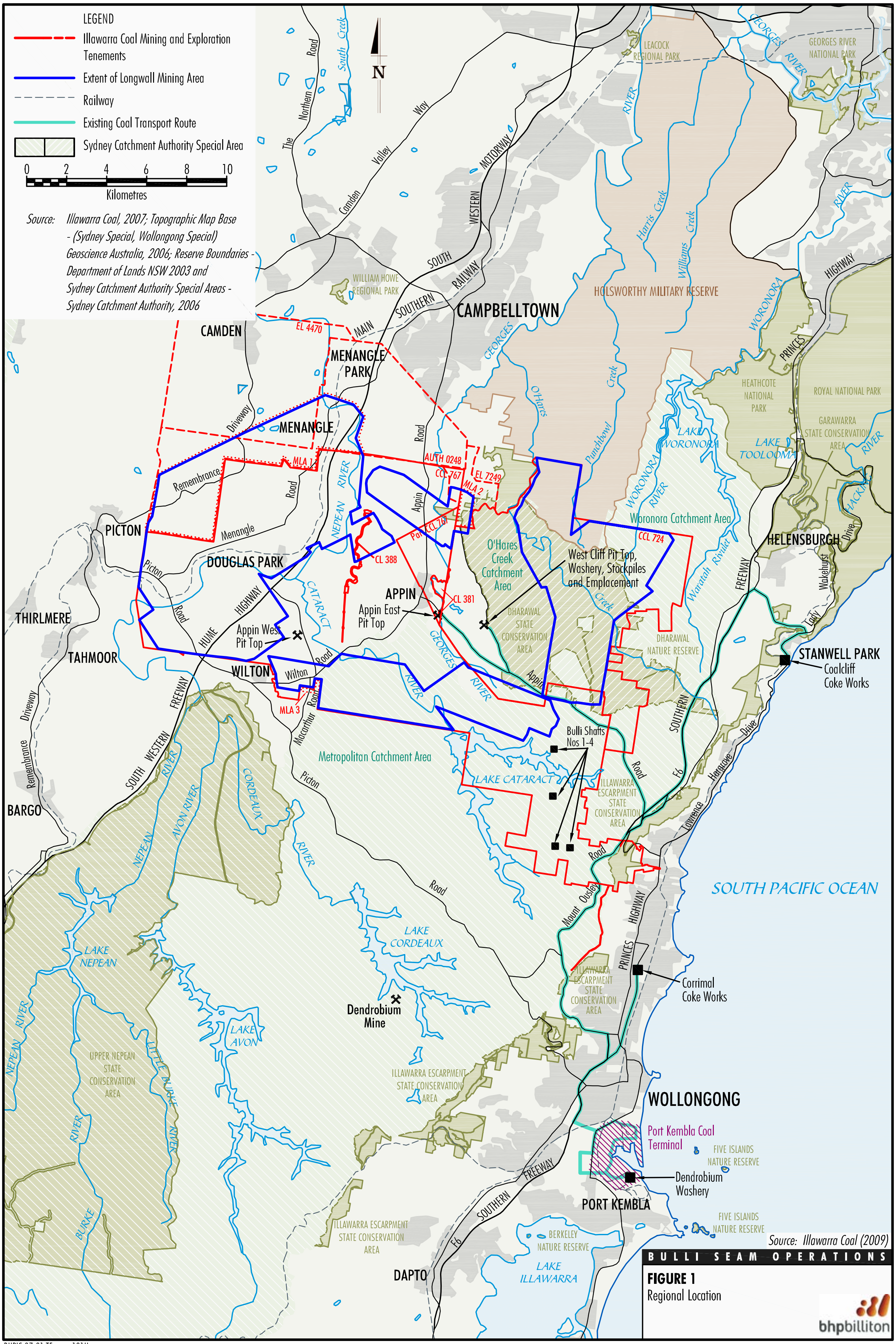

FIGURE 1
Regional Location

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1.1 SURVEY OBJECTIVES

The objectives of the fauna surveys were to:

- Conduct fauna surveys in the study area utilising recognised fauna survey techniques.
- Assess fauna species diversity (native and introduced) and their relative abundance.
- Identify and describe the range of habitats utilised by fauna.
- Conduct targeted surveys for threatened fauna species considered possible occurrences within the study area or surrounds (including those listed in the Schedules of the NSW *Threatened Species Conservation Act, 1995* [TSC Act] and the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* [EPBC Act]) and map the location of any threatened species identified.
- Report on the findings of the fauna surveys.

This Fauna Survey and Assessment has been prepared for the EA in accordance with Part 3A of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act), Director-General's Environmental Assessment Requirements (EARs), *Threatened Species Survey and Assessment: Guidelines for Developments and Activities* (NSW Department of Environment and Conservation [DEC], 2004a) and *State Environmental Planning Policy No. 44 – Koala Habitat Protection* (SEPP 44).

1.2 BIOGEOGRAPHIC AND ZOOGEOGRAPHIC REGIONAL SETTING

1.2.1 Sydney Basin Bioregion

Thackway and Cresswell (1995) describe a bioregion as a "*complex land area composed of a cluster of interacting ecosystems that are repeated in similar form throughout*." Bioregional descriptions seek to describe the dominant landscape scale attributes of climate, lithology, geology, landform and vegetation.

Bioregions provide a way of viewing landscape and biotic patterns in ecological terms, since they represent major structural geologies and climatic differences, particularly where geomorphology is the major driver of soil and vegetation (Morgan, 2001; Smart, 2002). Thackway and Cresswell (1995) argued that bioregions provide a relatively homogenous landscape with their associated biota, as well as linking ecosystems with relatively strong linkages compared with those found between bioregions.

As such, the boundaries of bioregions and sub-regions (where rainfall may over-ride geomorphology to some extent) (Smart, 2002):

- *Provide a fundamental framework within which finer scale assessments of biodiversity distribution, condition, priorities and monitoring should take place.*
- *Provide a basis for communicating this information and these finer priorities at a State, national and international level in a standard format.*

The study area and surrounds lie wholly within the Sydney Basin Interim Biogeographic Regionalisation for Australia (IBRA) bioregion on the NSW central coast. The Sydney Basin bioregion covers an area of approximately 3,632,890 hectares (ha) and extends from just north of Batemans Bay to Nelson Bay on the central coast, and almost as far west as Mudgee (Commonwealth Department of the Environment, Water, Heritage and the Arts [DEWHA], 2007).

As in most parts of the Great Dividing Range, the coastal side of the divide along the Great Escarpment features deep gorges eroded by streams and cliff faces back into the uplifted block (DEWHA, 2007). The frontal slope of the Blue Mountains is formed along the Lapstone monocline. A secondary flexure and similar escarpments occur at the coast forming the Hornsby Plateau and the Illawarra escarpment. These structural features combine with different rock types and strong trends in joint patterns to control drainage patterns and the distribution of gorges and swamps (DEWHA, 2007). Much of the Basin landscape is elevated sandstone plateau with the exceptions being the Hunter Valley and the low-lying Cumberland Plain. In the south and west the Basin ends in cliff lines formed on sandstones and conglomerates of the basal Permian sediments (DEWHA, 2007).

The Sydney Basin bioregion is characterised by Mesozoic sandstones and shales; dissected plateaus; forests, woodlands and heaths; skeletal soils, sands and podzolics (Environment Australia, 2000).

1.2.2 Zoogeographic Region

The study area and surrounds are also located within the Bassian zoogeographic region proposed by Spencer (1896) (and modified by Schodde [1994]) (cited in Date *et al.* [2000]). The Bassian zoogeographic region (coastal zone) is a coarse but more useful predictor of faunal assemblages than the Sydney Basin IBRA bioregion. While IBRA bioregions have helped to rationalise our understanding of landscape patterns, fauna species tend to respond more to vegetation structure (i.e. grassland, woodland and forest) rather than to particular vegetation communities *per se.*

1.3 PREVIOUS FAUNA SURVEYS

A number of fauna surveys have been carried out in recent years in the wider region and general locality of the Project and were reviewed as part of this survey and assessment.

Numerous fauna surveys have been undertaken on behalf of ICHPL to identify fauna species present within previous and current underground mining areas. These surveys have been undertaken between 2000 and 2008 with the results detailed in the following reports:

- Biosis Research (2001a) *Dendrobium Coal Project Species Impact Statement*.
- Biosis Research (2001b) *Dendrobium Coal Project: Terrestrial and Aquatic Habitat Assessment.*
- Biosis Research (2002) *Terrestrial Flora and Fauna Habitat Assessment West Cliff Colliery LW 5A5-5A8.*
- Biosis Research (2005a) *Appin Area 3 Longwalls 301A, 301 and 302 Impacts of Subsidence on Terrestrial Flora and Fauna.*
- Biosis Research (2005b) *Dendrobium Coal Mine Flora and Fauna Environmental Management Program (Subsidence): Base Line Monitoring Summary Report Area 1 – Longwalls 1 and 2.*
- Biosis Research (2005c) *West Cliff Colliery Area 5 – Longwalls 31-33 Impacts of Subsidence on Terrestrial Flora and Fauna.*
- Biosis Research (2006a) *Douglas Area 7 Impacts of Subsidence on Terrestrial Flora and Fauna*.
- Biosis Research (2006b) *Flora and Fauna Assessment of Longwall 409, Appin Colliery, NSW.*
- Biosis Research (2006c) *Flora and Fauna Assessment: East Appin 66kV Switching Station.*
- Biosis Research (2006d) *Flora and Fauna Assessment of Appin Colliery Longwall 219.*

- Biosis Research (2007a) *West Cliff Colliery Area 5 – Longwalls 34-36 Impacts of Subsidence on Terrestrial Flora and Fauna.*
- Biosis Research (2007b) *West Cliff Colliery Stage 3 Coal Wash Emplacement Application - Volume 3 Species Impact Statement.*
- Biosis Research (2008) *Appin Colliery Area 7 – Longwalls 705-710 Impacts of Subsidence on Terrestrial Flora and Fauna.*
- In addition to the above, numerous other fauna reports have been prepared for ICHPL and these are cited within this report where relevant.

In addition, several regional fauna surveys have been undertaken by the NSW Department of Environment and Climate Change (DECC) and NSW National Parks and Wildlife Service (NPWS) between 1997 and 2004 including the following:

- DECC (2007a) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region: Volume 1 - Background Report; Volume 2 - Fauna of Conservation Concern including Priority Pest Species; Volume 4 – The Fauna of the Metropolitan, O'Hares Creek and Woronora Special Areas - Summary of Findings and Recommendations.* A joint project between the Sydney Catchment Authority (SCA) and the DECC.
- NPWS (2002a) *Fauna of the Illawarra Escarpment, Coastal Plain and Plateau*, *Wollongong Local Government Area Bioregional Assessment Part II*.
- NPWS (2004) *Post-fire Study of the Fauna of the Woronora Plateau.*

Fauna studies undertaken for the Metropolitan Coal Project, which adjoins the eastern boundary of the Project, are described in the following documents:

- Western Research Institute and Biosphere Environmental Consultants Pty Ltd (2008) *Metropolitan Coal Project Terrestrial Vertebrate Fauna Survey.*
- FloraSearch and Western Research Institute (2008) *Metropolitan Coal Project Terrestrial Flora and Fauna Impact Assessment*.

1.4 DESCRIPTION OF THE STUDY AREA

1.4.1 General

The Project is located within the Campbelltown, Wollondilly and Wollongong local government areas (LGAs). The eastern and southern portions of the Project lie partially within the O'Hares Creek, Metropolitan and Woronora Special Areas and the Dharawal State Conservation Area. The Project encompasses the extent of longwall mining area (Figure 1), the current and previous mine development areas, the proposed Stage 4 Coal Wash Emplacement and surrounds and other Project related activities outlined in Section 1.

1.4.2 Climate

The study area experiences a wet temperate climate. Based on nearby Bureau of Meteorology (BoM) rainfall gauges with reliable long-term records, rainfall has averaged (across the study area) between 758 millimetres (mm) and 1,419 mm per year with potential (pan) evaporation some 1,283 mm per year (Heritage Computing, 2009).

1.4.3 Fire History

Wildfire is a common source of spatial and temporal disturbance to plant communities in south-eastern Australia (Gill, 1975; Whelan, 1995; in Chafer *et al.*, 2004) and extensive wildfires have occurred in the region over the last 35 years together with targeted fuel reduction burns (NPWS, 1998; Tozer *et al.,* 2006). Map 5 in SCA and NPWS (2003) *The Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments* presents information on the frequency of fire in the Woronora, O'Hares and Metropolitan catchments since 1970. The mapping indicates that the O'Hares, western Cordeaux, and southern Nepean catchments have been most frequently burnt (SCA and NPWS, 2003).

Extensive wildfires occurred in the Sydney Basin from 3 December 2001 to 14 January 2002 (Chafer *et al.*, 2004). The catchments of Woronora, O'Hares, Nepean and Avon were all extensively burnt during this period (SCA and NPWS, 2003). Fire severity in the majority of the Woronora and Dharawal catchments was assessed as being moderate, high, very high or extreme (Chafer *et al.*, 2004). Hence much of the vegetation in this area is early successional post-fire vegetation (approximately seven to eight years). The western portion of the study area is more extensively cleared and managed and observations indicate that it was less impacted by recent bushfires.

1.4.4 Hydrology and Topography

As described in Heritage Computing (2009), there is significant topographic relief across the study area, and a relatively high stream density. Surface elevations vary from approximately 100 metres (m) to 450 m Australian Height Datum (AHD) with ridgelines typically rising between 50 and 150 m above the stream floor (*ibid*).

The study area extends from the Woronora Plateau in the east to the Cumberland Plain in the west. The topography of the eastern part of the study area (i.e. on the Woronora Plateau) falls from elevations of up to 450 m AHD near Cataract Reservoir to elevations of 200 m AHD near the Woronora River in the north and 250 m AHD near Appin and Wilton in the north-west (*ibid*). Hydrology in this area is characterised by deeply incised valleys cut into the Hawkesbury Sandstone. Figures 2-8 to 2-11 in Section 2 of the Main Report of the EA provide further detail on the streams within the study area. Major streams include the Cataract River, Georges River, Lizard Creek, O'Hares Creek, Stokes Creek, Wallandoola Creek, Woronora River and associated tributaries. A detailed description of all streams within the study area is provided in the Surface Water Assessment (Appendix C of the EA).

The topography of the western part of the study area (i.e. the Cumberland Plain) slopes gently from approximately 250 m AHD in the Appin – Wilton area in the south along the Nepean Valley to 60 m AHD near Menangle Park to the north. Higher relief within the Cumberland Plain is found in the north-west of the study area nearby to the Razorback Range, which reaches an elevation of 348 m AHD at Evelyn's Ridge. Hydrology in this area is characterised by predominantly less incised streams that flow across the Cumberland Plain toward the Nepean River. Drainage lines in this area include the Nepean River, Allens Creek, Carriage Creek, Racecourse Creek, Navigation Creek, Foot Onslow Creek, Mallaty Creek and associated tributaries (Figures 2-8 to 2-11 in Section 2 of the Main Report of the EA).

1.4.5 Geology and Soils

The geological and subsequent soil characteristics of an area play a major role in determining the types of vegetation present and therefore the types of habitat available to fauna species. Three major topographic and geological units have been identified within the study area (i.e. Dissected Hawkesbury Sandstone Plateau, Shale-dominated Areas and the Razorback Range area).

The Dissected Hawkesbury Sandstone Plateau comprises a large portion of the eastern and southern parts of the study area associated with the Woronora Plateau, much of which is reserved as Sydney Water catchment areas and the Dharawal State Conservation Area.

The central portion of the study area is a Shale-dominated Area associated with the Nepean and lower Georges River valleys. The majority of this land is privately owned and has been cleared for agriculture or urban development. Unlike the sandstone areas, the topography of the Shale-dominated Area is not dominated by deep gullies and stark rock exposures; this landscape generally comprises lower, rounder hills and broader, flatter valleys.

The Razorback Range rises in the western portion of the study area. The flanks of the range have been deeply eroded to create narrow, sheltered gullies. Large parts of the range have been cleared for agriculture or semi-rural residential dwellings and weed species are prevalent (FloraSearch, 2009).

1.4.6 Vegetation and Habitat Types

Vegetation communities in the study area and surrounds have been mapped by SCA and NPWS (2003) and Tozer *et al.* (2006) and more recently to a greater level of detail (in some areas) as part of the baseline flora survey by FloraSearch (2009).

Vegetation units cannot necessarily be equated with vertebrate fauna habitats since vertebrate species respond primarily to a complex of factors including local climate, vegetation species, structure, vegetation formation and density, flowering timing and frequency, fire history, specialised habitats including swamps and waterways, and topographic and geological variability.

1.4.7 Possible Occurrences of Threatened Species

A number of database sources were used to identify threatened species which may occur in the study area, including:

- the DECC Atlas of NSW Wildlife for the search area covering the Wollongong 1:100,000 map sheet (DECC, 2009a);
- DECC's list of threatened species found within the Sydney Cataract and Cumberland Catchment Management Authority (CMA) subregions (DECC, 2009b; 2009c);
- an EPBC Act Protected Matters Search using a search area of approximately 40 km x 50 km covering the study area (DEWHA, 2009a);
- Birds Australia (2008) database records using a search area of approximately 40 km x 50 km covering the study area;
- Australian Museum (2009) database records using a search area of approximately 40 km x 50 km covering the study area;
- Bionet database (2009); and
- previous fauna surveys as described in Section 1.3.

Attachment A contains the results of the database searches. The list of threatened fauna species in Attachment A was refined to a list of those species considered to possibly occur within the study area or immediate surrounds (Table 1) considering the known distribution of the species and the potential habitats available within the study area.

Table 1
Threatened Fauna Species Considered Possible Occurrences within the Study Area or Immediate Surrounds

Scientific Name	Common Name	Conservation Status	
		TSC Act[1]	EPBC Act[2]
Invertebrates			
Camaenidae			
Meridolum corneovirens	Cumberland Plain Land Snail	E	-
Amphibians			
Myobatrachidae			
Heleioporus australiacus	Giant Burrowing Frog	V	V
Pseudophryne australis	Red-crowned Toadlet	V	-
Hylidae			
Litoria aurea	Green and Golden Bell Frog	E	V
Litoria littlejohni	Littlejohn's Tree Frog	V	V
Reptiles			
Varanidae			
Varanus rosenbergi	Heath Monitor	V	-
Elapidae			
Hoplocephalus bungaroides	Broad-headed Snake	E	V
Birds			
Anatidae			
Stictonetta naevosa	Freckled Duck	V	-
Oxyura australis	Blue-billed Duck	V	-
Ciconiidae			
Ephippiorhynchus asiaticus[3]	Black-necked Stork	E	-
Ardeidae			
Botaurus poiciloptilus	Australasian Bittern	V	-
Lxobrychus flavicollis	Black Bittern	V	-
Accipitridae			
Lophoictinia isura	Square-tailed Kite	V	-
Burhinidae			
Burhinus grallarius	Bush Stone-curlew	E	-
Psittacidae			
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-
Neophema pulchella	Turquoise Parrot	V	-
Lathamus discolor	Swift Parrot	E	E
Pezoporus wallicus wallicus	Eastern Ground Parrot	V	-
Tytonidae			
Tyto tenebricosa	Sooty Owl	V	-
Tyto novaehollandiae	Masked Owl	V	-

Table 1 (Continued)
Threatened Fauna Species Considered Possible Occurrences within the Study Area or Immediate Surrounds

Scientific Name	Common Name	Conservation Status	
		TSC Act[1]	EPBC Act[2]
Birds (Continued)			
Strigidae			
Ninox strenua	Powerful Owl	V	-
Ninox connivens	Barking Owl	V	-
Climacteridae			
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	-
Acanthizidae			
Dasyornis brachypterus	Eastern Bristlebird	E	E
Pyrrholaemus saggitatus	Speckled Warbler	V	-
Meliphagidae			
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	-
Anthochaera phrygia	Regent Honeyeater	E	E
Petroicidae			
Melanodryas cucullata	Hooded Robin	V	-
Petroica rodinogaster	Pink Robin	V	-
Pachycephalidae			
Pachycephala olivacea	Olive Whistler	V	-
Estrildidae			
Stagonopleura guttata	Diamond Firetail	V	-
Mammals			
Dasyuridae			
Dasyurus maculatus	Spotted-tailed Quoll	V	E
Peramelidae			
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E	E
Phascolarctidae			
Phascolarctos cinereus	Koala	V	-
Burramyidae			
Cercartetus nanus	Eastern Pygmy-possum	V	-
Petauridae			
Petaurus australis	Yellow-bellied Glider	V	-
Petaurus norfolcensis	Squirrel Glider	V	-
Potoroidae			
Potorous tridactylus	Long-nosed Potaroo	V	V
Pteropodidae			
Pteropus poliocephalus	Grey-headed Flying-fox	V	V
Emballonuridae			
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	-

Table 1 (Continued)
Threatened Fauna Species Considered Possible Occurrences within the Study Area or Immediate Surrounds

Scientific Name	Common Name	Conservation Status	
		TSC Act[1]	EPBC Act[2]
Mammals (Continued)			
Molossidae			
Mormopterus norfolkensis	Eastern Freetail-bat	V	-
Vespertilionidae			
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	-
Chalinolobus dwyeri	Large-eared Pied Bat	V	V
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	-
Myotis macropus	Large-footed Myotis	V	-
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-

Nomenclature for Family, Genus, Species and Common Names in accordance with Commonwealth Scientific and Industrial Research Organisation (CSIRO) (2006).

1 Threatened species status under the TSC Act (current as at 11 May 2009).

2 Threatened species status under the EPBC Act (current as at 11 May 2009).

E - Endangered V – Vulnerable

3 The Black-necked Stork is known only as a vagrant and considered to be a very rare visitor in the area (DECC, 2007a). This species is therefore not assessed any further in this report.

2 SURVEY METHODS

This section describes the methodology used during the fauna surveys including the survey timing and conditions (Section 2.1), selection of fauna survey sites (Section 2.2), fauna survey techniques (Section 2.3), habitat assessment methodology (Section 2.4) and criteria used for determining species relative abundance (Section 2.5). The methodology was designed cognisant of the previous fauna surveys carried out in the wider region and general locality of the Project described in Section 1.3.

2.1 SURVEY TIMING AND CONDITIONS

Fauna surveys were conducted in the study area in March/April/May 2008 (autumn), September/October 2008 (spring) and March/April/May 2009 (autumn) by Biosphere Environmental Consultants Pty Ltd.

Moon phase, temperature and rainfall records during the survey period are provided in Table 2. Maximum temperatures ranged from 13.9 to 35.7 degrees Celsius (^{o}C) and minimum temperatures from 0.7 to 17.2^{o}C during the spring survey period (Table 2). For the autumn 2008 survey period, maximum temperatures ranged from 17.2 to 31.9^{o}C and minimum temperatures from 2.2 to 17.4^{o}C (Table 2). Maximum temperatures ranged from 17.9 to 29.4^{o}C and minimum temperatures from 3.9 to 17.6 ^{o}C during the autumn 2009 survey period (Table 2).

Table 2
Temperatures, Total Rainfall and Moon Information for the Survey Period

Date	Temperature (^{o}C) Campbelltown (Mount Annan) (Station No. 68257)[1]		Rainfall (mm) Darkes Forest (Station No. 68024)[2]	Rainfall (mm) Douglas Park (Station No. 68200)[2]	Moon Phase
	Maximum	Minimum			
1/03/08	22.7	7.8	0	0	-
2/03/08	23.7	9.4	0	0	-
3/03/08	26.2	10.9	0	0	-
4/03/08	30.8	10.3	0	0	-
5/03/08	26.1	15.9	0	0	-
6/03/08	31.2	17.3	0	0	-
7/03/08	26.1	14.4	0.4	0	New Moon
8/03/08	26.0	14.2	18.2	6.2	-
9/03/08	26.8	11.9	0	0	-
10/03/08	28.6	14.5	0	0	-
11/03/08	-	14.2	0	0	-
12/03/08	29.8	-	0	0	-
13/03/08	28.8	17.3	0	0	-
14/03/08	29.6	14.0	0	0	First Quarter
15/03/08	31.4	14.6	0	0	-
16/03/08	28.4	15.3	0	0	-
17/03/08	28.4	15.4	0	0	-
18/03/08	29.8	13.1	0	0	-
19/03/08	27.2	15.7	0	0	-
20/03/08	31.9	16.3	0	0	-
21/03/08	18.1	16.1	9.8	3.8	Full Moon
22/03/08	21.4	15.2	7.6	3.0	-
23/03/08	26.0	13.4	3	0	-
24/03/08	28.8	17.4	1.4	0	-

Table 2 (Continued)
Temperatures, Total Rainfall and Moon Information for the Survey Period

Date	Temperature (°C)		Rainfall (mm)		Moon Phase
	Campbelltown (Mount Annan) (Station No. 68257)[1]		Darkes Forest (Station No. 68024)[2]	Douglas Park (Station No. 68200)[2]	
	Maximum	Minimum			
25/03/08	23.8	16.1	0	4.8	-
26/03/08	26.9	12.5	13.8	10	-
27/03/08	23.6	9.2	0	0	-
28/03/08	21.1	12.3	1.6	3.6	-
29/03/08	24.6	11.2	3.2	14.4	Last Quarter
30/03/08	26.3	6.0	2.6	6.4	-
31/03/08	24.6	8.6	0	0	-
1/04/08	25.0	5.7	0	0	-
2/04/08	28.8	8.7	0	0	-
3/04/08	20.4	13.5	0	0	-
4/04/08	22.1	5.6	0	0	-
5/04/08	23.7	6.3	0	0	-
6/04/08	23.5	9.5	0	0	New Moon
7/04/08	23.0	12.7	8	0	-
8/04/08	22.2	12.5	19.2	1.0	-
9/04/08	22.6	13.6	3.6	2.6	-
10/04/08	24.5	10.6	0	0	-
11/04/08	24.5	9.4	0	0	-
12/04/08	24.1	8.8	0	0	First Quarter
13/04/08	23.4	10.3	0	0	-
14/04/08	20.0	8.8	16.8	5.0	-
15/04/08	20.2	8.8	3.6	0	-
16/04/08	20.8	12.5	3.2	0	-
17/04/08	18.2	13.0	14.8	1.0	-
18/04/08	-	13.1	4.0	2.4	-
19/04/08	-	-	4.4	2.0	-
20/04/08	17.4	-	8.4	2.6	Full Moon
21/04/08	19.8	12.5	11.6	3.4	-
22/04/08	20.5	10.9	11.2	3.0	-
23/04/08	19.2	12.4	7	1.4	-
24/04/08	21.6	13.1	15.8	0	-
25/04/08	22.4	14.6	29.2	1.4	-
26/04/08	23.8	8.3	1.2	0	-
27/04/08	25.2	8.3	0	0	-
28/04/08	-	5.6	2.4	0	Last Quarter
29/04/08	18.7	-	0.6	0	-
30/04/08	20.1	2.2	0	0	-
1/05/08	18.4	6.4	0	0	-
2/05/08	22.1	5.8	0	0	-
3/05/08	20.9	4.2	0	0	-
4/05/08	20.3	5.9	0	0	-
5/05/08	-	2.9	0	0	New Moon
6/05/08	22.1	-	0	0	-
7/05/08	-	6.8	0	0	-

Table 2 (Continued)
Temperatures, Total Rainfall and Moon Information for the Survey Period

Date	Temperature (°C)		Rainfall (mm)		Moon Phase
	Campbelltown (Mount Annan) (Station No. 68257)[1]		Darkes Forest (Station No. 68024)[2]	Douglas Park (Station No. 68200)[2]	
	Maximum	Minimum			
8/05/08	-	-	0	0	-
9/05/08	22.5	-	0	0	-
10/05/08	20.9	9.2	0	0	-
11/05/08	20.1	10.3	0	0	-
12/05/08	21.3	9.6	0	0	First Quarter
13/05/08	21.6	10.2	0	0	-
14/05/08	21.4	7.4	0	0	-
15/05/08	23.5	8.1	0	0	-
16/05/08	22.9	10.6	1.4	1.4	-
17/05/08	20.7	7.2	0	0	-
18/05/08	17.2	3.5	2.2	1.2	-
19/05/08	21.0	4.6	0	0	-
20/05/08	21.5	5.1	0	0	Full Moon
21/05/08	20.2	4.1	0	0	-
22/05/08	17.7	6.7	0.6	0	-
23/05/08	18.5	5.8	0	0	-
24/05/08	18.7	6.7	0	0	-
25/05/08	18.7	3.6	0	0	-
26/05/08	21.3	5.8	0	0	-
27/05/08	22.1	6.3	0	0	-
28/05/08	21.3	7.4	0	0	Last Quarter
29/05/08	20.0	6.1	1.4	19.0	-
30/05/08	21.0	7.5	0	0	-
31/05/08	21.5	4.7	0	0	-
1/09/08	21.0	5.6	0	1.8	-
2/09/08	21.7	2.6	0	0	-
3/09/08	16.6	5.9	9.8	0	-
4/09/08	16.6	8.0	22.0	12.4	-
5/09/08	14.0	8.8	0	0	-
6/09/08	13.9	10.4	45.2	12.0	-
7/09/08	20.2	7.9	14.4	3.8	First Quarter
8/09/08	18.1	4.9	0	0	-
9/09/08	17.9	3.7	0	0	-
10/09/08	17.9	1.7	0	0	-
11/09/08	20.3	0.7	0	0	-
12/09/08	25.1	2.0	0	0	-
13/09/08	31.9	7.0	0	0	-
14/09/08	21.2	15.4	4.8	0	-
15/09/08	27.0	10.4	14.8	6.2	Full Moon
16/09/08	17.7	10.0	0	0	-
17/09/08	15.8	5.9	0	0	-
18/09/08	21.4	3.8	0	0	-
19/09/08	28.0	10.9	0	0	-
20/09/08	32.3	9.5	0	0	-
21/09/08	25.6	8.0	0	0	-
22/09/08	30.7	6.9	0	0	Last Quarter
23/09/08	18.2	14.1	5.6	3.0	-

Table 2 (Continued)
Temperatures, Total Rainfall and Moon Information for the Survey Period

Date	Temperature (°C)		Rainfall (mm)		Moon Phase
	Campbelltown (Mount Annan) (Station No. 68257)[1]		Darkes Forest (Station No. 68024)[2]	Douglas Park (Station No. 68200)[2]	
	Maximum	Minimum			
24/09/08	20.4	5.5	0	0	-
25/09/08	21.0	5.7	0	0	-
26/09/08	25.8	4.6	0	0	-
27/09/08	29.1	6.8	0	0	-
28/09/08	32.7	10.8	0	0	-
29/09/08	21.9	7.0	0	0	New Moon
30/09/08	21.9	6.2	0.8	0	-
1/10/08	25.8	9.4	0	0	-
2/10/08	32.7	9.1	0	0	-
3/10/08	34.9	13.4	0	0	-
4/10/08	20.0	17.2	4.2	3.4	-
5/10/08	17.3	13.0	10.6	14.4	-
6/10/08	23.6	13.7	1.0	1.0	-
7/10/08	22.5	3.5	0	0	First Quarter
8/10/08	21.3	5.9	0	0	-
9/10/08	21.7	5.7	0	0	-
10/10/08	24.8	7.5	0	0	-
11/10/08	25.4	10.8	0	0	-
12/10/08	26.3	9.6	0	0	-
13/10/08	30.4	9.9	6.8	0	-
14/10/08	20.6	14.9	0	9.4	Full Moon
15/10/08	19.8	12.2	7.6	0	-
16/10/08	22.4	7.2	0	0	-
17/10/08	26.8	6.3	0	0	-
18/10/08	27.5	10.9	0	0	-
19/10/08	31.9	11.8	0	0	-
20/10/08	24.8	15.0	0	0	-
21/10/08	19.6	13.3	1.2	0	Last Quarter
22/10/08	16.9	7.8	11.2	8.0	-
23/10/08	17.3	6.9	10.2	0	-
24/10/08	23.1	4.2	2	0	-
25/10/08	26.8	7.3	0	0	-
26/10/08	28.7	7.5	0	0	-
27/10/08	34.4	13.3	0	0	-
28/10/08	24.4	12.6	0	0	New Moon
29/10/08	17.7	15.0	11.4	2.6	-
30/10/08	25.1	11.5	3.6	0	-
31/10/08	35.7	15.9	0	1.2	-
2/03/09	28.8	17.6	0	0	-
3/03/09	29.4	15.7	0	0	-
4/03/09	-	-	0.4	0	First Quarter
5/03/09	26.3	10.4	0	0	-
6/03/09	25.9	9.8	0	0	-
7/03/09	29.2	13.7	0.6	0	-
17/04/09	24.2	7.5	0	0	Last Quarter
18/04/09	23.9	10.0	0	0	-
19/04/09	20.5	12.2	0	0	-

Table 2 (Continued)
Temperatures, Total Rainfall and Moon Information for the Survey Period

Date	Temperature (°C)		Rainfall (mm)		Moon Phase
	Campbelltown (Mount Annan) (Station No. 68257)[1]		Darkes Forest (Station No. 68024)[2]	Douglas Park (Station No. 68200)[2]	
	Maximum	Minimum			
20/04/09	18.5	13.6	31.2	1.2	-
21/04/09	20.4	13.1	28.4	1.4	-
22/04/09	22.1	13.2	38.2	2.4	-
23/04/09	21.0	13.3	7.2	0	-
24/04/09	22.9	8.9	0	0	-
25/04/09	23.3	10.4	0	0	New Moon
26/04/09	20.1	13.3	1.2	0	-
27/04/09	17.9	8.3	0	0	-
28/04/09	20.8	3.9	0	0	-
29/04/09	18.0	5.2	0	0	-
30/04/09	19.2	6.5	0.8	0	-
1/05/09	21.4	5.2	0	0	First Quarter
2/05/09	22.1	6.5	0	0	-
3/05/09	22.1	6.2	0	0	-
4/05/09	23.5	6.9	0	0	-
5/05/09	21.3	11.8	0	0	-
6/05/09	22.2	7.0	7.8	0	-
7/05/09	22.9	8.8	0	0	-
8/05/09	21.1	6.6	0	0	-
9/05/09	22.8	6.3	0	0	Full Moon
10/05/09	18.9	8.7	0.6	0	-
11/05/09	20.4	6.6	0.8	0	-

1 BoM (2009a).
2 BoM (2009b).

2.2 FAUNA SURVEY SITES

Fifty-four systematic survey sites (i.e. Sites 1 to 54) were selected using a random stratified sampling process covering all major habitat types across the study area (Table 3; Figures 2 and 3). Systematic survey techniques (including trapping, direct observations and searches for tracks and scats) were carried out at each of these 54 sites. In addition, 53 targeted survey sites (i.e. Sites T1 to T53) were selected across the study area to maximise coverage of all habitat types present (Table 3; Figures 2 and 3). Techniques undertaken at targeted survey sites were selected based on the habitat type present and included Anabat detectors, hair tubes, spotlighting, herpetological searches, bird surveys, call playback, platypus surveys, limited trapping, motion sensing cameras and identification of tracks and traces[1]. Opportunistic sightings were also recorded throughout the study area.

All survey sites (systematic and targeted) were approximately 2 ha (approximately 200 x 100 m), with variations to suit site specific topography.

1 Targeted surveys were not undertaken for the Cumberland Plain Land Snail. This species is considered to potentially occur in the study area and a threatened species evaluation was undertaken (Section 6.1.1) assuming that the species occurs in the western portion of the study area.

Table 3
Fauna Survey Sites

Site	Eastings/ Northings (AMG)	Site Location[1]	Habitat Description	Survey Timing
Systematic Survey Sites				
1	306683, 6213298	North Cliff	Upland Swamp	March 2008
2	294832, 6207282	Appin Area 3 Extended	Tall Forest	March 2008
3	304900, 6210100	North Cliff	Upland Swamp	March 2008
4	303500, 6211950	Historical West Cliff Mining Area	Low Woodland Heath	March 2008
5	303852, 6213623	North Cliff	Gully Forest	March 2008
6	300900, 6216250	Outside Mining Area – Near O'Hares Creek Crossing on Fire Road 10D	Riparian	March/April 2008
7	298600, 6213800	Historical West Cliff Mining Area	Low Woodland Heath	March/April 2008
8	298004, 6215784	Historical West Cliff Mining Area	Open Woodland	March/April 2008
9	297200, 6211000	Historical Appin Area 2 Mining Area	Gully Forest	March/April 2008
10	295558, 6214639	Historical Appin Area 1 Mining Area	Open Woodland	April 2008
11	293350, 6210350	Outside Mining Area – Near Cataract River, Jordan's Pass	Riparian	April 2008
12	293100, 6210400	Outside Mining Area – Near Cataract River, Wilton Road	Open Woodland	April 2008
13	293900, 6208800	Appin Area 3 Extended	Open Woodland	April 2008
14	294456, 6203411	Outside Mining Area – Near Cataract River and Fire Road 8A	Upland Swamp	April 2008
15	298040, 6207202	Appin Area 2 Extended	Low Woodland Heath	April 2008
16	288600, 6214100	Appin West (Area 9)	Gully Forest	April 2008
17	292900, 6219300	Appin Area 7	Riparian	April 2008
18	286702, 6217561	Appin West (Area 9)	Gully Forest	April 2008
19	286460, 6217086	Appin West (Area 9)	Open Woodland	April 2008
20	297450, 6216800	West Cliff (Area 5)	Gully Forest	April 2008
21	287800, 6213511	Appin Area 8	Open Woodland	April 2008
22	298651, 6211840	Historical West Cliff Mining Area	Low Woodland Heath	April/May 2008
23	298754, 6211643	Historical West Cliff Mining Area	Gully Forest	April/May 2008
24	298590, 6212835	Historical West Cliff Mining Area	Low Woodland Heath	April/May 2008
25	306404, 6215046	North Cliff	Gully Forest	April/May 2008
26	303574, 6214754	North Cliff	Gully Forest	September 2008
27	303728, 6213664	North Cliff	Gully Forest	September 2008
28	304929, 6213708	North Cliff	Upland Swamp	September 2008
29	305661, 6212968	North Cliff	Gully Forest	September 2008
30	290924, 6207403	Outside Mining Area	Gully Forest	September 2008
31	296670, 6207314	Appin Area 3 Extended	Gully Forest	September 2008
32	299155, 6207755	Appin Area 2 Extended	Low Woodland Heath	September 2008
33	300860, 6208953	Outside Mining Area	Upland Swamp	September 2008
34	297854, 6213030	Historical West Cliff Mining Area	Gully Forest	September/October 2008
35	298406, 6212774	Historical West Cliff Mining Area	Upland Swamp	September/October 2008
36	298471, 6212505	Historical West Cliff Mining Area	Gully Forest	September/October 2008
37	298618, 6212396	Historical West Cliff Mining Area	Gully Forest	September/October 2008
38	298950, 6212944	Historical West Cliff Mining Area	Gully Forest	October 2008
39	297618, 6212887	Historical West Cliff Mining Area	Gully Forest	October 2008

Table 3 (Continued)
Fauna Survey Sites

Site	Eastings/ Northings (AMG)	Site Location[1]	Habitat Description	Survey Timing
40	299705, 6211666	Historical West Cliff Mining Area	Open Woodland	October 2008
41	300144, 6211316	Historical West Cliff Mining Area	Open Woodland	October 2008
42	300435, 6210420	Outside Mining Area	Gully Forest	October 2008
43	287612, 6212114	Appin Area 8	Gully Forest	October 2008
44	288924, 6211507	Appin Area 8	Open Woodland	October 2008
45	292980, 6221816	Appin Area 7	Riparian	October 2008
46	292268, 6220511	Appin Area 7	Open Woodland	October 2008
47	292791, 6219537	Appin Area 7	Riparian	October 2008
48	291117, 6225571	Outside Mining Area	Open Woodland	October 2008
49	289837, 6222260	Appin Area 7	Cleared Agricultural Land	October 2008
50	291272, 6222958	Appin Area 7	Riparian	October 2008
51	305277, 6208133	Outside Mining Area	Upland Swamp	March 2009
52	304212, 6208270	North Cliff	Low Woodland Heath	March 2009
53	301991, 6206768	Appin Area 2 Extended	Riparian	March 2009
54	301321, 6207612	Appin Area 2 Extended	Upland Swamp	March 2009
Targeted Survey Sites				
T1	288117, 6213009	Appin Area 8	Open Woodland	April 2008
T2	305292, 6215413	North Cliff	Tall Forest	March 2008
T3	286951, 6217041	Appin West (Area 9)	Dry Rainforest	April 2008
T4	302704, 6213361	North Cliff	Low Woodland Heath	March 2008
T5	304938, 6210488	North Cliff	Upland Swamp	March 2008
T6	299688, 6217601	Outside Mining Area – Near the O'Hares Creek Crossing on Fire Road 10B	Gully Forest	April 2008
T7	306020, 6215356	North Cliff	Low Woodland Heath	March 2008
T8	306627, 6214786	North Cliff	Low Woodland Heath	March 2008
T9	298010, 6215312	Historical West Cliff Mining Area	Water	April 2008
T10	297067, 6215290	West Cliff Area 5	Water	April 2008
T11	287121, 6212086	Appin Area 8	Water	April 2008
T12	298400, 6211643	Historical West Cliff Mining Area	Water	April 2008
T13	287860, 6213455	Appin Area 8	Water	March 2008
T14	289022, 6214145	Outside Mining Area – Near the Nepean River Causeway on Douglas Park Drive	Water	April 2008
T15	293122, 6219067	Appin Area 7	Water	April/May 2008
T16	288051, 6221357	Appin Area 7	Water	April/May 2008
T17	305138, 6213387	North Cliff	Tall Forest	September 2008
T18	305060, 6215260	North Cliff	Water	September 2008
T19	296744, 6207520	Appin Area 3 Extended	Gully Forest	September 2008
T20	296740, 6214098	Appin Area 1	Gully Forest	September 2008
T21	297544, 6212845	Historical West Cliff Mining Area	Gully Forest	September 2008
T22	298695, 6211965	Historical West Cliff Mining Area	Gully Forest	September 2008
T23	299976, 6209988	Historical West Cliff Mining Area	Open Woodland	September 2008
T24	300585, 6211638	Historical West Cliff Mining Area	Gully Forest	September 2008
T25	301700, 6210106	Outside Mining Area	Upland Swamp	September 2008

Table 3 (Continued)
Fauna Survey Sites

Site	Eastings/ Northings (AMG)	Site Location[1]	Habitat Description	Survey Timing
T26	289419, 6212857	Historical Tower Mining Area	Open Woodland	September/October 2008
T27	287668, 6211985	Appin Area 8	Gully Forest	September/October 2008
T28	289900, 6213960	Historical Tower Mining Area	Riparian	October 2008
T29	291612, 6226665	Outside Mining Area	Riparian	October 2008
T30	287500, 6215500	Appin West (Area 9)	Riparian	October 2008
T31	290910, 6223112	Outside Mining Area	Water	October 2008
T32	290880, 6224248	Outside Mining Area	Water	October 2008
T33	288961, 6225094	Outside Mining Area	Cleared Agricultural Land	October 2008
T34	286705, 6210420	Appin Area 8	Cleared Agricultural Land	October 2008
T35	302503, 6207970	Appin Area 2 Extended	Open Woodland	March 2009
T36	301446, 6207139	Appin Area 2 Extended	Open Woodland	March 2009
T37	297500, 6213600	Historical West Cliff Mining Area	Gully Forest	April 2009
T38	298400, 6213500	Historical West Cliff Mining Area	Gully Forest	April 2009
T39	298900, 6213100	Historical West Cliff Mining Area	Gully Forest	April 2009
T40	299350, 6213750	Historical West Cliff Mining Area	Gully Forest	April 2009
T41	299580, 6213300	Historical West Cliff Mining Area	Gully Forest	April 2009
T42	299880, 6213450	Historical West Cliff Mining Area	Gully Forest	April 2009
T43	300100, 6212950	Historical West Cliff Mining Area	Gully Forest	April 2009
T44	300450, 6210500	Historical West Cliff Mining Area	Gully Forest	April 2009
T45	300600, 6211550	Historical West Cliff Mining Area	Gully Forest	April 2009
T46	301050, 6210300	Historical West Cliff Mining Area	Gully Forest	April 2009
T47	301440, 6207405	Appin Area 2 Extended	Gully Forest	April/May 2009
T48	300574, 6211485	Historical West Cliff Mining Area	Gully Forest	April/May 2009
T49	299937, 6213550	Historical West Cliff Mining Area	Gully Forest	April/May 2009
T50	300077, 6212826	Historical West Cliff Mining Area	Gully Forest	April/May 2009
T51	298735, 6207688	Appin Area 2 Extended	Upland Swamp	April/May 2009
T52	302913, 6208012	North Cliff	Upland Swamp	April/May 2009
T53	301321, 6207612	Appin Area 2 Extended	Gully Forest	April/May 2009

[1] Refer to Figures 2 and 3.

2.3 FAUNA SURVEY TECHNIQUES

The survey techniques utilised were based on DEC (2004a) and are described below. The surveys were undertaken by a team of four people, led by Dr Arthur White. The survey effort implemented at each survey site is described in Attachment B.

Where necessary, species identifications were checked using the following references: Marchant and Higgins (1993); Churchill (1998); Pizzey and Knight (1999); Cogger (2000); Strahan (2000); Menkhorst and Knight (2001); Barret *et al*. (2003); Morcombe (2004); and Swan *et al*. (2004). Playback calls were selections from Stewart (1999a; 1999b) and mammalian tracks and traces were identified where possible using Triggs (2004).

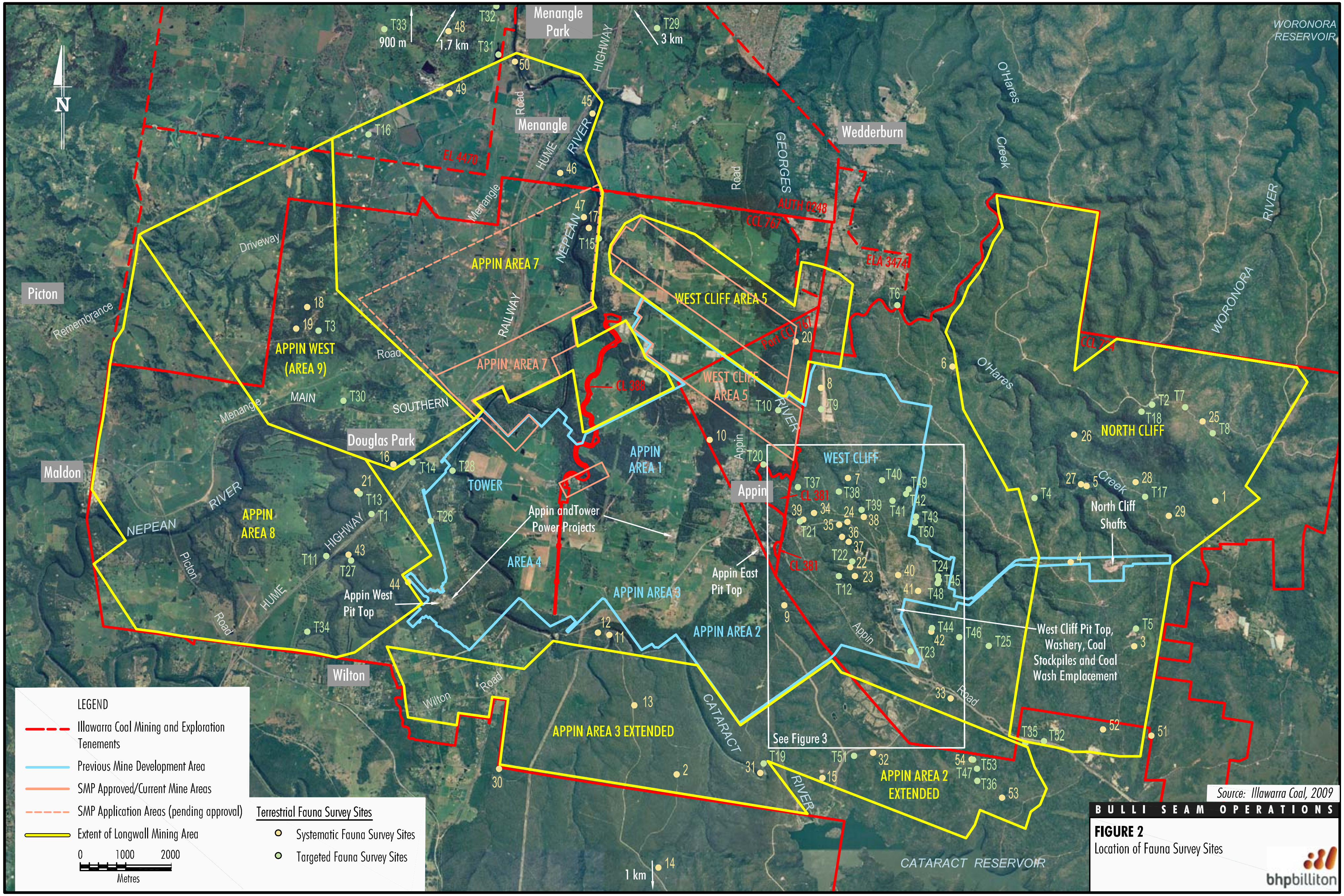
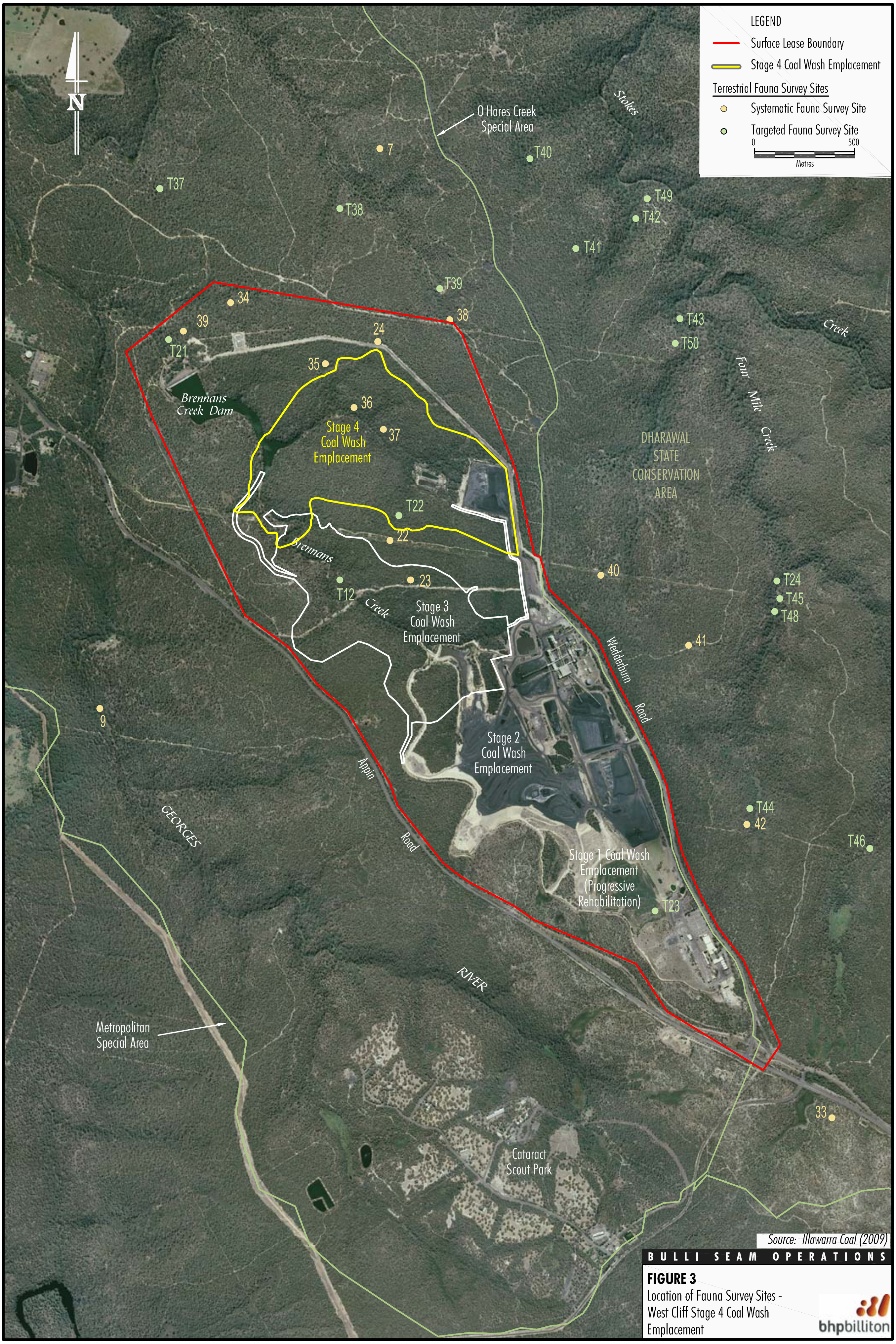


FIGURE 2
Location of Fauna Survey Sites

BHPIC-07-01 EA TFauna_102J



BULLI SEAM OPERATIONS

FIGURE 3
Location of Fauna Survey Sites - West Cliff Stage 4 Coal Wash Emplacement

bhpbilliton

BHPIC-07-01 EA TFauna_105D

Anabat Detectors

During the surveys, one Anabat detector was set for two consecutive nights at all systematic survey sites (i.e. Sites 1 to 54) and at targeted survey sites where suitable habitat was available (i.e. two detector nights at each site, with a total of 138 detector nights). The Anabat detectors were operating from dusk to dawn.

Hair Tubes

Hair tubes were set out in pairs at all systematic survey sites (i.e. Sites 1 to 54) and at targeted sites T3 and T37 to T53. Large (10 centimetre [cm] diameter) hair tubes were used on the ground and a combination of large and small (4 cm diameter) hair tubes were used (depending on the site characteristics) in arboreal locations. Hair tubes were left out for a minimum of four days and four nights at each site. Hair tubes were set for a total of 4,250 nights (comprising 3,150 large hair tube nights and 1,100 arboreal hair tube nights).

Hair tubes were baited with a mixture of peanut butter, oatmeal and vegemite. Where arboreal hair tubes were used, the tree was sprayed in the vicinity of the tube site with a mixture of honey and water. The hair tubes were designed to contain the bait, be easily smelt but not able to be removed by an investigating animal.

Hair sampled during the surveys was analysed by either Dr David Read or Dr Barbara Triggs.

Spotlighting

The primary targets of spotlighting were arboreal and ground dwelling larger mammals, nocturnal birds, nocturnal amphibians and reptiles.

During the surveys, up to two person hours of spotlighting was undertaken at each site, walking at around 1 kilometre per hour (km/hr), on two separate evenings. Spotlighting was undertaken at all systematic survey sites (i.e. Sites 1 to 54) and at targeted survey sites where suitable habitat was available. A total of 154 person hours of spotlighting was undertaken. Amphibians, where present, were identified by call and direct observation. Additional spotlighting was carried out from a vehicle travelling at around 5 km/hr, focusing on habitats along available fire trails.

Herpetological Searches

Systematic searches were conducted for reptiles and amphibians at all systematic survey sites (i.e. Sites 1 to 54) and at targeted survey sites where suitable habitat was available.

During the surveys, one person hour of diurnal herpetological searches was undertaken at each site on two separate days (i.e. a total of two person hours searched per site, for a total of 172 person hours). In addition, one person hour of nocturnal amphibian searches were undertaken at each site on two separate nights (i.e. a total of two person hours searched per site, for a total of 150 person hours). Bark was prised from trees, ground litter was raked, logs were turned over and cavities examined, fallen branches were moved, where present rocks were turned and slow walking facilitated the flushing out of reptiles or amphibians present. The survey also looked for burrows, shed skins and droppings.

Daytime searches were conducted for amphibians and hand-netting was carried out to search for tadpoles.

Opportunistic reptile and amphibian searches were also carried out in other parts of the study area.

Bird Surveys

A 30-minute bird survey was conducted on two separate days at all systematic survey sites (i.e. Sites 1 to 54) and at targeted survey sites where suitable habitat was available. A total of 75 person hours of bird surveys were undertaken. Birds were recognised by sight, calls and flight patterns. The surveys were conducted along a 200 m transect at each survey site.

Opportunistic bird surveys were also carried out during the day.

Call Playback

Nocturnal and diurnal call playbacks were conducted at all systematic survey sites (i.e. Sites 1 to 54) and at targeted survey sites where suitable habitat was available. Calls played included the Powerful Owl, Sooty Owl, Barking Owl, Masked Owl, Barn Owl, Southern Boobook Owl, Squirrel Glider, Koala, Yellow-bellied Glider, Giant Burrowing Frog, Red-crowned Toadlet, Green and Golden Bell Frog and Littlejohn’s Tree Frog where suitable habitat was present. Bird and mammal calls were not played in the same session.

Call playback was undertaken on two separate nights at each site. Up to approximately 20 minutes of call playback was undertaken per night at each site (i.e. a total of 46 hours). Each playback session commenced with approximately three minutes of call playback followed by a listening period and a break (where the surrounding vegetation was spotlighted). This process was then repeated once.

Platypus Surveys

Up to a total of 54 person hours of platypus survey were undertaken at sites 5, 6, 9, 20, T6, T14, T19, T28 and T30. At each site, up to 6 hours of observational platypus surveys were carried out at dawn and dusk.

The platypus surveys involved scanning streams and stream banks for platypus using binoculars. Platypus surveys were undertaken from the shore at sites located along the Georges and Cataract Rivers and from a small dinghy at sites located along the Nepean River.

Opportunistic Observations

Any opportunistic sightings of fauna were recorded whilst travelling throughout the study area. To maximise such sightings the routes to various locations were varied as much as possible.

Tracks and Traces

Searches for tracks and traces were combined with other activities, particularly herpetological searches. Searches were conducted for tracks, burrows, hair samples, bones, drays, animal droppings, diggings and bite/scratch marks, etc. Any scats and hair samples collected were analysed by either Dr David Read or Dr Barbara Triggs.

Elliott A and B Traps

Elliott A traps (8 x 10 x 33 cm) and Elliott B traps (16 x 16 x 46 cm) were baited with a mixture of peanut butter and oatmeal, provided with a handful of nesting material to keep captured animals warm, and partially covered with a plastic bag to keep animals dry.

Twenty Elliott A traps and five Elliott B traps were set in 200 m long trapping lines at each site (i.e. Sites 1 to 54) and the locations were marked with flagging tape. In addition, five arboreal Elliott traps (8 x 10 x 33 cm) were set in appropriate habitat along each of the trap lines. A second five night (consecutive) survey was undertaken at Sites 51 to 54 using 25 Elliot A traps and five Elliot B traps during the March/April/May 2009 survey period.

Traps were left out at each location for a minimum of four consecutive nights (i.e. 80 to 125 ground Elliott A trap nights per site [a total of 4,820 trap nights], 20 to 25 Elliott B trap nights per site [a total of 1,180 traps nights] and 20 to 25 arboreal Elliott trap nights per site [a total of 1,180 traps nights]). Traps were checked soon after dawn each morning, any captured animal identified, assessed and released. Disturbance and false trap closures were noted and the traps reset as appropriate at night.

Cage Traps

Five wire cage folding traps (30 x 30 x 60 cm) suitable for larger mammals such as bandicoots, spotted-tailed quolls and possums were placed at about 40 m intervals through the centre of Sites 1 to 54, the location flagged and the trap covered with a large plastic bag to protect captured animals from the weather. A second five night (consecutive) survey was undertaken at Sites 51 to 54 using five cage traps during the March/April/May 2009 survey period. In addition, ten cage traps were placed at targeted Sites T37 to T46 for seven consecutive nights during the March/April/May 2009 survey period. Half the traps were baited with oatmeal-peanut butter mix and the other half with canned cat (fish) food. Traps were left out at each location for four to seven consecutive nights providing 20 to 70 trap nights per site, a total of 1,880 trap nights.

Traps were checked soon after dawn each morning, any captured animal identified, assessed and released, disturbance and false trap closures noted and the traps reset as appropriate.

Pitfall Traps

No pitfall traps were used as the predominant geology makes the use of pitfall traps overly time consuming and logistically impractical.

Motion Sensing Cameras

Five infrared motion sensing cameras were placed at systematic survey site 54 and targeted sites T47 to T53. Cameras were positioned to record ground dwelling fauna and were located in areas with evidence of fauna activity (i.e. diggings). Cut apples were spread across the ground in the focus of the camera to attract fauna. Cameras were left in position for 11 days and nights, totalling 88 camera days/nights.

Targeted Surveys for Threatened Fauna Species

A list of threatened amphibian, reptile, bird and mammal species listed in the Schedules of the TSC Act and EPBC Act which are considered possible occurrences within the study area or immediate surrounds is provided in Table 1. A selection of the above fauna survey techniques were used to target the threatened species listed in Table 1 based on the habitat type present at each targeted survey site.

2.4 HABITAT ASSESSMENT

A habitat assessment was conducted at each site based on visual observations. The habitat characteristics and parameters that were assessed included:

- aspect/slope;
- habitat layers and heights (e.g. litter, logs, grass-herb layer, understoreys and canopy);
- percent cover including vegetation components, bare soil and rock;
- rock formation, tree hollows;
- fire history;
- successional stage;
- tree/shrub density;
- habitat connectivity;
- presence of water;
- habitat condition and trends;
- dominant vegetation species, and
- disturbance characteristics (weed invasion, erosion, loss of functional integrity).

This information was recorded in a database and used to categorise and describe the broad fauna habitat types within the study area.

2.5 RELATIVE ABUNDANCE

The relative abundance of each species recorded was estimated as follows:

1	One sighting of the species, or at least one trace found.
U	Uncommon, 2-5 observations of the species, as well as an assessment of how widespread and persistent the species was.
C	Common, 6-30 observations of the species, as well as an assessment of how widespread and persistent the species was.

Hence relative abundance was based on empirical data as well as being a value judgement made by an experienced surveyor.

3 SURVEY RESULTS

3.1 MAJOR FAUNA HABITAT TYPES

The topographical and geological characteristics of an area have a major impact on the types of habitat present. The three major topographic and geological units identified within the study area are discussed in Section 1.4.5 and include the Dissected Hawkesbury Sandstone Plateau and the Shale-dominated areas, including the Razorback Range.

The habitats identified within the study area can be broadly categorised into nine habitat types, as listed below.

- Dry Rainforest.
- Tall Forest.
- Open Woodland.
- Gully Forest.
- Riparian.
- Low Woodland Heath.
- Upland Swamp.
- Cleared Agricultural Land.
- Water.

Sections 3.1.1 to 3.1.9 below provide a description of each of the nine habitat types and any variation within the habitat types across the underlying topographical/geological units described above. A more detailed botanical description of vegetation within the study area is provided in the Terrestrial Flora Assessment (Appendix E of the EA).

Broad fauna habitat types in the eastern and southern portions of the study area are in early to mid-succession phase following the 2001 bushfires. Survey sites located in relatively uncleared vegetation (e.g. those in the eastern and southern portion of the study area) (Table 3 and Figure 2) were assessed as having high internal and external habitat connectivity, variable internal habitat homogeneity, with high quality habitat in regards to the particular phase of post fire succession. Survey sites located in the northern and western portion of the study area (Table 3 and Figure 2) generally were assessed as having lower external habitat connectivity with lower quality habitat due to past and current urban and agricultural practices including clearing, pasture improvement techniques (including development of monoculture paddocks), introduction of livestock (which directly impact the lower and mid strata habitat) and subsequent invasion of weed plant species.

The variability in available habitat in the 2008/2009 surveys was enhanced by significant rain events leading up to and during some of the survey periods creating wet areas, some minor ephemeral flows in road side gutters, seepage across rock platforms, thereby optimising the likelihood of detecting amphibian species.

Habitat values are further enhanced at those sites located in the eastern and western portions with variable rock formations including boulders, rock pavements and breakaway slopes to the adjacent valley floor.

The broad fauna habitat types are described below based on the results of the habitat assessment conducted at each survey site. However, a number of survey sites demonstrated ecotonal characteristics and other micro-habitat nuances.

3.1.1 Dry Rainforest

Dry Rainforest species generally occur on the Razorback Range in southern and eastern facing gullies. The most common canopy species is Grey Myrtle (*Backhousia myrtifolia*) with various ferns and climbers. Historically, this habitat was more widespread but land clearing and agricultural practises have greatly reduced the amount of dry rainforest habitat available in the survey area. Dry rainforest accounted for less than 0.3% of the total survey area and the remaining habitats are mostly degraded as a result of weed invasion, impacts of fire and feral animals. Only one site (i.e. Site T3) was established in dry rainforest habitat, while two others (i.e. Sites 18 and 19) were located at the boundary of old rainforest areas.

The remaining pockets of dry rainforest occur in sheltered gullies around the periphery of the Razorback Range. These pockets have persisted because they are on steep slopes and are generally not suitable for grazing or agriculture. Most of the rainforest remnants are discontinuous and isolated by broad areas of cleared land or tall escarpments. Because the remaining areas are on such steep slopes, erosion is rapid and little leaf litter or fallen timber remains on the ground. Only in places where surface rocks protrude does fallen vegetation accumulate and dark, humic soils begin to form. The recovery of the rainforest areas is being thwarted by the cropping of seedlings by goats, rabbits and hares, permitting exotic species (e.g. Lantana and Privet) to germinate in the better soil areas.

In some areas, dense tangles of exotic weeds and/or native vines create useful understorey cover for animals. The general lack of logs and fallen timber means that there is otherwise little shelter available for ground-dwelling species.

3.1.2 Tall Forest

Tall Forest habitats were identified in the dissected Hawkesbury Sandstone plateau in the east and the shale-dominated river flats in the west. Tall Forest habitat occurs in isolated areas where the remnants of the eroded, overlying shale layer remains, often as a clay-rich sediment mixed with the less fertile sand derived from the sandstone. Plants which are able to extract the extra nutrients in the clays grow as distinct enclaves within the sandstone-dominated vegetation.

Distinct from the Gully Forest habitat, this habitat type occurs along ridge tops in isolated locations and along river flats with a canopy up to 20 m in height. The dominant tree cover is associated with an understorey of small trees, tall shrubs and thick ground cover plants. Grasses and herbs occur sporadically. A moderate amount of scattered fire trash is present in the eastern and southern portions of the study area which was subject to fire in 2001. The forest trees provide a moderate abundance of tree hollows and fallen logs, the ground may be covered by a moderately-thick layer of leaves and twigs.

Survey Sites 2, T2 and T17 were located within typical examples of this habitat type. Site 2, for example, was located near the 8a Fire Trail in the Cataract Dam catchment area. The fire trail runs along the top of a broad ridge to the west of Lizard Creek. The majority of the habitats either side of the fire trail are low woodland heath, but the road travels slightly onto the remnants of a deeply eroded shale lens; quickly, the vegetation changes and the trees become noticeably taller and straighter and heathy shrubs become less abundant. The shale has almost been completely eroded away at this site but the surface soils still contain large amounts of clay and sand. Tall Forest habitat is scarce in the study area and only comprises about 1% of the total area of the survey.

On the Dissected Hawkesbury Sandstone Plateau, this habitat type is characterised by tall trees (e.g. *C. gummifera*, *E. piperata* and *A. costata*) and an understorey dominated by bracken and grasses. On the river flat Shale-dominated areas, this habitat type is dominated by tall She-oaks (*Casuarina cunninghamiana*), although in a number of areas exotic species such as Willows (*Salix* spp.) and Privet (*Ligustrum* spp.) have replaced the native species. The associated flood plains in these areas also contain remnant Tall Forest habitat comprising Bangalay (*E. botyroides*) and Blue Box (*E. baueriana*). Rocky habitats are more-or-less absent being confined to lightly and patchy surface rock.

3.1.3 Open Woodland

The exposed sandstone ridges of the Dissected Hawkesbury Sandstone Plateau generally have various thicknesses of weathered sandstone and sand. These sand beds are nutrient poor but support low open woodland dominated by Scribbly Gum (*Eucalyptus haemastoma/racemosa*), Red Apple (*Angophora costata*) and Sydney Peppermint (*E. piperita*). The understorey of this woodland comprises stunted Banksia (*B. serrata*, *B. ericifolia*), Geebungs (*Persoonia* spp), Wattles (*Acacia* spp) Conesticks (*Petrophile* spp) and an assortment of sedges, grasses and herbs. In some areas, heath vegetation may intrude into the undergrowth.

The majority of the Shale-dominated Areas were originally covered by tall open woodland, either as Cumberland Plains Woodland, dominated by Grey Box (*E. moluccana*), Forest Gum (*E. tereticornis*) and Narrow-leaved ironbark (*E. crebra*), or shale-sandstone transition forests, also dominated by Grey Box (*E. moluccana*), Forest Gum (*E. tereticornis*) and Narrow-leaved ironbark (*E. crebra*), but including Broad-leaved Ironbark (*E. fibrosa*), stringybarks and box trees. Exotic grasses and pasture weeds often prevail, although in some areas *Bursaria spinosa* occurs in dense thickets.

Open Woodland habitat accounts for approximately 16% of the total habitat within the study area. Systematic survey sites 8, 10, 12, 13, 19, 21, 40, 41, 44, 46, 48 and several targeted sites (i.e. T1, T23, T26, T35 and T36) were located in this habitat. Open Woodland was found in elevated places on the Woronora Plateau (approximately 370 m AHD), and extended down to the open river valleys (e.g. 190 m AHD). Open Woodland generally contains many fallen trees, logs and branches and these elements provide most of the available ground shelter for small animals. Rock escarpments are uncommon although scattered boulders and small outcrops were observed throughout this habitat type.

3.1.4 Gully Forest

Gully forest habitats were identified in the Dissected Hawkesbury Sandstone Plateau and the Shale-Dominated Areas, where they occur as sandstone gullies and moist shale forests, respectively.

Within the Dissected Hawkesbury Sandstone Plateau, narrow and often steep sandstone gullies have been created where streams have penetrated the upper sandstone surfaces. These gullies are protected from strong winds and high temperatures by the surrounding sandstone slopes and are a relatively cool, moist area below the plateau surface. As the sandstone is strongly layered, steps or benches form in the gullies and these often trap seepage and form pools in shady areas. Moisture-seeking plants, such as ferns and some sedges and rushes thrive in these areas. The slopes are often dominated by Sydney Peppermints (*E. piperita*), Red Bloodwood (*Corymbia gummifera*) and the lower gullies tend to be dominated by Blackbutt (*E. pilularis*) or Sydney Blue Gum (*E. saligna*). The range of rocky habitats include stepped sandstone, cracks, fissures, overhangs and small caves with up to 40% of the area being exposed rock surfaces.

The secondary slopes and intervening gullies of the Razorback Range are dominated by shale forest. These comprise Red Gums, White Stringybark (*E. globoidea*) and Grey Gums (*E. punctata*).

Gully Forest occurs widely across the study area. In the sandstone areas to the east of the study area, it is generally present in small, perched gullies at elevations between 250 and 300 m AHD, whereas further west, Gully Forest is present at 50 m AHD. Because of the highly dissected nature of the Woronora Plateau and the deep river valleys of the Nepean, Cataract and Georges Rivers, Gully Forest comprises approximately 12% of the total habitat area in the study area.

Many of the Gully Forest areas are located on steep slopes and contained within narrow and sinuous valleys. The soils in the gullies are often deeper and more fertile than soils on the ridge tops and generally contain more moisture. As a result, the ground vegetation is generally denser and the tree canopy is higher further down the valleys. In the sandstone areas, Gully Forest often straddles sandstone ledges as it descends to the valley floor; sandstone escarpments, overhangs and small caves are often present in this habitat.

Sites located in the Gully Forest included systematic survey sites 5, 9, 16, 18, 20, 23, 25, 26, 27,29, 30, 31, 34, 36, 37, 38, 39, 42 and 43 and targeted sites T6, T19, T20, T21, T22, T24, T27, T37 to T50 and T53. The concentration of survey sites in this habitat type reflects the importance of these more protected habitats which shelter the ridgetop species during drier times, but also the more mesic animals during times of heavy rain or flooding.

3.1.5 Riparian

In the lower sections of the major rivers and streams within the study area, the watercourses cease eroding deeply into the sandstone and instead, begin flowing more gently across sandstone beds. Sand banks often form alongside the streams and She-oaks (*Casuarina cunninghamiana*) often colonise these sandy tracts. As the slope is not steep, the water often spreads out across the rocky bars and fills holes and crevasses to create deep, permanent pools as well as an assortment of smaller and less permanent water holes. The trees lining the lower valleys are often tall (e.g. Blackbutts and Sydney peppermints) and contain hollows and roosting sites for a variety of animals. Riparian habitat accounts for about 6% of the total area of available habitat; this habitat is different to most of the other habitats in that water is readily available and the areas are often protected from strong winds and direct sun for the majority of the day.

Shelter materials are abundant in this habitat type and include large boulders, fallen trees, logs, flood debris and scree. In addition, the ground cover vegetation may be dense in areas that are not prone to flood scouring. Shelter materials and dense ground cover is less common (sometimes absent) in this habitat where it occurs along streams within the extensively cleared Shale-dominated Areas (Section 3.1.8). Systematic survey sites 6, 11, 17, 45, 47, 50 and 53 and several targeted sites (i.e. T28, T29 and T30) are located in Riparian habitat. Some of these sites were located approximately 100 m below the plateau ridge line, some had near-vertical sandstone walls leading down to them, while others had more gentle, vegetated slopes descending to them. In many cases, these areas appeared to have escaped the impacts of recent wildfires, whereas the nearby slopes and hills have been severely burnt. Fallen boulders and Tallus formations were observed to be reasonably common in Riparian habitat within the Dissected Hawkesbury Sandstone Plateau areas.

3.1.6 Low Woodland Heath

On the Dissected Hawkesbury Sandstone plateau, Low Woodland Heath is found in shallow, sandy areas close to or in weathered sandstone basins. Where the sand is deep, the heath vegetation was observed to be tall (2.5 m) and almost impenetrable. In shallower areas, the heath is generally sparser and more stunted. The heath is often dominated by Heath Banksia (*B. ericifolia*), Dagger Hakea (*Hakea teretifolia*), Drumsticks (*Isopogon anemonifolius*), Spider Flowers (*Grevillea* sp.), various epacrids and narrow-leaved ground cover plants. Low Woodland Heath was particularly abundant in the sandstone areas in the eastern parts of the survey area and comprised 18% of the total area. Heath was present from the elevated sites (e.g. along the Darkes Forest Ridge at an elevation of 380 m AHD), down to river margin areas along the Georges River at 180 m AHD.

Systematic survey sites 4, 7, 15, 22, 24, 32 and 52, and targetted sites T4, T7 and T8 were located in Low Woodland Heath habitat. Vegetation cover in these areas was typically variable (e.g. where heath was tall and dense, ground cover plants were often scarce and where the heath was lower or discontinuous, ground cover plants were more evident). In some cases, areas of open ground were present. On ridgetops and upper slopes, the heath was often interrupted by sandstone ledges, platforms and boulders. As the trees in this habitat type were generally small and spindly, there was little fallen timber on the ground and the leaf litter was usually sparse.

3.1.7 Upland Swamps

Upland swamps were identified in the upper Dissected Hawkesbury Sandstone Plateau in areas where sand beds have collected atop sandstone and clay layers. These swamps often do not have areas of open water and may be quite dry at various times of the year. Sedges proliferate creating broad, low vegetation zones between woodland areas. Sedges such as *Baumea, Gymnocephaus*, *Lepidosperma*, *Gahnia*, and *Lepyrodea* are common, and often interspersed by Grass Trees (*Xanthorrhoea minor* and *X. resinosa*). Heath vegetation may become established where the swamps are dry for long periods.

Upland swamps account for approximately 4% of the survey area and most were located in the Dharawal State Conservation Area or in the Metropolitan Catchment Area. These swamps rarely had areas of open water and varied from very boggy and wet to being quite dry. Sedges dominated in the wetter areas but where the swamps were more prone to drying out, shrubs such as tea-trees (*Leptospermum* spp.) and Swamp Banksia (*B. robur*) predominate. In areas that had been affected by fire, Dagger Hakea (*Hakea teretifolia*) often penetrated the swamp. A more detailed botanical description of upland swamps is provided in the Terrestrial Flora Assessment (Appendix E of the EA).

The upland swamps typically had very dense ground cover which was often observed to contain small animal runways and tunnels. There were no logs or rocks to provide cover, all shelter was created by the dense ground cover vegetation. Many of the upland swamps were located on the upper parts of the Woronora Plateau, at elevations of up to 320 m AHD, and some occupied the headwaters of small, wide valleys. Sites located in upland swamps included systematic survey sites 1, 3,14, 28, 33, 35, 51 and 54 and targetted sites T5, T25, T47, T51 and T52.

3.1.8 Cleared Agricultural Land

Cleared Agricultural Land was identified in the Shale-dominated Areas and the Razorback Range area. The habitat characteristics of cleared agricultural land vary depending on the local topographic and geological characteristics.

The relatively flat, fertile soils of the Shale-dominated Areas have been extensively cleared and utilised for agriculture (e.g. dairy and meat cattle grazing, pig and chicken farms). Large areas of land have been sub-divided for the creation of residential estates, motorways and other infrastructure. The spread of agricultural practices through this area has resulted in vast tracts of Open Woodland habitat being felled; the only trace of its past presence is old, isolated trees along fence lines. In areas where grazing stock have been removed, some regeneration has occurred.

The more accessible parts of the Razorback Range were cleared over a hundred years ago for agriculture. In current agricultural areas, there has been limited regeneration of native vegetation. The success of the regeneration appears to be limited by stock grazing.

Cleared Agricultural Land accounts for 40% of the total land area within the study area. Most of the Cleared Agricultural Land was located in the western half of the study area and was associated with the Nepean and Georges River floodplains. These areas contained mostly alluvial soils and are relatively flat, making them very suitable for agriculture.

Most of the Cleared Agricultural Land had been cleared of trees although in some areas, there was some partial regeneration of native trees. In many areas, exotic trees had been planted and exotic ground cover species dominated these areas. This habitat type provides little safe habitat for native animals as it generally lacks fallen logs, branches, rock piles or areas of dense ground cover vegetation. Systematic survey site 49 and targeted survey sites T33 and T34 were located in Cleared Agricultural Land.

3.1.9 Water

Water habitats available across the study area include persistent sources of water (e.g. Cataract River, Nepean River, O'Hares Creek, Georges River, Stokes Creek), intermittent sources of water (e.g. Ousedale Creek, Harris Creek and Byrnes Creek and flood lagoons and ox-bows such as those in the lower sections of the Nepean River near Menangle), farm dams and non-persistent sources of water (e.g. surface seeps, ponded water adjacent to fire trails and ephemeral streams).

In the Shale dominated areas, the installation of weirs and dams along the Nepean River has greatly reduced the incidence of flooding in these water habitats and lagoons are often dry for long periods and sometimes only fed by local runoff. Where they have survived, thickets of rushes (*Typha orientalis*, *Baumea* spp.) and sedges (*Cyperus* spp.) have formed around the perimeter of the lagoons. Most of the lagoons and oxbows are now surrounded by pasture.

Targeted survey sites T9, T10, T11, T12, T13, T14, T15, T16, T18, T31 and T32 specifically focussed on this habitat. Other systematic and targeted sites (those in riparian areas) also sampled this habitat type to some extent although are not listed above. Some areas of the more open water habitats were characterised by evidence of poor water quality (e.g. algal blooms). At several sites, the fringing vegetation had been altered and replaced by a range of exotic plants. The Nepean and Georges Rivers were running throughout the survey period, but other water bodies (e.g. Menangle Pond and Barragul Lagoon) that are disconnected from these rivers, were prone (during the survey period) to great variations in the total surface area and water depth in response to variations in the rainfall.

3.2 FAUNA SPECIES DIVERSITY AND RELATIVE ABUNDANCE

3.2.1 Species Diversity Across Survey Sites

Species diversity across survey sites for amphibians, reptiles, birds, mammals and introduced mammals is provided in Table 4.

Table 4
Distribution of Fauna Species Across Survey Sites

	Survey Sites 1-20																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
No. Native Amphibians	4	0	4	0	5	6	0	0	4	1	9	0	0	1	0	0	3	1	0	3
No. Native Reptiles	0	1	3	1	6	2	2	1	3	3	1	1	0	3	1	4	5	0	2	3
No. Native Birds	8	10	3	6	9	7	4	9	17	10	17	16	13	7	5	14	24	39	27	8
No. Introduced Birds	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	4	1
No. Native Mammals	0	4	3	2	3	0	3	3	5	5	3	0	3	1	1	0	3	6	3	9
No. Introduced Mammals	0	0	0	0	1	0	0	1	1	1	0	1	0	1	1	2	0	1	1	1
Total Native Species	12	15	13	9	23	15	9	13	29	19	30	17	16	12	7	18	35	46	32	23

	Survey Sites 21-40																			
	21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
No. Native Amphibians	0	0	0	6	4	0	3	2	0	1	0	0	3	2	1	2	1	2	0	0
No. Native Reptiles	3	1	5	1	2	5	6	9	5	1	7	4	4	2	4	6	6	4	4	6
No. Native Birds	22	20	18	12	1	12	11	7	12	14	11	7	9	17	7	12	12	10	13	8
No. Introduced Birds	1	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No. Native Mammals	1	2	1	0	5	6	4	6	8	8	7	4	8	3	2	8	9	9	6	4
No. Introduced Mammals	1	0	1	1	0	0	0	0	3	1	1	3	1	2	5	0	2	1	2	0
Total Native Species	26	23	24	19	12	23	24	24	25	24	25	15	24	24	14	28	28	25	23	18

	Survey Sites 41-T6																			
	41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
No. Native Amphibians	1	0	2	1	6	0	3	2	1	4	4	0	2	5	0	0	3	0	7	0
No. Native Reptiles	4	3	9	4	6	5	3	7	3	5	4	4	3	5	2	0	1	1	0	5
No. Native Birds	6	5	20	22	24	16	16	22	15	8	14	14	9	9	9	2	11	2	6	3
No. Introduced Birds	0	0	0	0	2	0	2	0	1	1	0	0	0	0	1	0	1	0	0	0
No. Native Mammals	3	2	10	4	6	2	3	4	2	4	6	10	7	7	0	0	0	0	0	0
No. Introduced Mammals	0	0	1	3	3	3	4	1	1	1	0	1	0	0	0	0	2	0	0	0
Total Native Species	14	10	41	31	42	23	25	35	21	21	28	28	26	26	11	2	15	3	13	8

Table 4 (Continued)
Distribution of Fauna Species Across Survey Sites

	Survey Sites T7-T26																			
	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26
No. Native Amphibians	0	0	6	0	1	0	4	0	4	5	0	4	0	1	0	0	0	0	0	0
No. Native Reptiles	0	0	0	0	3	0	0	0	1	0	0	1	0	0	0	1	0	3	0	0
No. Native Birds	3	3	4	4	5	9	4	5	25	31	0	6	0	18	8	0	1	0	6	17
No. Introduced Birds	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	1
No. Native Mammals	0	0	1	0	3	0	0	0	3	0	0	0	0	1	0	0	3	0	0	0
No. Introduced Mammals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Native Species	3	3	11	4	12	9	8	5	33	36	0	11	0	20	8	1	4	3	6	17

	Survey Sites T27-T46																			
	T27	T28	T29	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41	T42	T43	T44	T45	T46
No. Native Amphibians	0	1	1	2	5	1	4	2	2	2	0	0	0	0	0	0	0	0	0	0
No. Native Reptiles	0	2	0	2	3	1	4	3	4	6	0	0	0	0	0	0	0	0	0	0
No. Native Birds	0	0	8	0	7	1	7	12	8	5	0	0	1	0	0	0	0	1	0	0
No. Introduced Birds	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No. Native Mammals	0	0	1	1	1	1	0	1	0	0	0	1	1	2	1	1	1	1	1	1
No. Introduced Mammals	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0
Total Native Species	0	3	10	5	16	4	15	18	14	13	0	1	2	2	1	1	1	2	1	1

	Survey Sites T47-T53							Total Number of Species Recorded
	T47	T48	T49	T50	T51	T52	T53	
No. Native Amphibians	0	0	0	0	0	0	0	19
No. Native Reptiles	0	0	0	0	0	0	0	30
No. Native Birds	0	1	1	0	0	0	0	145
No. Introduced Birds	0	0	0	0	0	0	0	6
No. Native Mammals	1	0	1	2	0	0	1	28
No. Introduced Mammals	0	0	0	0	0	0	0	8
Total Native Species	1	1	2	2	0	0	1	222

Native species diversity varied between zero and 46 species per site. Amphibian diversity across sample sites ranged from zero to nine species, reptile diversity ranged from zero to nine species, bird diversity ranged from zero to 39 species and mammal diversity from zero to ten species.

3.2.2 Species Composition and Abundance

During the survey, a total of 236 species were identified in the study area (including 222 native and 14 introduced species) (Table 5; Attachment C). A total of 19 amphibians, 30 reptiles, 151 birds and 36 mammals were located in the study area. A summary of the species located and their abundance is provided in Attachment C. The total species recorded during this study compared with the total species located in similar regional surveys is shown in Table 5. Table 5 shows that the majority of native fauna species (a total of 330) were located during the DECC survey in 2007 (DECC, 2007a). The DECC (2007a) survey was followed by the Project survey which located 222 native species, while NPWS (2002a) located 207 native species, and Western Research Institute and Biosphere Environmental Consultants (2008) recorded a total of 140 native species (Table 5). The DECC (2007a) survey also recorded the largest amount of species per fauna group when compared to the other surveys, while Western Research Institute and Biosphere Environmental Consultants (2008) recorded the smallest amount of species per fauna group (Table 5). The Project survey recorded more native amphibians (a total of 19 species) and birds (a total of 145 species) than the NPWS (2002a) and Western Research Institute and Biosphere Environmental Consultants (2008) surveys (Table 5). A total of 30 reptile species and 14 introduced species were recorded during both the Project surveys and the NPWS (2002a) surveys (Table 5).

Table 5
Comparison of Species Located in Selected Fauna Surveys from 2002 to 2009

Fauna Group	Project Survey	DECC (2007a)	NPWS (2002a)	Western Research Institute and Biosphere Environmental Consultants (2008)
Native Amphibians	19	25	16	17
Native Reptiles	30	45	30	19
Native Birds	145	217	130	77
Native Mammals	28	43	31	27
Introduced Species	14	18	14	5
Total Native Species	222	330	207	140

The number of fauna species in each of the three abundance groupings is illustrated in Table 6 below. Eight species were located based on one observation or trace, 41 species were assessed as uncommon and 187 species were assessed as common.

Table 6
Relative Abundance in Fauna Groupings

Fauna Group	One sighting/Trace	Uncommon (2 to 5 observations)	Common (6 to 30 observations)
Amphibians	0	5	14
Reptiles	2	6	22
Birds	2	22	127
Mammals	4	8	24

3.2.3 Amphibians

Nineteen native amphibian species were located during the survey (Table 5; Attachment C). The number of species located at each of the sampling sites varied between zero and nine species (Table 4). Nine Myobatrachidae and 10 Hydlidae were observed. In addition to the species located at the sampling sites, three amphibian species were located opportunistically (one of which, the Red-crowned Toadlet, was also located at Site 11 and 26) (Attachment C). The frog species most widely distributed across the study area was the Common Eastern Froglet (*Crinia signifera*).

3.2.4 Reptiles

Thirty native reptile species were located during the survey (Table 5; Attachment C). The number of species located at each of the sampling sites varies between zero and nine species (Table 4). Two Chelidae, three Gekkonidae, 11 Scincidae, four Agamidae, two Varanidae, one Boidae and seven Elapidae were located (Attachment C). In addition, two reptile species located at sites were also located opportunistically. The Dark-flecked Garden Sunskink (*Lampropholis delicata*) was located at 45 sites, the Eastern Water-skink (*Eulamprus quoyii*) was located at 25 sites, the Pale-flecked Garden Sunskink (*Lampropholis guichenoti*) and Copper-tailed Skink (*Ctenotus taeniolatus*) were both located at 22 sites (Attachment C).

These data indicates that reptiles are still diverse and relatively abundant, particularly in the eastern portion of the study area. Reptile diversity is greatly diminished in the cleared agricultural areas of the western portion of the study area.

3.2.5 Birds

One hundred and fifty-one bird species were identified during the survey, 145 of which were native (Table 5; Attachment C). The number of species located at all sampling sites varied between zero and 39 species (Table 4). In addition, 52 bird species (50 of which were native) located at sites were also located opportunistically, while an additional seven species (all of which were native) were only located opportunistically.

Overall, six Anatidae, one Podicipedidae, three Threskiornithidae, four Ardeidae, four Phalacrocoracidae, one Anhingidae, four Falconidae, eight Accipitridae, three Rallidae, one Turnicidae, one Recurvirostridae, one Charadriidae, one Laridae, five Columbidae, 14 Psittacidae, six Cuculidae, one Strigidae, one Podargidae, two Apodidae, one Coraciidae, three Alcedinidae, one Menuridae, one Climacteridae, three Maluridae, two Pardalotidae, 11 Acanthizidae, 18 Meliphagidae, four Petroicidae, two Eupetidae, one Neosittidae, five Pachycephalidae, six Dicruridae, five Artamidae, one Campephagidae, one Oriolidae, one Corvidae, one Corcoracidae, one Ptilonorhynchidae, two Sturnidae, three Hirundinidae, one Pycnonotidae, one Zosteropidae, three Sylviidae, one Dicaeidae, two Passeridae, one Motacillidae and two Estrildidae were recorded (Attachment C).

Birds most widely distributed across the study area included the Eastern Spinebill (*Acanthorhynchus tenuirostris*), Little Wattlebird (*Anthochaera chrysoptera*), Spotted Pardalote (*Pardalotus punctatus*) and New Zealand Fantail (*Rhipidura fuliginosa*) (Attachment C).

These data indicate that bird diversity is relatively high, especially in the eastern portion of the site where larger tracts of relatively undisturbed bushland still occur. In the cleared agricultural lands that dominate the western portion of the study area, exotic birds become more prevalent.

3.2.6 Mammals

Thirty-six mammal species were located during the survey, 28 of which were native (Table 5; Attachment C). The number of native mammal species located at each of the sampling sites varied between zero and ten species (Table 4). In addition, one mammal species (the Eastern Grey Kangaroo [*Macropus giganteus*]) located at several survey sites was also recorded opportunistically in the study area.

The native mammals included one Ornithorhynchidae, one Tachyglossidae, four Dasyuridae, two Peramelidae, one Phascolarctidae, one Vombatidae, one Burramyidae, one Petauridae, two Pseudocheiridae, one Phalangeridae, three Macropodidae, one Pteropodidae, one Rhinolophidae, five Vespertilionidae and three Muridae (Attachment C).

These data indicate that mammal diversity is still quite high despite the high incidence of introduced mammals in the area. Native mammals were more diverse in the intact bushland areas of the eastern and southern portions of the study area whereas exotic mammals were more prevalent in the cleared agricultural areas in the west. Foxes were particularly evident across the whole of the study area and appear to be having an adverse impact on certain native species.

3.2.7 Introduced Fauna

Six introduced birds and eight introduced mammal species were located during the survey (Table 5; Attachment C). The number of introduced species located at each of the sample sites varied between zero and five species (Table 4).

The species included the Spotted Turtle-Dove (*Streptopelia chinensis*), Common Starling (*Sturnus vulgaris*), Common Myna (*Acridotheres tristis*), Red-whiskered Bulbul (*Pycnonotus jocusus*), House Sparrow (*Passer domesticus*), Eurasian Tree Sparrow (*Passer montanus*), House Mouse (*Mus musculus*), Black Rat (*Rattus rattus*), Domestic Dog (*Canis lupus familiaris*), Red Fox (*Vulpes vulpes*), Cat (*Felis catus*), Brown Hare (*Lepus capensis*), Rabbit (*Oryctolagus cuniculus*) and Goat (*Capra hircus)* (Attachment C).

Of particular note was the extent to which the Red Fox was recorded across the study area. While only sighted at seven sites, fox scats were observed at most sites and also opportunistically across the whole study area, including within the less cleared/disturbed areas such as Dharawal State Conservation Area and the SCA Special Areas.

3.3 THREATENED FAUNA SPECIES

Seventeen threatened species were recorded during the surveys (Figures 4 and 5). These species, together with their sampling sites, respective location co-ordinates and numbers of individuals observed, are outlined in Table 7.

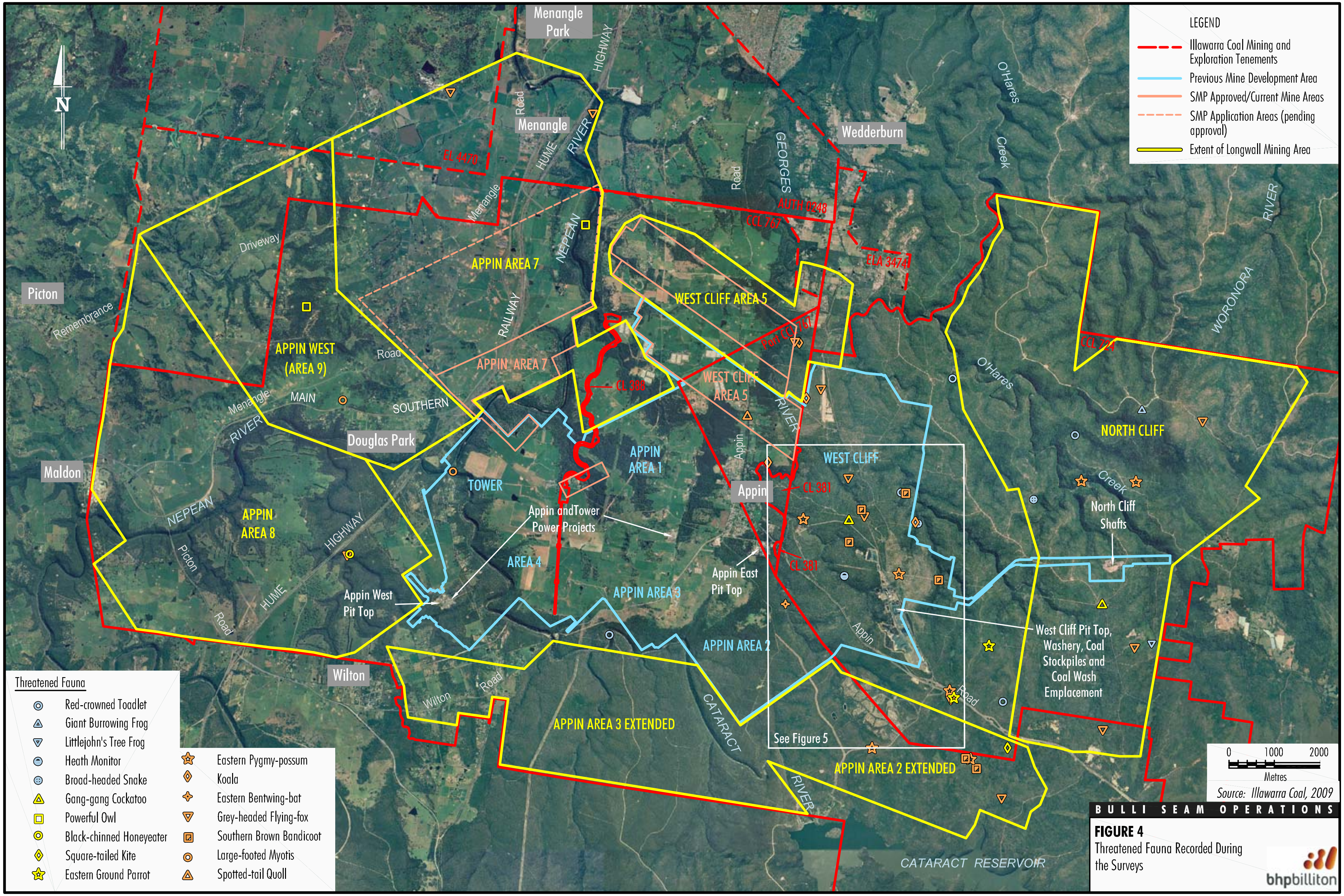


FIGURE 4
Threatened Fauna Recorded During the Surveys

BHPIC-07-01 EA TFauna_104I

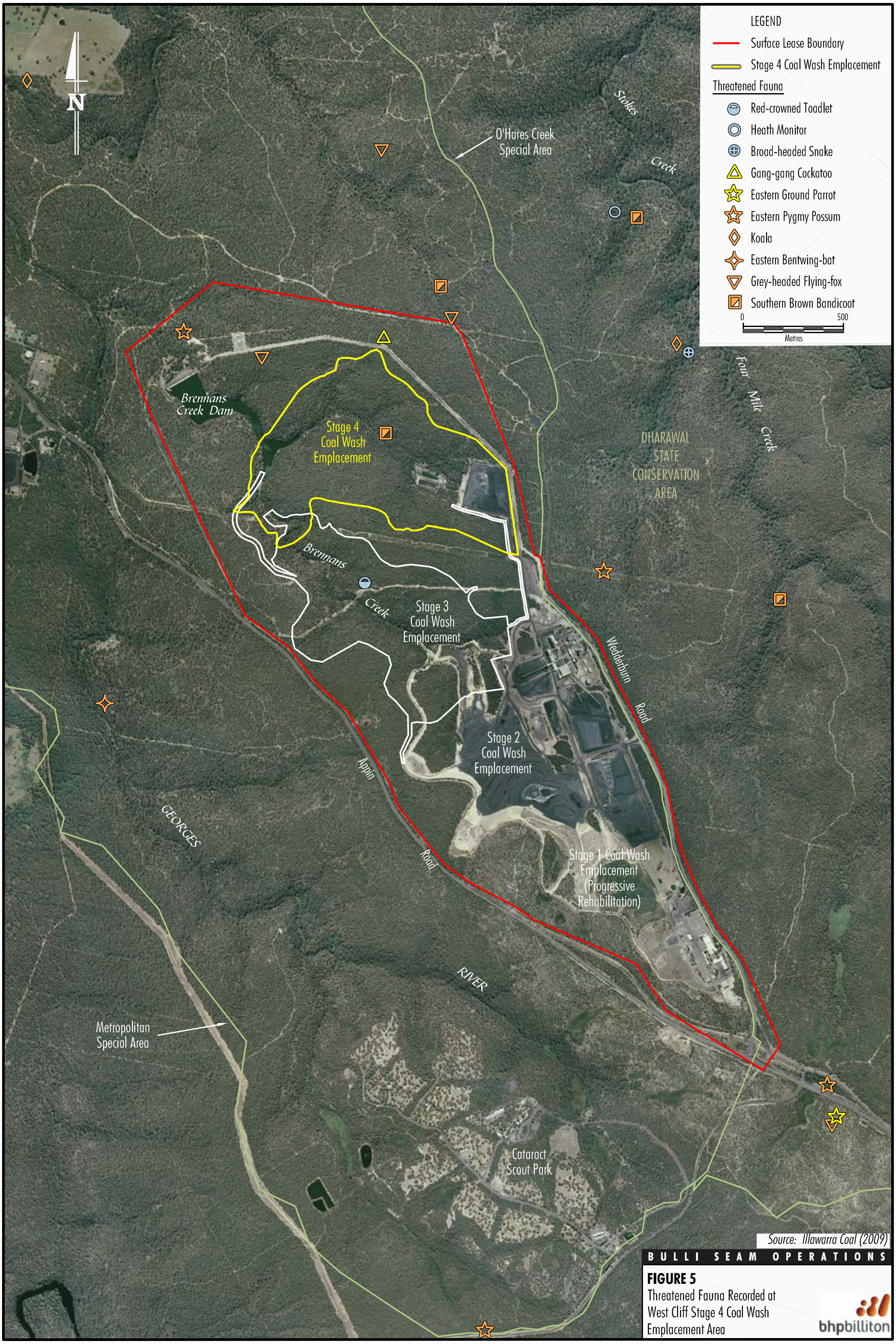


FIGURE 5
Threatened Fauna Recorded at West Cliff Stage 4 Coal Wash Emplacement Area

BHPIC-07-01 EA TFauna_106E

Table 7
Threatened Fauna Species Located During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites	Location of Record (AMG)		Number of Individuals
		TSC Act[1]	EPBC Act[2]		Easting	Northing	
Amphibians							
Giant Burrowing Frog	*Heleioporus australiacus*	V	V	T18	305060	6215260	Tadpoles
Red-crowned Toadlet	*Pseudophryne australis*	V	-	11	293350	6210350	4
				26	303574	6214754	Tadpoles
				Opp	300907	6215976	7
				Opp	299766	6213461	4
				Opp	302009	6208877	3
Littlejohn's Tree Frog	*Litoria littlejohni*	V	V	Opp	305267	6210138	3
Reptiles							
Heath Monitor	*Varanus rosenbergi*	V	-	23	298520	6211642	1
Broad-headed Snake	*Hoplocephalus bungaroides*	E	V	T4	302687	6213326	1
				Opp	300144	6212798	1[3]
Birds							
Eastern Ground Parrot	*Pezoporus wallicus*	V	-	33	300860	6208953	1
				T25	301700	6210106	2
Gang-gang Cockatoo	*Callocephalon fimbriatum*	V	-	24	298590	6212835	6
				Opp	304186	6211016	7
Square-tailed Kite	*Lophoictinia isura*	V	-	Opp	302112	6207865	1
Powerful Owl	*Ninox strenua*	V	-	18	292830	6219360	1
				47	292791	6219537	1
Black-chinned Honeyeater (eastern subspecies)	*Melithreptus gularis*	V	-	43	287612	6212114	2
Mammals							
Spotted-tail Quoll[#]	*Dasyurus maculatus*	V	E	Opp	296391	6215160	1
Southern Brown Bandicoot (eastern)	*Isoodon obesulus obesulus*	E	E	37	298618	6212396	1
				T39	298900	6213100	+
				T42	299880	6213450	+
				T45	300600	6211550	+
				T47	301440	6207405	Skull[4] and +
				T53	301321	627612	+
Koala	*Phascolarctos cinereus*	V	-	20	297523	6216766	1
				T9	297684	6215545	1
				T20	296827	6214124	^
				T50	300077	6212826	1
Eastern Pygmy-possum	*Cercartetus nanus*	V	-	5	303736	6213723	1
				28	304929	6213708	1
				32	299155	6207755	1
				33	300860	6208953	1
				39	297618	6212887	1
				40	299705	6211666	1
				54	301321	6207612	1

Table 7 (Continued)
Threatened Fauna Species Located During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites	Location of Record (AMG)		Number of Individuals
		TSC Act[1]	EPBC Act[2]		Easting	Northing	
Grey-headed Flying-fox	*Pteropus poliocephalus*	V	V	3	304900	6210100	2
				7	298600	6213800	7
				8	298004	6212784	3
				20	297450	6216800	>10
				25	306404	6215046	4
				33	300860	6208953	9
				38	298950	6212944	>10
				43	287612	6212114	4
				45	292980	6221816	4
				49	289837	6222280	10
				52	304212	6208270	7
				53	301991	6206768	4
Eastern Bentwing-bat	*Minopterus schreiberseii oceanensis*	V	-	9	297200	6211000	*
Large-footed Myotis	*Myotis macropus*	V	-	T28	289900	6213960	*
				T30	287500	6215500	*

1 Threatened species status under the TSC Act (current as at 11 May 2009).

2 Threatened species status under the EPBC Act (current as at 11 May 2009).

E – Endangered V – Vulnerable

3 Species identified from shredded skin.

4 Southern Brown Bandicoot (eastern) skull identified by Henk Godthelp (Palaeontologist) from the University of NSW. The skull was identified to the genus *Isoodon* although could not be indentified to species level due to missing the lower jaw. The skull is considered to be recent (i.e. less than 18 months old) due to the presence of skin material and therefore is considered to be the species *Isoodon obesulus* (Southern Brown Bandicoot) due to the historic range restriction of the species *Isoodon macrourus* (Northern Brown Bandicoot) which occurs north of the Hawkesbury River (DECC, 2008; Strahan, 2000).

+ Species identified from diggings inspected in the field by Professor David Goldney with a 90% confidence level that the diggings belonged to the Southern Brown Bandicoot (eastern).

^ Species identified from scratches and number of individuals unknown.

Species observed dead on roadside, due to vehicle strike.

* Species identified using Anabat detectors and number of individuals unknown.

All threatened fauna species in Table 7 were sighted or detected (bats), with the exception of one Koala recording, which was identified from scratches, one Broad-headed Snake recording, which was identified from shedded skin, and five Southern Brown Bandicoot (eastern) recordings, which were identified from diggings and a skull.

4 POTENTIAL IMPACTS ON TERRESTRIAL FAUNA AND THEIR HABITATS

In this section the potential impacts of the Project on terrestrial fauna and their habitats are evaluated.

Potential impacts of the Project on terrestrial fauna and their habitats include those associated with mine subsidence impacts (i.e. the physical changes to the ground and its surface caused by subsidence effects [e.g. surface cracking, buckling and/or dilation]). Alteration of habitat following subsidence due to longwall mining is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2005a). The potential environmental consequences of the subsidence impacts on terrestrial fauna and their habitats are described in Sections 4.1 to 4.5 according to their general locations within the landscape (i.e. slopes and ridgetops, upland swamps, riparian, gently undulating lands and water habitats).

Vegetation clearance and other potential direct or indirect impacts on terrestrial fauna and their habitats are described in Sections 4.6 to 4.8. Cumulative impacts of the Project are described in Section 4.9. An assessment of Koala habitat, in accordance with SEPP 44, is provided in Section 4.7.

Management measures that would be implemented to avoid, minimise or manage potential impacts on terrestrial fauna and their habitats are described in Section 5.

An assessment of the potential impacts of the Project on threatened fauna species, their populations and habitats is provided in Section 6.

While all available evidence has been considered, significant weight has been given to the findings of the *Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield Strategic Review* (herein referred to as the Southern Coalfield Panel Report [SCPR]) (Department of Planning [DoP], 2008) and specific contemporary on-site studies. Hence this evaluation draws on the potential subsidence impacts described in MSEC (2009), potential groundwater impacts described in Heritage Computing (2009), the potential surface water impacts as described in Gilbert and Associates (2009) and the potential flora impacts described in FloraSearch (2009).

Subsidence impacts and other direct, indirect and cumulative impacts have the potential to result in short or long-term changes in fauna habitats and fauna populations. Whether or not a significant impact on fauna in general or a specific species is likely to occur is determined by predicting how potential physical changes to fauna habitats resulting from the Project could initiate changes to fauna species distribution and/or abundance, as well as impact on species-specific population viability. These assessments are based on:

- current baseline knowledge of fauna from surveys described in this report and elsewhere;
- ecological theory including current understanding of population dynamics;
- current studies on mine subsidence-related impacts, hydrogeological and hydrological assessments, and flora surveys;
- knowledge of fire history in this location and the known impacts of fire on fauna distribution and abundance; and
- consideration of relevant legislation including the TSC Act.

4.1 SUBSIDENCE IMPACTS ON SLOPE AND RIDGETOP HABITATS

The habitats identified as Dry Rainforest, Tall Forest, Gully Forest, Open Woodland and Low Woodland Heath and described in Section 3.1 are associated with slopes and/or ridgetops.

Vegetation communities representative of these habitat types include (FloraSearch, 2009):

- Grey Myrtle Dry Rainforest.
- Cumberland Shale Sandstone Transition Forest.
- Cumberland Shale Hills Woodland.
- Nepean Shale Cap Forest.
- Cumberland Moist Shale Woodland.
- Burragorang-Nepean Hinterland Woodland.
- Coastal Sandstone Gully Forest.
- Hinterland Sandstone Gully Forest.
- Sydney Shale – Ironstone Cap Forest.
- Sydney Hinterland Transition Woodland.
- Coastal Sandstone Plateau Heath.
- Coastal Rock Plate Heath.
- Coastal Sandstone Ridgetop Woodland.

The vegetation communities are mapped on Figures 4 to 9 in Appendix E of the EA (Terrestrial Flora Assessment).

Upland Swamp and Riparian habitats are assessed in Sections 4.2 and 4.3, respectively. Subsidence impacts on gently undulating lands are assessed in Section 4.4 and on water habitats in Section 4.5.

Slopes and ridgetops occur across the Project area and would be subject to mine subsidence. Mine subsidence has the potential to result in cracking of the ground surface and shallow rock strata. Surface tension cracking can occur near the tops of the slopes and has the potential to form areas capable of ‘trapping’ some ground dwelling fauna (e.g. frogs and reptiles) in the same way that pitfall traps operate. For example, surface tension cracks have been reported at the Tahmoor Colliery near the top of steep slopes (MSEC, 2009). A single surface tension crack on a steep slope has also been reported at the Metropolitan Colliery (HCPL, 2008). Only minor surface tensile cracking would be expected at the depths of cover in the Project area.

The magnitude of potential surface cracking is considered to be too small to influence the hydrological processes in the slope and ridgetop areas and is therefore unlikely to have any biologically significant effect on existing vegetation due to soil moisture change (Gilbert and Associates, 2009). Any impacts on fauna due to surface cracking would very likely be minor and would not result in an impact that would threaten the viability of any terrestrial fauna species population.

Rock falls occur naturally, however subsidence has the potential to further reduce the stability of features (e.g. cliffs and overhangs) and thereby to increase the incidence of rock fall. Rock falls have the potential to reduce terrestrial fauna habitat resources (e.g. roost sites for bats, nest sites for birds, and shelter for reptiles) or result in the loss of individuals in a few cases (e.g. by entrapment or direct fatal rock fall). However, such rock fall occurrences would be expected to be rare (MSEC, 2009).

There is also limited potential for sections of rock on cliff faces to become unstable, resulting in sliding or toppling failures along the cliffs (*ibid.*). Most of the mining induced cliff falls to date have been observed where the depth of cover to mining was shallow, as in the Western Coalfield, and few cliff falls or rock falls have been observed where the depth of cover is more than 400 m, as generally occurs in the Southern Coalfield (*ibid.*). Cliff instabilities are dependent on a number of factors such as jointing, weaknesses in the rockmass and seepage flow. Potential and likely extent of cliff instabilities are discussed in the Subsidence Assessment (Appendix A of the EA) and in the Major Cliff Line Risk Assessment (Appendix R of the EA).

In regard to the potential for subsidence to result in cliff falls, the DoP SCPR (DoP, 2008), states:

> *Cliff falls, impacts to overhangs, rock outcrops and steep slopes resulting from subsidence have been monitored from a geomorphological perspective for a number of years by Illawarra Coal. More recently, ecological monitoring associated with rock falls and other morphological changes for the Dendrobium area has only identified very minor terrestrial or aquatic ecological impacts (Biosis, 2006).*
>
> *There is little to no evidence that vegetation or fauna habitats have been significantly altered as a result of cliff falls associated with subsidence. The existence of the cliff with a rocky talus slope below is a demonstration that these are dynamic environments, where rock falls are not uncommon over significant periods of time. However, there is potential for large cracks at the surface to act as temporary pitfalls for small ground fauna such as reptiles or small mammals.*
>
> *The Panel inspected valley sides at a number of sites which have been affected by subsidence, including Waratah Rivulet, Upper and Lower Cataract River, Nepean River and Bargo River. It was the opinion of the Panel that whilst a number of small cliff and overhang collapses were observed, these were relatively isolated incidents. It was the general observation of the Panel that the cliff lines and valley sides in many of the areas inspected were remarkably robust, when considering the amount of valley closure that has occurred in places (eg Nepean Gorge valley closure in excess of 460 mm, see Figures 19 and 25).*

Given the predicted low incidence of rock falls (MSEC, 2009), it is considered unlikely that rock falls or other instabilities at the surface resulting from mine subsidence would threaten the viability of any individual species population.

4.2 SUBSIDENCE IMPACTS ON UPLAND SWAMP HABITAT

Upland swamps on the Woronora Plateau occur in small headwater valleys that are characteristically sediment choked and swampy. The upland swamp habitat is described in Section 3.1.7. Vegetation communities representative of the upland swamp habitat include Coastal Upland Swamp, Fringing Eucalypt Woodland, Banksia Thicket, Sedgeland-heath complex and/or Tea Tree Thicket and form complex blending mosaics across the landscape. The distribution of upland swamps across the Project area is shown in the Terrestrial Flora Assessment (Appendix E of the EA) and the Upland Swamp Risk Assessment (Appendix O of the EA). These two appendices also provide further information regarding the characteristics of the upland swamps of the Project area.

Alteration of habitat following subsidence due to longwall mining is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2005a). Concerns raised by the Scientific Committee, government agencies and the community are that mine subsidence may significantly affect the water balance of upland swamps through cracking, buckling, dilating and/or tilting of their underlying sandstone base leading to subsequent desiccation of the swamp, increased susceptibility to fire, erosion and associated loss of specialised swamp biota (DoP, 2008).

These concerns are based on severe soil erosion events and/or vegetation composition changes in three in-valley swamps, Swamp 18, Swamp 19 and Flat Rock Swamp that have been attributed by some to underground mining (Krogh, 2007 in FloraSearch, 2009). However, in all three cases the evidence for the association between mining and the disturbance to the swamps is equivocal (DoP, 2008). A key problem in determining the impact of underground mining on upland swamps is distinguishing natural disturbances to swamps from any that may be related to mining (FloraSearch, 2009).

Further to the above, the NSW Planning Assessment Commission's *Metropolitan Coal Project Review Report* (May, 2009) (the Metropolitan PAC Report) identified three potential impact mechanisms for upland swamps and recommended an assessment framework. In accordance with this recommendation the potential impacts of the Project on upland swamps are assessed in the Upland Swamp Risk Assessment (Appendix O of the EA). The information presented in the Upland Swamp Risk Assessment has been prepared with input from Bio-Analysis, FloraSearch, Biosphere Environmental Consultants, Gilbert & Associates, Heritage Computing, MSEC and Gillespie Economics. As provided in the Upland Swamp Risk Assessment, only a small proportion of upland swamps are likely to be subject to significant negative consequences. These swamps would have detailed Risk Management Plans prepared which would include detailed mitigation, remediation and monitoring measures (Appendix O of the EA). Given this, it is considered unlikely that fauna species associated with upland swamps would be adversely impacted by the Project to the extent that the viability of any fauna population would be put at risk.

4.3 SUBSIDENCE IMPACTS ON RIPARIAN HABITAT

The Riparian habitat is described in Section 3.1.5. Vegetation communities representative of the Riparian habitat include areas of Cumberland River Flat Forest, Riverbank Forest, Sandstone Riparian Scrub and Coastal Sandstone Gully Forest (Figures 4 to 9 in Appendix E of the EA). The degradation of native riparian vegetation along NSW watercourses is listed as a key threatening process under the *Fisheries Management Act, 1994* (FM Act).

Mining can potentially result in localised increases in levels of ponding, flooding or scouring in locations where mining induced tilts are greater than the natural stream gradients (MSEC, 2009). However, the predicted tilts (between 6.5 millimetres per metre [mm/m] [0.65%] and 11 mm/m [1.1%]), are small when compared to the existing natural grades and are unlikely to result in any significant increases in the level of ponding, flooding or scouring in the majority of streams (*ibid.*)

MSEC (2009) indicate that the downstream sections of Foot Onslow, Navigation and Racecourse Creeks at the base of the Razorback Range have average bed slopes of 10 mm/m, 9 mm/m and 11 mm/m, respectively. Mining induced tilts in these areas may cause localised reversal of the existing bed slope and subsequent additional ponding in some sections (MSEC, 2009). These changes are expected to be localised in nature (e.g. within a 130 m section for Navigation Creek and two short sections of Foot Onslow Creek [both less than 90 m]), minor (e.g. pond depths of less than 500 mm), and are not expected to significantly alter the hydrology and subsequent habitat availability along these streams (Gilbert and Associates, 2009). In addition, the ponding is expected to be retained within the existing stream alignments (MSEC, 2009).

The Project stream impact minimisation criteria includes avoidance of impacts such as significant cracking of rock bars that would result in surface flow diversion and draining of pools along a number of streams, including the Cataract River, Georges River (in West Cliff Area 5), Lizard Creek, Nepean River O'Hares Creek and Stokes Creek (downstream of Longwall 5a – refer to Appendix A of the EA). In addition, the Project avoids directly mining beneath the headwater reaches of the Georges and Woronora Rivers labelled as "perennial" on 1:25,000 topographic mapping (Lands Department, 2000). This would reduce potential impacts on the Riparian habitat of these streams.

However there are a number of streams within the Project area which are predicted to experience cracking to an extent that diversion of some flow would be expected (Section 4.5). In these sections of stream, low flows are expected to be less persistent and some pools would drain more rapidly. In some areas this may result in a reduction of water availability for riparian vegetation during prolonged dry periods, leading to potential consequences such as vegetation dieback. However, evidence to date from existing mining operations suggests that such occurrences are quite limited in extent and are temporary. At the Metropolitan Colliery a small section of streamside vegetation dieback was observed along the bank of Waratah Rivulet following subsidence effects such as those described above and the onset of drought conditions (HCPL, 2008). However, monitoring indicated that the effects to vegetation condition were predominantly temporary with plants recovering upon the return of stream flows (*ibid.*).

Strata gas emissions have been observed in the bases of steams and other areas as a result of longwall mining and may adversely impact on riparian vegetation (MSEC, 2009). There is one known case where strata gas emissions within the Cataract River gorge at Tower Colliery adversely affected vegetation in a localised area (approximately 0.12 ha). Subsequently, with the assistance of tubestock planting, impacted riparian vegetation within the Cataract River gorge was observed to regenerate rapidly (Biosis, 2007). Strata gas emissions are expected to occur as a result of mine subsidence caused by the Project (MSEC, 2009), however such occurrences are not expected to significantly impact on Riparian habitat for fauna.

Mine subsidence is also expected to result in rock fall which may impact on riparian vegetation. However, given the predicted low incidence of rock falls and cliff instabilities (MSEC, 2009), the potential impacts on Riparian habitats as a result of rock fall are expected to be minor. Further, the DoP SCPR (DoP, 2008), states:

> *There is little to no evidence that vegetation or fauna habitats have been significantly altered as a result of cliff falls associated with subsidence.*

Potential impacts of subsidence on water habitats are described in Section 4.5.

4.4 SUBSIDENCE IMPACTS ON GENTLY UNDULATING LANDS

The habitats identified as Open Woodland and Cleared Agricultural Land described in Sections 3.1.3 and 3.1.8, respectively, are associated with gently undulating lands. Vegetation communities representative of these habitat types include Cumberland Shale Sandstone Transition Forest, Cumberland Shale Hills Woodland, Cumberland Shale Plains Woodland, and Modified or Disturbed Land. The vegetation communities are mapped on Figures 4 to 9 of the Terrestrial Flora Assessment (Appendix E of the EA). Riparian habitats associated with gently undulating lands are assessed in Section 4.3.

Mine subsidence has the potential to cause cracking. However, cracking of the soil profile on gently undulating lands is not commonly observed at depths of cover greater than 400 m (MSEC, 2009). The depth of cover in the Project areas of gently undulating lands is typically greater than 480 m (MSEC, 2009). Were cracking to occur, it is expected to be minor occurrences only and considered highly unlikely that it would be capable of trapping any significant number of ground dwelling fauna.

The magnitude of potential surface cracking would be too small to influence the hydrological processes in these areas and is unlikely to have any biologically significant effect on existing vegetation of the Open Woodland habitats due to soil moisture change (Gilbert and Associates, 2009).

4.5 SUBSIDENCE IMPACTS ON WATER HABITATS

Potential impacts on water habitats are described below. The following section is substantially based on Gilberts and Associates (2009). Water habitats include more persistent or perennial sources of water (e.g. Cataract River, Nepean River, O'Hares Creek, Georges River, Stokes Creek), intermittent sources of water (e.g. Ousedale Creek, Harris Creek and Byrnes Creek and flood lagoons and ox-bows such as those in the lower sections of the Nepean River near Menangle), farm dams and non-persistent sources of water (e.g. general surface ponding, ponded water adjacent to fire trails and the headwaters of ephemeral streams).

A range of fauna species are likely to utilise water habitats as a source of drinking water (e.g. the Eastern Grey Kangaroo) or for other components of their lifecycle such as feeding (e.g. many lizards, small mammals and microchiropteran bats), bathing (e.g. small birds) or breeding (e.g. frogs). For example, the Eastern Water Dragon (*Physignathus lesuerii*), a semi-aquatic arboreal lizard feeds on a variety of insects and aquatic organisms including frogs, as well as other small terrestrial fauna, while the Common Eastern Froglet (*Crinia signifiera*) is known to breed in slow-flowing streams after rain, calling from within shallow water or fringing grass or leaf-litter (Cogger, 2000).

Due to the spatial extent of the Project and the number and variation of water habitats present, potential subsidence impacts on water habitats are described separately in Sections 4.5.1 to 4.5.7 for each of the seven mining domains (i.e. Appin Area 2 Extended, Appin Area 3 Extended, West Cliff Area 5, Appin Area 7, Appin Area 8, Appin West [Area 9] and North Cliff) and are then summarised in Section 4.5.8.

The effects of subsidence on flow and water quality in streams will depend on its geomorphic nature and its hydrological characteristics. The character of streams in the Project Application area varies significantly in terms of (Gilbert and Associates, 2009):

- scale (i.e. ranging from the Nepean River which commands a catchment of 1,233 square kilometres [km^2] [at the downstream end of the Project area] compared to the tributary of Carriage Creek which has a catchment area of approximately 0.5 km^2);
- geology and geomorphic character (i.e. ranging between catchments dominated by Hawkesbury Sandstone which are typically deeply incised gullies that follow a strata controlled alignment dominated by rock-bars, pools and boulders with sparse fine sediment deposits; and those formed in Wianamatta Shales which typically follow an alignment and have a cross sectional form determined by alluvial processes); and
- level of development (i.e. ranging from the highly regulated and modified watercourses such as the Nepean River to streams in largely undisturbed catchments such as Stokes Creek in the Dharawal State Conservation Area).

The potential effects of subsidence on streams within the Project area can be usefully generalised into two types (*ibid.*):

1. Incised, strata controlled watercourses which have formed in the erosion resistant Hawkesbury Sandstone terrain.
2. Alluvial watercourses which are controlled by fluvial morphological processes and which have formed in weathered and erodible Wianamatta Shale terrains.

Incised Valleys in Hawkesbury Sandstone

Where subsidence and in particular valley closure in streams formed in the Hawkesbury Sandstone is sufficient to result in cracking of rock bars and development of significant cracking and dilation (generally limited to 15 to 20 m in depth), the following effects are expected (Gilbert and Associates, 2009):

- capture of a proportion of low flows and the diversion of this water downstream via the created underground fracture network;
- re-emergence of surface flow downstream of the affected area;
- reduced frequency of pools overflowing and lower pool water levels during dry weather;
- reduced and periodic loss of interconnection between pools during dry weather;
- small changes in bed gradients and limited potential for scouring at locations where tilts considerably increase the natural pre-mining stream gradients;
- localised and transient increases in iron concentrations and other minerals due to flushing from freshly exposed fractures in the sandstone rocks;
- creation and/or enhancement of existing rich springs; and
- drainage of strata gas (i.e. release of methane-rich gases from overburden sequences above the coal seam).

Alluvial Valleys in Wianamatta Shale

These streams are typically formed in relatively shallow open valleys and the valley closure and upsidence are usually smaller than occurs in the Hawkesbury Sandstone terrains. In addition, the nature of the substrates in these areas generally allow the sediments to be subject to subsidence movements without creating the interconnected dilation type of cracking that occurs in the Hawkesbury Sandstone terrains (MSEC, 2009). Past experience indicates that subsidence impacts on streams formed in the Wianamatta shale terrain typically include localised and relatively isolated cracking of bed sediments; creation of transient and permanent pools in subsidence depressions and/or alteration to existing pools; and small scale bed and bank scour due to local increases in bed and bank slope. The predominance of clay rich (cohesive) bed sediments in these watercourses means that subsidence induced cracks are more likely to self-seal over time when compared to streams bedded in the Hawkesbury Sandstone. The cohesive bed sediments are also expected to result in reduced bed and bank erosion and morphological change would be toward a new equilibrium in channel form. These changes are expected to be relatively slow and be masked by and much less significant than earlier disturbances associated with general land clearing in these catchments (Gilbert and Associates, 2009).

There is also the possibility of transient strata gas emissions from the subsided landscape including within these streams. Emissions within streams are evident from bubbling in existing pools or slow moving water bodies. There is unlikely to be any significant loss of flow, with any localised loss being of a temporary nature (*ibid.*).

Farm Dams

Farm dams are typically constructed within streams. Mining induced tilts have the potential to affect water levels around the perimeters of farm dams (with the freeboard increasing on one side and decreasing on the other) and therefore reducing the storage capacity. Where farm dam walls are subjected to higher strains they may experience some minor cracking and leakage of water (MSEC, 2009). However, it is unlikely that these effects would have a material impact on water habitats available to terrestrial fauna, particularly given that any such damage to landowner improvements would be repaired by the Mine Subsidence Board (Appendix A of the EA).

4.5.1 Water Habitats in Appin Area 2 Extended

Streams within this domain include the headwater reach of the Georges River, unnamed tributaries of the Cataract Reservoir and Cataract River and a section of the Cataract River downstream from the Cataract Dam, all of which are classed as incised valleys in Hawkesbury Sandstone (*ibid.*).

Within this domain, the Project stream impact minimisation criteria includes avoidance of impacts such as significant cracking of rock bars that would result in surface flow diversion and draining of pools along the Cataract River. In addition, the Project avoids directly mining beneath the headwater reaches of the Georges River labelled as “perennial” on 1:25,000 topographic mapping (Lands Department, 2000) and therefore reduces potential impacts to this stream.

In regard to potential impacts of the Project on the Cataract River, Gilbert and Associates (2009) indicates that small localised impacts including increased iron staining and transient spikes in water quality parameters such as iron are expected. Emissions of strata gas which would be seen as bubbling for a period of time in some pools would also be expected.

In regard to the headwater reach of the Georges River and unnamed tributaries of the Cataract Reservoir and Cataract River, Gilbert and Associates (2009) indicate that potential impacts are expected to include localised cracking of rock bars and shelves, diversion of a portion of low flows during dry periods, along with continued iron staining, and periodic pulses of water quality parameters such as iron.

4.5.2 Water Habitats in Appin Area 3 Extended

Streams within this domain include the Cataract River, three named tributaries of the Cataract River (i.e. Lizard, Wallandoola and Cascade Creeks), one un-named tributary of the Cataract River (located between Lizard and Wallandoola Creeks), a section of Clements Creek and Third Point Creek, all of which are classed as incised valleys in Hawkesbury Sandstone (*ibid.*).

Within this domain, the Project stream impact minimisation criteria includes avoidance of impacts such as significant cracking of rock bars that would result in surface flow diversion and draining of pools along the Cataract River and Lizard Creek. Potential impacts of the Project on the Cataract River and Lizard Creek are expected to include localised cracks along with increased iron staining and transient spikes in water quality parameters such as iron. Emissions of strata gas which would be seen as bubbling for a period of time in some pools would also be expected.

Potential impacts of the Project on Wallandoola Creek, Cascade Creeks, the un-named tributary of the Cataract River, Clements Creek and Third Point Creek include cracking and localised flow diversion (including reduced water level and drying during dry weather at some pools), iron staining and transient spikes in water quality parameters such as iron in areas where flows emerge from subsidence induced cracks and temporary strata gas emissions for a period of time (*ibid.*).

4.5.3 Water Habitats in West Cliff Area 5

Streams

Streams within this domain include the Georges River, Stokes Creek and several small tributaries of the Nepean River, notably Nepean Creek and Mallaty Creek, all of which are classed as incised valleys in Hawkesbury Sandstone[2] (*ibid.*).

Within this domain, the Project stream impact minimisation criteria includes avoidance of impacts such as significant cracking of rock bars that would result in surface flow diversion and draining of pools along the Georges River and Stokes Creek. Whilst cracking leading to localised surface flow loss via underflow is unlikely to occur in these streams, it is likely that there would be isolated instances of cracking and associated iron staining, transient spikes in water quality parameters such as iron and temporary strata gas releases in some pools (Gilbert and Associates, 2009).

Potential impacts of the Project on smaller streams in this domain, notably Nepean Creek and Mallaty Creek include reduced pool water levels and persistence of inter-pool flow, isolated iron staining and spikes in water quality parameters such as iron and likely transient strata gas emissions.

Platypus Record

A Platypus was recorded in the Georges River at Site 20 (within the West Cliff Area 5 domain) during the Project surveys. In April 2009, a Platypus was also recorded at the Appin East pit top discharge point to Georges River by ICHPL employees. Although the Platypus is not listed as a threatened species in the TSC Act or EPBC Act, they are viewed as iconic animals within Australia and the need to assess any impacts to the species remains. Mainly nocturnal, the Platypus forages on stream biota such as insect larvae, freshwater shrimp or adult insects on the surface of the water (DEC, 2002). Out of the water, the Platypus spends most of its time in burrows which have been dug into the river bank, with their entrances usually above water level (DEC, 2002). The Platypus uses a number of short resting burrows (3 to 5 m long) as protection from predators and temperature extremes.

Potential habitat for the Platypus may occur in streams other than the Georges River, although extensive surveys within the Stokes Creek catchment, O'Hares Creek catchment and the upper Georges River catchment by Grant *et al.* (2008), did not identify any Platypus. Prior to the Project surveys there were only a few relatively recent reports of platypuses occurring in the upper Georges River or its tributary streams (Grant *et al.*, 2008). Grant (2002) surveyed the upper reaches of the Georges River, between the Cataract Scout Camp and The Woolwash, at the junction with O'Hares Creek, near Campbelltown. The 2002 survey yielded no definite observations or captures of platypuses in the upper Georges River, but reported several tentative sightings (Grant, 2002). In 2004, an animal was apparently found trapped in a rock hole in the sandstone less than a kilometre upstream of Freres Crossing at Campbelltown in March, 2004 (reported to Dr Rob Close UWS by Tina and Paul Hines).

[2] Although classified as incised valleys in Hawkesbury Sandstone, significant fluvial/alluvial processes occur in the less incised upper reaches of Nepean Creek and Mallaty Creek (Gilbert and Associates, 2009).

As described above and in Section 2 of the EA, the Project stream impact minimisation criteria includes avoidance of impacts such as significant cracking of rock bars that would result in surface flow diversion and draining of pools along the Georges River (in West Cliff Area 5), O'Hares Creek, Stokes Creek (downstream of Longwall 5a – refer to Appendix A of the EA), Nepean River, Cataract River and Lizard Creek. In addition, the Project avoids directly mining beneath the headwater reaches of Georges and Woronora Rivers labelled as "perennial" on 1:25,000 topographic mapping (Lands Department, 2000) which would reduce potential impacts on these streams. Based on the limited potential impacts of the Project on known and potential habitat for this species, it is considered very unlikely that Project would impact a Platypus population within the Project extent of longwall mining area.

4.5.4 Water Habitats in Appin Area 7

Named streams within this domain include the Nepean River, Foot Onslow Creek, Navigation Creek and Ousedale Creek. The Nepean River and Ousedale Creek are classified as incised valleys in Hawkesbury Sandstone while Foot Onslow and Navigation Creeks are classified as alluvial valleys in Wianamatta Shale that may also contain isolated rocky outcrops (Gilbert and Associates, 2009).

Within this domain, the Project stream impact minimisation criteria includes avoidance of impacts such as cliff falls along the Nepean River. Gilbert and Associates (2009) consider it highly unlikely that there would be any observable effects on stream flow or water levels in the Nepean River within this domain. Some shallow in-stream cracking is expected, resulting in iron staining, transient spikes in water quality parameters such as iron and transient strata gas releases causing bubbling in the Menangle Weir pool (*ibid.*).

In regard to Foot Onslow and Navigation Creeks, Gilbert and Associates (2009) indicate that impacts on these streams are expected to be limited to: localised areas of iron staining; possibly cracking and enhanced leakage from farm dams and pools (where present); and possible low flow diversion in areas of rock outcrop or where bedrock is covered by a thin mantle of alluvium. These effects are unlikely to be pervasive.

The expected impacts of the Project on Ousedale Creek within Appin Area 7 would be similar to those observed in the previously undermined section of the streams namely reduced low flow persistence due to underflow diversion, minor iron staining and transient spikes in water quality parameters such as iron and transient releases of strata gas.

4.5.5 Water Habitats in Appin Area 8

Named streams within this domain include the Nepean River and Allens, Carriage, Byrnes and Racecourse Creeks. The Nepean River, Allens Creek, Carriage Creek, Byrnes Creek and the upper reaches of racecourse Creek are classified as incised valleys in Hawkesbury Sandstone while the lower reaches of Racecourse Creek is classified as an alluvial valley in Wianamatta Shale (*ibid.*).

Within this domain, the Project stream impact minimisation criteria includes avoidance of impacts such as cliff falls along the Nepean River. The predicted valley closure movements along the Nepean River within this domain are considered insufficient to cause any significant cracking and subsequent flow loss. Some shallow cracking is expected, however the cracks are unlikely to extend greater than 15 to 20 m in depth and being located wholly within a ponded section of the Nepean River there is unlikely to be any loss of the ponded water other than a "one off" settling of water to fill the cracks.

In regard to Allens Creek, the confluence with the Nepean River is within the weir pondage of the Douglas Park Weir which is unlikely to be affected by mining. The first 500 m of Allens Creek upstream of the confluence with the Nepean River, which is mostly a boulder field, is not expected to have any noticeable flow and/or water level impacts. Potential impacts in the upstream sections of Allens Creek include lowering of pool water level (in the few locations where pool water levels are controlled by rock bars) or loss of surface flow over rock bars during dry weather flow conditions. Iron staining, transient spikes in water quality parameters such as iron and strata gas emissions are also expected (*ibid.*).

In regard to Carriage Creek, the predicted subsidence effects are sufficient to cause cracking of at least some of the rock bars, which would lead to low flow diversion and lowering of pool water levels and reduced interconnectivity between pools during dry weather. There is expected to be some localised and transient increases in iron concentrations and transient strata gas releases (*ibid.*).

Potential impacts on Byrnes Creek include iron staining and transient increases in iron concentrations in runoff waters and possibly a lowering of water level and more frequent drying of the pool mapped in the upper reaches (*ibid.*).

In regard to Racecourse Creek, the predicted impacts are expected to be limited to localised areas of iron staining, possibly cracking and surface flow diversion in the headwaters and induced leakage in pools and farm dams in the lower reaches. Gilbert and Associates (2009) consider it unlikely that any of these types of impact would be pervasive but rather isolated incidents.

4.5.6 Water Habitats in Appin West (Area 9)

Streams within this domain include the Nepean River, the upper reaches of Racecourse Creek, the upper reaches of Navigation Creek, the upper reaches of Matahill Creek, Harris Creek and a small un-named tributary of the Nepean River. The Nepean River, Harris Creek and the un-named tributary of the Nepean River are classified as incised valleys in Hawkesbury Sandstone while Racecourse Creek and the upper reaches of Matahill Creek are classified as an alluvial valley in Wianamatta Shale (*ibid.*)

Within this domain, the Project stream impact minimisation criteria includes avoidance of impacts such as cliff falls along the Nepean River. Gilbert and Associates (2009) indicates that due to the protection afforded to the Douglas Park Weir, there are no expected impacts to flow or pool depth in the long pool created by the Douglas Park Weir. Some iron staining caused by shallow in-stream cracking liberating iron and other minerals is expected, as is the transient strata gas releases causing bubbling in the weir pool. Marginal increases in predicted valley closure further downstream and opposite the former Tower Colliery longwall panels is expected to result in small iron stains, transient spikes in water quality parameters such as iron and strata gas emissions (*ibid.*).

Impacts on the headwaters of Racecourse Creek are expected to include localised areas of iron staining, transient spikes in water quality parameters such as iron and areas of surface flow diversion.

In regard to Matahill and Navigation Creeks, Gilbert and Associates (2009) indicate that the potential impacts are expected to include isolated instances of iron staining and spikes in water quality parameters such as iron, transient strata gas emission and induced leakage in pools and farm dams. It is considered unlikely that any of these types of impact would be pervasive but rather there may be some isolated incidents (*ibid.*).

The potential impacts of subsidence on Harris Creek and the un-named tributary of the Nepean River include iron staining, transient spikes in water quality parameters such as iron, likely strata gas emissions, reduced pool levels in dry weather and localised underflow. These effects are likely to be isolated (*ibid.*).

4.5.7 Water Habitats in North Cliff

Streams within this domain include Woronora River and O'Hares, Stokes, Dahlia, Cobbong and Punchbowl Creeks, all of which are classified as incised valleys in Hawkesbury Sandstone (*ibid.*)

Within this domain, the Project stream impact minimisation criteria includes avoidance of impacts such as significant cracking of rock bars that would result in surface flow diversion and draining of pools along O'Hares Creek and Stokes Creek (downstream of Longwall 5a – refer to Appendix A of the EA). In addition, the Project avoids directly mining beneath the headwater reaches of Woronora River labelled as "perennial" on 1:25,000 topographic mapping (Lands Department 2000) and therefore reduces potential impacts to this stream.

In the Woronora River, there is expected to be minor (i.e. localised and small scale) impacts including cracks forming in rock bars and rock shelves, increases in iron staining naturally present and the potential for minor transient strata gas emission in some pools (although this has not been observed at the adjacent Metropolitan Colliery). These effects, if they do occur, are expected to be isolated. The risk of subsidence effects leading to flow loss within the Woronora River catchment being anything other than a localised loss of surface water and increase in underflow where natural underflow has already been observed is considered to be very low (*ibid.*).

Gilbert and Associates (2009) indicates that the potential impacts on surface water hydrology of O'Hares Creek are expected to be small and from a practical perspective negligible. There is however a risk of minor impacts including isolated cracking and associated iron staining and increases in iron concentrations. Transient strata gas emissions seen as bubbling in pools is considered unlikely given that none have been observed at the adjacent Metropolitan Colliery.

In regard to Stokes Creek, there is some potential for cracking leading to localise underflow to occur over a relatively short stretch of stream where the predicted valley closure is in excess of 200 mm (i.e. upstream of Longwall 5a – refer to Appendix A of the EA). This could lead to reduced pool water levels during dry weather and possibly shallow pools drying up during prolonged dry weather. It is also likely that increased iron staining and transient spikes in water quality parameters such as iron could occur in the area and some strata gas release (*ibid.*).

Potential impacts of the Project on Dahlia, Cobbong, and Punchbowl Creeks include cracking and localised surface flow diversion (including reduced water level and drying of pools during dry weather), transient increases in iron concentrations and iron staining in areas where flows emerge from subsidence induced cracks (*ibid.*). Transient strata gas emissions seen as bubbling in pools is considered unlikely given that none have been observed at the adjacent Metropolitan Colliery.

4.5.8 Subsidence Impacts on Water Habitats – Summary

The alteration of natural flow regimes of rivers and streams is recognised as a key threatening process under the TSC Act and FM Act. The Project stream impact minimisation criteria includes avoidance of impacts such as significant cracking of rock bars that would result in surface flow diversion and draining of pools along the Cataract River, Georges River (in West Cliff Area 5), Lizard Creek, Nepean River, O'Hares Creek and Stokes Creek (downstream of Longwall 5a – refer to Appendix A of the EA). In addition, the Project avoids directly mining beneath the headwater reaches of the Georges and Woronora Rivers labelled as "perennial" on 1:25,000 topographic mapping (Lands Department 2000), and therefore reducing potential impacts to these streams.

Mine subsidence would result in cracking of the rock strata in other streams (e.g. Allens Creek, Carriage Creek, Dahlia Creek, Punchbowl Creek, Tributary of Cataract Reservoir and Wallandoola Creek) which is expected to result in reaches of streams where the conveyance of a portion of low flows via the fracture network occurs, and a reduction in water level in pools as they become hydraulically connected with the fracture network. There is also expected to be reduced continuity of flow between affected pools during dry weather. Gilbert and Associates (2009) indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flow conditions.

Pool water levels would fluctuate in response to stream flow variability (i.e. increasing during periods of increasing flow and reducing with flow recession). Gilbert and Associates (2009) indicate that during periods of significant rainfall and runoff, the water level in subsidence impacted pools would be similar to pools unaffected by subsidence. Under these flow conditions pools and their downstream rock bars would become "drowned out". During dry periods when flows are in a low, recessionary regime the water level in pools affected by subsidence would recede much faster than is the case in unaffected pools (*ibid.*). Experience has shown however that a range of different effects can occur in response to subsidence induced cracking with some pools retaining water through dry periods (Gilbert and Associates, 2009).

Mine subsidence is also expected to result in localised changes in stream water quality. The effects of subsidence on water quality have been most noticeable as localised and transient changes (spikes or pulses) in iron, manganese and to a lesser extent aluminium, zinc and nickel and minor associated increases in electrical conductivity (Gilbert and Associates, 2009). The most likely mechanism for this appears to be flushing of minerals from freshly exposed cracks created by upsidence and valley closure (*ibid.*). These pulses are generally isolated and non-persistent (Gilbert and Associates, 2009).

Farm dams are typically constructed within streams. Mining induced tilts have the potential to affect water levels around the perimeters of farm dams (with the freeboard increasing on one side and decreasing on the other) and therefore reducing the storage capacity. Where farm dam walls are subjected to higher strains they may experience some minor cracking and leakage of water (MSEC, 2009). However, it is unlikely that these effects would have a material impact on water habitats available to terrestrial fauna, particularly given that any such damage to landowner infrastructure would be repaired by the Mine Subsidence Board (Appendix A of the EA).

Non-persistent sources of water (e.g. seeps, general surface ponding, ponded water adjacent to fire trails and the headwaters of ephemeral streams in slope and ridgetop or gently undulating lands) are generally available to terrestrial fauna during and for a period following rain. The magnitude of surface cracking predicted by MSEC (2009) is considered unlikely to significantly influence the hydrological processes in these areas (Gilbert and Associates, 2009) and therefore significant changes to the availability of these sources of water to terrestrial fauna is not expected.

In consideration of the nature of the potential impacts described above and the lifecycle components of terrestrial fauna that may utilise the water habitats, it is unlikely that any fauna population would be put at risk by the potential subsidence-related impacts. Many of the terrestrial fauna species are known to utilise a range of habitats, or are mobile allowing them to move to alternative habitat in response to changes in stream flows or water levels. For species that are likely to utilise small pools rather than large bodies of water (e.g. frogs), a number of small pools that create micro-habitat are expected to remain which hold water even during periods of persistent low flows.

4.6 VEGETATION CLEARANCE ACTIVITIES

The Project includes some vegetation clearance activities. Clearing of native vegetation is listed as a key threatening process under the TSC Act. Vegetation within the Project area provides terrestrial fauna with opportunities (to varying degrees) for foraging, breeding, nesting, shelter and movement between areas. These opportunities could potentially be reduced by Project-related habitat disturbance.

Coal wash produced by the Project would be placed at the West Cliff Stage 4 Coal Wash Emplacement (Figure 3). The West Cliff Stage 4 Coal Wash Emplacement covers an area of approximately 76 ha and would remove approximately 65 ha of remnant vegetation of Coastal Sandstone Ridgetop Woodland (approximately 43 ha) and Hinterland Sandstone Gully Forest (approximately 22 ha) (Figure 9 of the Terrestrial Flora Assessment [Appendix E of the EA]).

The upper slopes and ridges of the West Cliff Stage 4 Coal Wash Emplacement Area comprise open woodland that is in various stages of regeneration following fire in 2000. Most of the trees are small, being less than approximately 8 m in height. Few have hollows and there is little fallen timber on the ground. The upper slopes have little surface rock protruding and it is not until ephemeral streams are reached that sandstone is exposed. The West Cliff Stage 4 Coal Wash Emplacement Area contains three small un-named tributaries of Brennans Creek that drain to Brennans Creek Dam. Logs and fallen timber occur across the valley floor. The Stage 4 Coal Wash Emplacement would result in the storage capacity of Brennans Creek Dam being reduced by approximately 15%.

Other vegetation clearance activities (less than 37 ha of the approximated 9,845 ha of remnant native vegetation across the study area) would primarily be associated with ongoing surface exploration activities, the upgrade and extension of surface infrastructure (e.g. gas wells and service boreholes), access tracks, environmental monitoring and management activities (e.g. installation of monitoring equipment), potential stream restoration activities and other minor Project-related surface activities. The specific location of these vegetation clearance activities would be detailed in the relevant Mining Operations Plan (MOP) and Extraction Plan[3] as required by the NSW Department of Primary Industries-Mineral Resources (DPI-MR). Where practicable, surface works would be sited to minimise the amount of vegetation clearance required.

Vegetation clearance at the West Cliff Stage 4 Coal Wash Emplacement and in other Project areas would be managed through the development and implementation of a Biodiversity Management Plan under the Part 3A Approval. Vegetation clearance would be progressive over the life of the Project. As a result, at any one time some small areas are likely to be disturbed (i.e. in the order of 4 ha outside of the emplacement area and in the order of 25 ha within the emplacement area), while other areas would be in various stages of rehabilitation.

3 In accordance with the precedent set by the Metropolitan Coal Project Approval, it is envisaged that the previous Mining Lease requirement for preparation of a Subsidence Management Plan prior to mining would be replaced by a requirement to prepare an Extraction Plan for the Project. Further discussion of the detail that would be provided in the Extraction Plan is provided in Section 7.3.1 of the EA Main Report.

Project infrastructure (including surface works such as surface exploration activities, access tracks, and environmental monitoring equipment) would generally be located to avoid vegetation clearance in Endangered Ecological Communities (EECs). Two EEC's, namely Shale Sandstone Transition Forest in the Sydney Basin Bioregion and Moist Shale Woodland in the Sydney Basin Bioregion are currently mapped extensively across the western portions of the Project area (FloraSearch, 2009) and complete avoidance of clearing in these is not feasible. However, the undertaking of surface activities in these EEC's would be subject to a specific management process (detailed in FloraSearch [2009]) and clearing would be limited to approximately 9 ha (Shale Sandstone Transition Forest in the Sydney Basin Bioregion) and 3 ha (Moist Shale Woodland in the Sydney Basin Bioregion) over the life of the Project. The location of the mapped EECs is shown on Figures 4 to 9 of the Terrestrial Flora Assessment (Appendix E of the EA). In addition, vegetation clearance for surface infrastructure would not take place in upland swamps except for very minor clearing for environmental monitoring purposes.

Fauna management strategies for the Project are summarised in Section 5.1. A Biodiversity Management Plan would be developed and implemented over the life of the Project. The Biodiversity Management Plan would be developed in consultation with the DECC, SCA and to the satisfaction of the DoP.

4.7 SEPP 44 – KOALA HABITAT ASSESSMENT

In response to a state-wide decline of Koala populations, the Department of Urban Affairs and Planning (now DoP) gazetted the SEPP 44 – Koala Habitat Protection in January 2005.

The policy aims to *encourage the conservation and proper management of areas of natural vegetation that provide habitat for Koalas, to ensure permanent free-living populations over their present range and to reverse the current trend of population decline*.

As discussed in Section 7 in the Main Report of the EA, the Director-General of the NSW DoP, under delegation from the Minister for Planning (the Minister), declared the Project to be a project to which Part 3A of the EP&A Act applies. In regard to SEPPs, Sections 75R(2) and (3) of the EP&A Act state:

> *(2) Part 3 and State environmental planning policies apply to:*
>
> > *(a) the declaration of a project as a project to which this Part applies or as a critical infrastructure project, and*
> >
> > *(b) the carrying out of a project, but (in the case of a critical infrastructure project) only to the extent that the provisions of such a policy expressly provide that they apply to and in respect of the particular project.*
>
> *(3) Environmental planning instruments (other than State environmental planning policies) do not apply to or in respect of an approved project.*

The effect of these provisions is that SEPPs only apply to the declaration of a project as a project to which Part 3A of the EP&A Act applies, and to the carrying out of a project where the SEPP expressly provides that they apply to Part 3A projects.

In respect of SEPP 44, it does not include any express provisions applying it to Part 3A projects and therefore is of no application to the carrying out of this Project.

In addition, SEPP 44 states:

5 Land to which this Policy applies

(2) However, it does not apply to land dedicated or reserved under the National Parks and Wildlife Act 1974 or to land dedicated under the Forestry Act 1916 as a State forest or flora reserve.

Dharawal State Conservation Area is reserved under the *National Parks and Wildlife Act, 1974* and hence SEPP 44 does not apply to the reserved land.

Notwithstanding the above, the following provides an assessment of potential impacts of the Project across the study area on core and potential koala habitat, as defined by SEPP 44, as follows:

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)*; and

potential koala habitat *means areas of native vegetation where the trees of the types listed in Schedule 2 constitute at least 15% of the total number of trees in the upper or lower strata of the tree component*.

An assessment of core koala habitat within the study area (including the Project extent of longwall mining areas [including reserved land within the Dharawal State Conservation Area], the proposed Stage 4 Coal Wash Emplacement and other clearance activities) has been undertaken. This assessment has utilised previous assessments by Biosis Research (Biosis Research, 2001a; 2001b) as part of the Environmental Impact Statement for the Dendrobium Project, consideration of the DECC Atlas of NSW Wildlife Database records for the study area (DECC, 2009a), and the extensive flora (FloraSearch, 2009) and fauna field work undertaken as part of this Project.

The highest concentration of koala records associated with the core koala habitat within the study area is located outside of the extent of longwall mining areas to the north of the West Cliff Area 5 domain and west of the North Cliff domain, approximately 7 to 8 km north of the proposed Stage 4 Coal Wash Emplacement, near the township of Wedderburn (Figure 2).

Records of koalas occur within other parts of the study area (i.e. Appin Area 8, Appin Areas 2 and 3 Extended, West Cliff Area 5 and on the edges of the North Cliff domain) although none of these records are of the same density as those near the township of Wedderburn.

As stated in Biosis Research (2001a; 2001b), *According to Robinson (1985) Koalas were once prevalent on the Woronora catchment but these have declined over the last 50 years. Individuals may disperse many kilometers (Dr Rob Close UWS pers. comm.) and move through a range of habitat types (not necessarily containing feed trees) when seeking favorable habitats*.

One SEPP 44 Schedule 2 Feed Tree Species occurs within the proposed Stage 4 Coal Wash Emplacement area (i.e. Grey Gum, *Eucalyptus punctata*) (FloraSearch, 2009). However, this species was only recorded in two of 23 samples within the Stage 4 Coal Wash Emplacement Area (an odd occurrence in low numbers) and does not constitute 15% of the upper or lower strata of the tree component. In addition, there are no historic records of koalas in the Stage 4 Coal Wash Emplacement (DECC, 2009a) nor were they recorded by the Project surveys. Hence the Stage 4 Coal Wash Emplacement does not fall within the definition of either core or potential koala habitat.

Potential impacts of the Project on koala habitat are primarily related to subsidence effects. As described in detail in Section 4, the predicted (and previously observed) effects of subsidence on fauna habitats are minimal and it is considered unlikely that subsidence resulting from the Project would have any real effect on koala habitat.

Clearance activities outside of the Stage 4 Coal Wash Emplacement Area (estimated at less than 37 ha of the approximated 9,845 ha of remnant native vegetation across the study area) would primarily be associated with ongoing surface exploration activities, the upgrade and extension of surface infrastructure (e.g. gas wells and service boreholes), access tracks, environmental monitoring and management activities (e.g. installation of monitoring equipment), stream restoration activities and other minor Project-related surface activities.

As described further in Section 5.1, vegetation clearance would be managed through the development and implementation of a Biodiversity Management Plan. Vegetation clearance activities would be progressive over the life of the Project with only small additional (i.e. outside of the Stage 4 Coal Wash Emplacement Area) areas (in the order of 4 ha) likely to be disturbed at any one time while other areas would be in various stages of rehabilitation. To minimise impacts on koala habitat, the location of surface activities requiring clearing would be selected with the aim of avoiding core koala habitat and SEPP 44 Schedule 2 Feed Tree Species where feasible. In addition, the pre-clearance surveys would include targeted searches for koalas and evidence of koala activity (e.g. koala scratches). Clearing activities would be located away from identified koalas and evidence of koala activity.

In addition to the above, Section 6.5.3 provides a specific impact assessment for the koala which has been undertaken in accordance with the Draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005) applicable under Part 3A of the EP&A Act.

4.8 OTHER DIRECT OR INDIRECT POTENTIAL IMPACTS ON TERRESTRIAL FAUNA

Loss of Habitat Connectivity

Connectivity is the “linkages of habitats … communities and ecological processes at multiple spatial and temporal scales” (Noss, 1991 in Lindenmayer and Burgman, 2005). Landscapes which retain more connections between remnant habitats are assumed to be more likely to maintain populations of species (Lindenmayer and Burgman, 2005). Connectivity is species-specific because it depends on a number of life history factors of the species (including dispersal behaviour and mode of movement) and their interaction with landscape patterns (*ibid.*). Indeed, not all species use corridors and the suitability of a corridor may depend on several factors including the ecology of the species and the physical attributes of the corridor (Lindenmayer and Burgman, 2005).

Habitats located in relatively uncleared vegetation (e.g. habitats in the eastern and southern portion of the Project area including those associated with the Woronora Plateau) are considered to have high internal and external habitat connectivity. The northern and western portion of the Project area (i.e. predominantly cleared agricultural land) can be described as having lower external habitat connectivity due to past and current urban and agricultural practices including clearing, pasture improvement techniques, introduction of livestock and subsequent invasion of weed plant species. Notwithstanding, a moderate level of connectivity in these areas is maintained in association with the riparian vegetation flanking the Nepean, Georges and Cataract Rivers.

Alteration of habitat can sometimes result in isolation of habitat through creation of barriers to movement between populations (i.e. disruption to habitat connectivity). The potential impacts of subsidence associated with the Project are unlikely to cause any changes to connectivity to habitats within the Project area. The vegetation clearance proposed to be undertaken for the West Cliff Stage 4 Coal Wash Emplacement is not expected to significantly disrupt connectivity for most fauna species (including threatened species that were recorded in close proximity to Stage 4 such as the Grey-headed Flying-fox, Gang-gang Cockatoo and Southern Brown Bandicoot [eastern]). Species could continue to move in a north-south direction through the retained vegetated corridor to the north of the Stage 4 Coal Wash Emplacement. In addition, the construction of Stage 4 is progressive over the life of the Project with active rehabilitation of previous emplacement areas (i.e. Stages 1 to 3) occurring at the same time.

Fire

Atypical and abnormal hazardous events associated with Project activities (e.g. fuel spill, explosion, etc.) have the potential to increase the risk of bushfire. High frequency fire is listed as a key threatening process in the TSC Act (NSW Scientific Committee, 2000a). ICHPL has fire and emergency response management plans and procedures in place at its pit tops that specifically address bushfire. These plans contain management measures that would be implemented for the Project and updated where necessary.

Fauna Traps

There is potential for native fauna to become trapped in excavated holes in the ground (e.g. drill holes associated with groundwater monitoring bores, remediation activities or exploration activities). To minimise the potential for native fauna to become trapped, the holes would be filled, capped and/or covered.

Fauna and Road Traffic

The movements of vehicles associated with the construction and operation of the Project has the potential to increase the incidence of fauna mortality caused by vehicular strike. Speed limits would be imposed on fire trails and tracks to reduce the potential for vehicle strike on native fauna in the Metropolitan, O'Hares and Woronora Special Areas.

Fauna and Noise

Numerous studies have been undertaken on the effects of noise on wildlife (e.g. Algers *et al.*, 1978, Allaire, 1978; Ames, 1978; Busnel, 1978; Lynch and Speake, 1978; Shaw, 1978; Streeter *et al.*, 1979; Poole, 1982). The studies indicate that many species are well adapted to human activities and noise.

Notwithstanding, surface activities associated with the Project (e.g. the operation of the West Cliff Coal Wash Emplacement, materials handling and vehicle movements) have the potential to result in adverse noise levels with the potential to disrupt the routine activities of some fauna species. Noise mitigation and management measures would be implemented at the Project surface facilities in accordance with the *NSW Industrial Noise Policy* (INP) (NSW Environment Protection Authority [EPA], 2000). Potential sources of noise in the Project extent of longwall mining area and surrounds include the ventilation shafts, vehicle movements and the operation of equipment (e.g. drill rig, compressors and other drilling-related equipment). The potential for noise generation in the Project extent of longwall mining area and surrounds is expected to be low. Construction-related noise-generating activities in this area would typically be localised and of short duration.

Fauna and Artificial Lighting

Project lighting has the potential to affect behavioural patterns of some species. Some bird and bat species, for example, are attracted to insects around lights. As a consequence of this, they could become prey for larger predators (e.g. owls).

Changes to Project lighting would be minimal compared to the existing lighting at the Appin East, Appin West and West Cliff pit tops. Most additional Project lighting would be associated with the operation of West Cliff Stage 4 Coal Wash Emplacement, which would extend the existing Stage 2 and Stage 3 emplacement operations further to the north. It is considered unlikely that the lighting associated with Stage 4 would have a significant adverse effect on fauna given that the amount of lighting to be used in the area at any one time is comparable to current lighting levels.

Night lighting of Project surface installations (e.g. North Cliff shafts) would be kept to the practical minimum.

Introduced Terrestrial Fauna Species

The provision of refuge or scavenging areas (e.g. discarded food scraps and other rubbish) has the potential to increase populations of introduced fauna species in or around the Project area. A clean, rubbish-free environment would be maintained in order to discourage scavenging and reduce the potential for colonisation of these areas by pest fauna. Employees and contractors would not be allowed to take domestic pets into the Metropolitan, O'Hares or Woronora Special Areas. The Biodiversity Management Plan would describe management measures to be implemented to reduce the potential for adverse impacts from introduced pest fauna species and would be developed in consultation with the SCA for activities in the Special Areas.

Amphibian Chytrid Fungus

Infection of frogs by amphibian chytrid causing the disease Chytridiomycosis is listed as a key threatening process under the TSC Act and infection of amphibians with chytrid fungus resulting in Chytridiomycosis is listed as a key threatening process under the EPBC Act.

A water-borne fungal pathogen *Batrachochytrium dendrobatidis*, commonly known as the amphibian or frog chytrid fungus, is responsible for the disease Chytridiomycosis (Berger *et al*., 1999). Infection occurs through water-borne zoospores released from an infected amphibian in water (NPWS, 2001a). Collection and handling of frogs and inadvertent transport of infected material between frog habitats may also promote the disease's spread (NSW Scientific Committee, 2003a).

To reduce the likelihood of spreading infection, personnel conducting amphibian surveys or surface water sampling for the Project would observe appropriate hygiene protocols in accordance with the NPWS (2001a) *Hygiene Protocols for the Control of Disease in Frogs*.

Rehabilitation of the Bulli Shafts Site

The Bulli Shafts site is located in the south-east of consolidated coal lease (CCL) 767 and consists of four (No.1 to No.4) disused (sealed) shafts (refer Section 2 in the Main Report of the EA). The shafts would be rehabilitated during the life of the Project in consultation with the DPI-MR, Wollongong City Council, Sydney Catchment Authority and DECC. Any rehabilitation works required would be undertaken in accordance with the measures outlined in the Project Biodiversity Management Plan.

Greenhouse Gas Emissions and Climate Change Effects

There has been significant growth in greenhouse gases from human activity which in turn affects climate variables such as cloud cover, rainfall, wind patterns, ocean currents, sea levels and the distribution of plant and animal species. Human-caused Climate Change is listed as a key threatening process under the TSC Act and Loss of Climatic Habitat Caused by Anthropogenic Emissions of Greenhouse Gases is listed as a key threatening process under the EPBC Act.

The distribution of most species, populations and communities is influenced by climate (NSW Scientific Committee, 2000b). Many species would be adversely affected unless populations were able to move across the landscape (DECC, 2009d). Species with long generations, poor mobility, narrow ranges, specific host relationships, isolated and specialised species and those with large home ranges are considered to be particularly at risk (Hughes and Westoby, 1994). Examples of fauna species potentially at risk in NSW include the Mountain Pygmy-possum, Long-footed Potoroo, Broad-toothed Rat, Smoky Mouse, Malleefowl, Plains-wanderer, Sooty Owl, Red-tailed Black-Cockatoo, Regent Parrot, Pink Robin, Red-lored Whistler, Striped Legless Lizard, Spotted Frog, Southern Bell Frog, Northern Corroboree Frog and Southern Corroboree Frog (NSW Scientific Committee, 2000b).

Greenhouse gas emissions associated with Scope 1 direct emission sources (i.e. consumption of diesel, fugitive coal seam gas emissions and vegetation clearance), Scope 2 indirect emission sources (i.e. generation of electricity purchased and consumed) and other Scope 3 indirect emissions (i.e. production and supply of diesel fuel, extraction of fuel used in electricity generation, emissions associated with the transport of coal and coal wash, emissions associated with the burning of coal in domestic and international power stations and the use of coal for off-site coke and subsequent steel and iron production) have been assessed for the Project by PAE Holmes (2009).

PAE Holmes (2009) estimate that on average over the 30 years of mining, the Project would directly release (i.e. Scope 1) approximately 5.4 Mtpa of carbon dioxide-equivalent (CO2-e) emissions (including fugitive emissions). Approximately 24.2 Mtpa of CO2-e emissions would be released indirectly (i.e. Scopes 2 and 3). Of the Scope 3 indirect emissions, it is estimated that 0.03 Mtpa and 23.4 Mtpa would be released through the transport and end use of the coal, respectively.

Measures to minimise greenhouse gas emissions are described in Section 5 in the Main Report of the EA (e.g. the Appin-Tower Project, WestVAMP and improvements to maximise efficiency of the use of fuels and minimise electricity consumption).

The *Climate Change - An Australian Guide to the Science and Potential Impacts* (Pittock, 2003) describes climate change projections for Australia. In eastern Australia, the El Niño-Southern Oscillation leads to alternations between floods and prolonged droughts and there is a possibility that climate change will result in a more El Niño-like state (*ibid.*). Annual average temperatures in Australia are expected to increase by 0.4 to 2.0°C by 2030, and 1.0 to 6.0°C by 2070 (relative to 1990) and evaporation and heatwaves are expected to increase and frosts to decrease (*ibid.*). In parts of south-eastern Australia annual rainfall is expected to change by -10% to +5% by 2030 and -35% to +10% by 2070 (Pittock, 2003). Based on the expected changes in rainfall and evaporation, soil moisture is likely to decrease and droughts are expected to become more severe (*ibid.*). An increase in the intensity of heavy rain events is also expected (*ibid.*). Sea level would also continue to rise (Pittock, 2003). Further to this, the *Carbon Pollution Reduction Scheme Green Paper* (Department of Climate Change, 2008) released in July 2008 updates the climate change predictions for Australia. A rise in average temperatures of up to 5°C by 2070 across Australia is predicted under a scenario of high emissions (Department of Climate Change, 2008).

The potential effects of climate change on the nature and extent of the Project potential impacts has been considered including those relating to groundwater (Heritage Computing, 2009), surface water (Gilbert and Associates, 2009) and terrestrial flora (FloraSearch, 2009). Heritage Computing (2009) indicates the Project is likely to have a negligible incremental effect on baseflow in streams and that the anticipated climate change effects on baseflow in the streams within the Project area are far greater than any changes in baseflow induced by mining. Gilbert and Associates (2009) indicate that climate change would produce more pronounced seasonal patterns of runoff in the region with increasing amounts of runoff occurring in the summer and less in the autumn, winter and spring. Relative to the current streamflows, which are more winter dominated, this might lead to a more uniform pattern of flows through the year (*ibid.*). Overall there would also be a tendency for reduced overall streamflow but with a possible increase in larger flow events in summer. These effects would occur irrespective of any effects of longwall mining in the Project area (Gilbert and Associates, 2009). Longwall mining is predicted to have localised effects on some pools and the frequency of interconnected flows between pools (*ibid.*). A climate change induced decrease in annual average rainfall and rainfall frequency has the potential to result in a reduction in low flow persistence, an increase in the frequency of low pool water levels and a reduction in inter-pool connection (*ibid.*).

The predicted small increase in summer rain and rainfall intensity might increase low flow persistence in summer which is likely to be the currently dominant time for low pool water levels and loss of inter-pool connection (Gilbert and Associates, 2009). Climate change induced reductions in winter and spring rainfall would be expected to result in a significant change to the flow regime irrespective of any mining impacts (*ibid.*). As described in FloraSearch (2009), the potential direct effects of the Project on vegetation, which are expected to be minor and limited in extent, are unlikely to significantly exacerbate the expected effects of climate change.

The likely impacts of climate change on fauna species are difficult to predict. Currently a team of DECC scientists along with other fauna specialists is seeking to determine likely impacts of climate change on protected and threatened fauna in NSW in particular (M. Pennay, DECC, pers. comm.). It becomes even more difficult to make precise predictions in specific locations such as what might possibly occur in respect to the Project area. The important local changes within the Project area appear likely to be:

- increasing temperatures;
- increasing evaporation rates;
- increased frequency of heat wave conditions;
- increased runoff in summer;
- decreased runoff in autumn, winter and spring;
- the possibility of more uniform flows throughout the year;
- an increase in the frequency of low pool levels and loss of inter-pool connectivity; and
- an increase in the intensity of storm events.

All fauna species operate within given tolerances being physiologically adapted to for example a particular temperature range. If tolerances are exceeded then fauna will seek to re-locate, possibly cease reproduction, and in some cases respond adversely with a resulting increase in mortality in various age groups. More vagile species may be able to move to more suitable locations and others could respond by changing their behaviour, for example spending longer periods sheltering in shady habitats that also help to minimise moisture loss.

It is likely that frogs might be adversely impacted, as might riparian species such as the Water Dragon. Birds can be susceptible to increasing heat wave conditions as can a number of terrestrial mammalian species. The climate change scenarios predicted are expected to lead to an increase in fire frequency with a corresponding loss in habitat quality that in the long-term could lead to some species becoming locally extinct as plant succession dynamics are impacted and/or habitat homogenisation occurs.

What appears to be reasonably certain is that it is likely that a significant number of species could be physiologically stressed by predicted climate change with variable adverse outcomes that are likely to be highly species specific and likely to be much greater than the predicted impacts of the Project.

Threatened Fauna

Evaluations have been conducted to assess potential impacts of the Project, including direct, indirect and cumulative potential impacts, on threatened fauna species and their habitats. The evaluations were conducted in accordance with the Draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005), which identify important factors that must be considered when assessing potential impacts on threatened species, populations, or ecological communities, or their habitats for development applications assessed under Part 3A of the EP&A Act (DEC and DPI, 2005). These evaluations are provided in Section 6.

4.9 CUMULATIVE IMPACTS ON TERRESTRIAL FAUNA

Cumulative impacts can be defined as the total impact on the environment that result from the incremental impacts of the action (the Project) added to other past, present, and reasonably foreseeable future actions in a defined area. Cumulative impacts include direct and indirect impacts on the environment. An assessment of the cumulative impacts of the Project on terrestrial fauna and their habitats is provided below.

Commercial mining to extract coal has been occurring in the Southern Coalfields since 1857 (DoP, 2008). There are eight underground coal mines currently operating within the Southern Coalfield: Appin Mine; West Cliff Colliery; Dendrobium Colliery; Metropolitan Colliery; NRE No. 1 Colliery (formerly known as Bellpac Colliery, South Bulli Colliery and Bellambi West Colliery); Wongawilli Colliery (formerly known as Elouera Colliery); Tahmoor Colliery and Berrima Colliery (DoP, 2008). Past mining has also occurred at Cordeaux, Huntley, Kemira, Darkes Forest, Avondale, North Cliff, and in the Burragorang and Camden district (*ibid.*).

A proportion of the Project underground mining area and surrounds occurs within the Woronora, Metropolitan and O'Hares Creek Special Areas, which are largely undeveloped and covered predominantly by native vegetation.

A number of other landuses exist in the vicinity of proposed mining operations (Figure 1) including:

- a reserve system (e.g. Dharawal State Conservation Area and Dharawal Nature Reserve);
- major water storage facilities (e.g. Cataract Reservoir and Woronora Reservoir);
- infrastructure (e.g. the South Western Freeway [Hume Highway], Main Southern Railway, overpasses and bridges, communications towers and cables, gas pipelines, water pipelines and electricity transmission lines);
- residential areas (e.g. Appin, Menangle, Douglas Park, Wilton, Picton and Maldon);
- agricultural land;
- small rural allotments; and
- private land.

Urban development exists along the northern margins of the Southern Coalfield on the outer edges of the wider Sydney metropolitan area. The NSW Government's *Sydney Metropolitan Strategy* provides a framework for promoting and managing growth in the wider Sydney metropolitan area, including further urban expansion proposed in the 'South West Growth Centre', which extends into the Southern Coalfield (DoP, 2005; 2007). The proposed urban growth is focussed on the areas around Leppington and Narellan located to the north of the Project (*ibid.*). Urban development in the region includes housing lots approved for development in Spring Farm and Elderslie south of Narellan and the Bingara Gorge development (formerly Wilton Parklands) at Wilton (DoP, 2008).

The likely extent and nature of the impacts of any future mining in the vicinity of the Project area is currently unknown. Future mining would be subject to separate assessment and approval, including the assessment of cumulative impacts.

The cumulative impact assessment has considered the species present (species diversity, abundance and dynamics), patterns of species distribution (the communities and ecosystem present that encompass all species), broad habitat types (the ecological niches for the range of species present), and ecosystem processes (how species interact through their involvement in key cycles, e.g. carbon, water and nutrient cycles, and the interception and flow of solar energy).

The following aspects have been considered in assessing cumulative impacts:

- the likely nature of the cumulative impacts;
- whether the cumulative impacts, including those associated with the Project, are likely to be linear, exponential or some other relationship;
- whether or not some or all impacts might interact synergistically to produce an overall impact greater than the sum of individual impacts;
- whether the Project is likely to cause an ecological threshold to be exceeded and thereby lead to a change in ecological state as a result of any impacts;
- whether or not the Project is likely to lead to a significant decline in the resilience of terrestrial ecosystems;
- whether or not key ecosystem cycles are likely to remain intact (e.g. carbon, water and nutrients) and whether or not solar energy interception is compromised as a result of cumulative impacts; and
- whether or not impact outcomes stabilise relatively quickly (e.g. in 1-2 years), take many year to fully express themselves (e.g. 10 year or more), or continue to develop over much longer periods of time.

Based on the studies carried out for the Project, other studies and available literature, the ecosystems and their associated communities in the assessment areas, excluding farming and residential lands, appear to be in good condition at all scales, and key ecosystem processes appear to be functionally intact. System resilience (the capacity of an ecosystem to self repair in response to perturbations such as fire etc) appears to be very high. The terrestrial fauna diversity is consistent with some areas being in mid-succession recovery from the 2001/2002 wildfire. The terrestrial flora is very diverse and species rich. Undeveloped portions of the area subject to this analysis have high ecological values. The ecology of much of the designated areas is reasonably well understood. The past and present actions described above, considered as part of this cumulative impact assessment, are located in a similar land-system to that within the Project area, comprising similar topographies, sandstone vegetation communities and faunal habitats, climate, geology and hydrology.

In relation to past and present mining, it is likely that the range and scale of impacts would be similar to those described for the Project. It is also likely that the accumulating impacts would increase linearly and proportionally with the area of longwall mining completed, given that the past and likely future impacts have or will occur within the one land system. Potential impacts of the Project on terrestrial fauna and their habitats are described in Section 4 and include those associated with mine subsidence effects and other direct and indirect potential impacts. Other land uses described in the vicinity of the Project (e.g. Cataract Reservoir, Woronora Reservoir, agricultural practices and other surface infrastructure) have primarily impacted on terrestrial flora, fauna and their habitats through vegetation/habitat clearance and associated secondary impacts (e.g. the introduction or spread of weeds and pest species).

When the cumulative impacts of the past and present actions described have peaked within the footprint area under consideration, the following outcomes are predicted. These predictions are based on the Surface Water Assessment (Appendix C of the EA) and Subsidence Assessment (Appendix A of the EA) and consequently rely on the precision, rigour and predictive capacity of these studies and the models therein. Therefore the predictions presented below are contingent on the actual surface water and subsidence effects being equal to or less than those predicted. These predictions are that:

- the impacts on terrestrial flora, fauna and their habitats are likely to increase linearly and proportionally with the longwall area mined;
- no ecological threshold(s) would be exceeded at point or landscape scale;
- ecological resilience across the footprint landscape would remain high and intact;
- key ecosystem cycles would remain intact at point and landscape scale; and
- energy interception across the footprint landscape would not be compromised.

The impacts described are likely to be fully expressed within a few years of the completion of site-specific mining and similarly at the landscape scale when all mining ceases. Although MSEC (2009) consider the subsidence predictions (on which this assessment is based) to be conservative, contingent management would be employed where the effects are greater than those predicted (Appendices O [Upland Swamp Risk Assessment] and P [Stream Risk Assessment] of the EA). In the event that impacts are greater than those predicted, ICHPL would implement these contingent measures such that the predictions described above remain relevant.

5 TERRESTRIAL FAUNA MANAGEMENT

Although the Project would avoid or minimise impacts on terrestrial fauna and their habitats wherever practicable, several measures have been developed and would be implemented as part of the Project to mitigate unavoidable impacts of the Project on terrestrial fauna. A Biodiversity Management Plan would be developed for the Project and would include the terrestrial fauna management measures described below.

5.1 VEGETATION CLEARANCE

Vegetation clearance associated with the Project would primarily be associated with the West Cliff Stage 4 Coal Wash Emplacement, ongoing surface exploration activities, the upgrade and extension of surface infrastructure (e.g. ventilation shafts), access tracks, environmental monitoring and management activities, potential stream restoration activities and other minor Project-related surface activities.

Sections 5.1.1 and 5.1.2 below provide a summary of the currently implemented vegetation clearance management strategies. These management stages would continue to be implemented for the Project and would be detailed in the Biodiversity Management Plan. Section 5.1.3 provides a summary description of the additional vegetation clearance management strategies that would be detailed in the Biodiversity Management Plan and implemented as part of the Project.

5.1.1 Existing Vegetation Clearance Management Strategies – Coal Wash Emplacement

The *West Cliff Coal Preparation Plant Stage 3 Coal Wash Emplacement Management Plan* (Cardno Forbes Rigby, 2007) describes various fauna management strategies to be undertaken as part of the rehabilitation works for the Stage 3 Coal Wash Emplacement. This Section (5.1.1) provides a summary of these strategies.

Vegetation Clearing

Prior to vegetation clearing, the following pre-clearance activities are undertaken (*ibid.*):

- survey of vegetation including locating, recording and marking specific habitat features (e.g. hollows, hollow bearing trees and hollow-bearing limbs) proposed for preservation and placement on active rehabilitation areas of the emplacement;
- identification of appropriate candidate boulders and outcrop rock that could be used for habitat creation in rehabilitation areas of the emplacement;
- inspection of habitat features to identify resident fauna species for relocation;
- development of appropriate capture and release methods (depending on observed fauna) and identification of appropriate release areas for the relocation of fauna species prior to clearing; and
- installation of temporary artificial nest/retreat sites such as nest boxes and hollows within remnants adjacent to the area proposed to be cleared before clearance.

As a preference, (i.e. where access to trees by an excavator is safe and practical) clearing of hollow bearing trees is performed in a two stage process where surrounding vegetation is cleared, one day before the removal of habitat trees to allow fauna an opportunity to move. Where hollow bearing trees are to be removed, the operation is performed by careful felling and leaving felled trees for a short period to allow fauna an opportunity to escape (*ibid.*).

All felled habitat trees are systematically checked for any remaining fauna. After the completion of fauna relocation, a brief record detailing the findings, methods and results of the survey and relocation are prepared (*ibid.*).

Identified significant fauna habitat features such as logs and tree hollows are either used on active rehabilitation areas or stockpiled for later use on rehabilitation areas.

Habitat Reinstatement

Habitat reinstatement within the emplacement area involves transplanting stags, placement of habitat logs and woody debris, replacement of nest sites and construction of rock outcrops with boulders and rock collected during clearing activities.

Soil Translocation

Prior to soil translocation the following activities are undertaken (*ibid.*):

- collection of local seeds (note: all seed collection, handling, and storage follow current best practice techniques outlined in *Flora Bank Guidelines* [Australian Tree Seed Centre and Mortlock, 1999]);
- identification and preparation of recipient site(s); and
- vegetation clearance and stockpiling.

Revegetation Activities Following Soil Translocation

Following placement of salvaged soil materials, collected logs and rock are distributed across the recipient site(s). Seed collected during vegetation clearing is spread over bare areas of the rehabilitating emplacement area. Direct seeding is undertaken in spring and autumn where necessary (*ibid.*).

Where required (i.e. in areas with poor regeneration for a period longer than six months), supplementary planting of local provenance tubestock is undertaken to assist with progressive reinstatement of vegetation.

Bushfire Management

Bushfire management considers the fire ecology of threatened species at the site. West Cliff Colliery is not currently subject to a hazard reduction burn regime and hazard reduction burns are not planned for the site.

Maintenance

Maintenance activities include (*ibid.*):

- Maintaining sediment and erosion control structures, especially after heavy rain as per existing requirements.
- Maintenance of drainage and ponding structures.
- Maintenance of tracks and haul roads and associated mitre drains, cross-banks and culverts.
- Weeding activities including noxious weed control including spot spraying.
- Additional direct seeding and planting of areas as required.

5.1.2 Existing Vegetation Clearance Management Strategies – General Surface Activities

Various management strategies are currently undertaken during the clearing of vegetation outside the emplacement area depending on the specific nature of the habitats present. These management strategies include:

- Pre-clearance strategies – identification and recording of habitat features suitable for salvage and use in rehabilitation.
- Strategies implemented during clearance – implementation of clearing methods such as shaking of trees with known habitat features to encourage resident fauna to relocate prior to felling and active capture and relocation of fauna.
- Post clearance activities – storage or use of salvaged habitat features in rehabilitation, reporting observed fauna to DECC in accordance with licence requirements, recording fauna management strategies undertaken.

5.1.3 Project Vegetation Clearance Management Strategies

The Project would include implementation of the existing management strategies and the development of additional vegetation management strategies. The Biodiversity Management Plan would identify areas in which specific surface works involving vegetation clearance would be avoided or limited. Project infrastructure (including surface works such as surface exploration activities, access tracks, and environmental monitoring equipment) would be located to minimise vegetation clearance in EEC's (Appendix E of the EA). Further, vegetation clearance for surface infrastructure would not take place in upland swamps except for very minor clearing for environmental monitoring purposes.

Where practicable surface works would be sited to minimise the amount of vegetation clearance required (e.g. the positioning of sites to avoid the removal of trees or the siting of infrastructure in previously disturbed areas).

Inspections of proposed disturbance areas would also be conducted to identify management measures to be implemented to minimise impacts on terrestrial fauna, prior to, during and/or following the completion of the surface works. A vegetation clearance protocol would be developed and would include measures to minimise disturbance to terrestrial fauna and their habitats (e.g. clear delineation of the boundary of disturbance areas so as to avoid accidental or over clearing).

As described further in Section 4.7, the location of proposed disturbance areas (outside of the Stage 4 Coal Wash Emplacement Area) would be selected with the aim of minimising the clearing of core koala habitat and SEPP 44 Schedule 2 Feed Tree Species. Pre-clearance surveys would include targeted searches for koalas and evidence of koala activity (e.g. koala scratches). Clearing activities would be located away from identified koalas and evidence of recent koala activity.

5.2 MANAGEMENT STRATEGIES FOR SPECIFIC THREATENED SPECIES

5.2.1 Broad-Headed Snake

Under the Dendrobium Mine Project EPBC Act approval, ICHPL prepared a Broad-headed Snake Management Plan specifically relating to potential impacts from the Stage 3 Coal Wash Emplacement. The Broad-headed Snake Management Plan was prepared by Biosis Research (2007c) and was approved by the DEWHA on 10 December 2007.

The description below provides a summary of the management strategies in the Broad-headed Snake Management Plan (Biosis, 2007c). These management strategies would continue to be implemented for the Stage 4 Coal Wash Emplacement and would be detailed in the Biodiversity Management Plan.

The purpose of the Broad-headed Snake Management Plan is to minimise impacts on the local Broad-headed Snake population and associated habitats within the study area. The plan provides detailed management actions and covers three key stages (Biosis, 2007c):

1. Relocation of Broad-headed Snakes (pre-clearing).
2. Progressive two-stage clearing and habitat translocation (during clearing).
3. Monitoring and maintenance recommendations (post clearing).

These stages are outlined below.

Stage 1 – Relocation of Broad-headed Snakes (Pre-clearing)

In order to reduce death of Broad-headed Snakes as a consequence of establishment of the Stage 3 Coal Wash Emplacement, targeted surveys for the snake within rocky outcrop habitat within the subject site would be carried out during winter by qualified ecologists. Any individuals found would be relocated to pre-determined suitable habitat outside, but within 1 km of the study area. Such sites would need to take into account the species home range and be evenly spaced to minimise social conflict.

Pre-determined relocation sites would ideally consist of the following (Biosis, 2007c):

- occur on Hawkesbury Sandstone within the current known range of the species and provide rocky outcrops with a westerly or north-westerly aspect, and horizontal crevices (Webb and Shine, 1998a);
- have large adjacent areas of woodland that support hollow-bearing trees and would ideally be larger than the area supporting rocky outcrops (Webb and Shine, 1997a);
- a population of Lesueur's Velvet Gecko (Webb and Shine, 2000) supported by suitable habitat e.g. loose rock on rock substrate (Webb and Shine, 1998a; Shine *et al.*, 1998);
- large stags with a number of hollows need to be present (Webb and Shine, 1997b);
- preferred species of 'habitat trees' (trees most often selected by Broad-headed Snakes) such as *Eucalyptus gummifera, E. punctata, E. agglomerata and E. pipperita* should be present and provide many hollows (both in the stem and in branches) (Webb and Shine, 1997b);
- 'habitat trees' at approximately 5 per ha, be evenly spaced, and be located both on plateaus and below cliff lines (Webb and Shine, 1997b); and
- hollow logs should be common in occurrence (Webb and Shine, 1997b).

Due to the Broad-headed Snakes' nature (i.e. they exhibit strong fidelity and are competitive if another Broad-headed Snake is present) they may not take to the new habitat in which they are relocated. Therefore, any Broad-headed Snake(s) collected from the study area and relocated elsewhere would be monitored to observe success (Biosis, 2007c).

During Stage 1, any other fauna located within the study area would also be relocated. In particular, any Lesueur's Velvet Geckos (and other lizards) encountered would be relocated to the same pre-determined sites for Broad-headed Snakes to provide prey for the translocated snakes (Biosis, 2007c).

Prior to any relocation of any fauna to a location more than 1 km from where it is found, an appropriate permit under provisions of the NSW *National Parks and Wildlife Act*, *1974* will be required to be issued by DECC (Biosis, 2007c).

Stage 2 – Progressive Two-Stage Clearing and Habitat Translocation (During Clearing)

The Broad-headed Snake uses two main types of habitat: rocky outcrops in winter and woodland with hollow-bearing trees in summer. Therefore, it is necessary to put measures in place to protect the snakes in both habitats during the clearing phase of the project. A number of measures would be implemented to ensure that detrimental impacts are avoided or minimised to the extent possible during clearing activities. These measures are discussed in detail below.

Pre-clearance Assessment

As described in Section 5.1.1, vegetation to be cleared is surveyed to locate, record and mark specific habitat features that are proposed for preservation and redistribution to the rehabilitating emplacement area. Specific habitat features of the Broad-headed Snake would also be located, recorded and marked during the pre-clearing assessment.

Progressive Two-stage Clearing

Progressive clearing creates an initial low impact disturbance that allows animals time to move into adjoining uncleared habitat before habitat features such as hollow-bearing trees and rocky outcrops are removed. Two-stage clearing refers to the removal of non-habitat trees first, immediately before habitat trees, to allow fauna the opportunity to move from the area being cleared and facilitates fauna rescue by allowing a qualified ecologist to concentrate their efforts on the most likely habitat trees. The progressive two-staged clearing approach will be applied separately to Broad-headed Snake winter habitat and summer habitat where possible, as described below.

Winter Habitat Translocation (Rocky Outcrops)

Rocky outcrops, crevices, caves and overhangs provide winter habitat for the Broad-headed Snake (Goldingay and Newell, 2000). Suitable winter habitat occurring within the study area would be identified during the pre-clearing assessment. Translocation of this habitat to the rehabilitating emplacement area would ideally occur in summer, while the species is occupying different habitat (woodland with hollow-bearing trees), and would consider/include the following (Biosis, 2007c):

- translocation of rocky outcrops and boulders positioned with a westerly or north-westerly aspect and crevices should remain horizontal (Webb and Shine, 1998a);
- translocation of suitable habitat for Lesueur's Velvet Gecko habitat (Webb and Shine, 2000);
- even spacing (at least 300 m apart) of shelter sites close/adjacent to suitable summer habitat to encourage a greater number of Broad-headed Snakes to the area (Webb and Shine, 1997a);

- addition of rocks (of differing sizes) to be placed in shaded and exposed areas on rocky substrate to increase habitat opportunities for prey items and the Broad-headed Snake (Webb and Shine, 2000); and
- translocation of hollow logs to provide additional retreat-sites for the Broad-headed Snake and its prey (Webb and Shine, 1997b).

Summer Habitat Translocation (Hollow-bearing Trees/Limbs)

Woodland, supporting hollow stags and hollow-bearing trees, provides summer habitat for the Broad-headed Snake (Webb and Shine, 1997b). Suitable summer habitat occurring within the study area would be identified during the pre-clearing assessment (Biosis, 2007c). Translocation of this habitat would ideally occur in winter while this species is occupying different habitat, and would consider/include the following (Biosis, 2007c):

- translocation of large stags (standing dead trees containing hollows) (Webb and Shine, 1997b);
- translocation of habitat trees of the Broad-headed Snake as well as large, hollow-bearing trees (with stem hollows and hollow branches), including the following flora species (in order of likely preference): *Eucalyptus gummifera, E. punctata, E. agglomerata, E. piperita and E. sieberi* (Webb and Shine, 1997b)*;*
- where translocation of entire live or dead trees is not possible, hollow-bearing limbs and/or trunks would be translocated onto trees in surrounding suitable habitat or onto erect poles within the emplacement area post rehabilitation (Webb and Shine, 1997b);
- summer habitat would be translocated adjacent to winter habitat and be evenly spaced, with five habitat trees translocated per hectare (Webb and Shine, 1997b);
- summer habitat and/or adjacent existing woodland would be larger than the area supporting rocky outcrops and where possible, habitat trees would be translocated to both plateau areas and areas below cliff lines (Webb and Shine, 1997b); and
- ensure that habitat for summer prey (e.g. small arboreal mammals) are available, such as tree hollows, hollow logs, shrubs and dense leaf litter as well as Banksia flora species to provide habitat for the Eastern Pygmy Possum (*Cercartetus nanus*).

Relocation Actions

In addition to the actions provided above, the following relocation actions would be followed for any Broad-headed Snakes salvaged (Biosis, 2007c):

- suitable sites for snake (and other fauna) translocation would be determined by a suitably qualified zoologist;
- where possible, snakes would be translocated from the initial capture point to the nearest site considered suitable for the long-term habitation by the species, but not more than 1 km from that point to reduce the possibility for unfavourable genetic mixing; and
- snakes would be released at sites as soon as practicable after capture. Relocation sites would be kept confidential (i.e. dissemination of this data would be limited to the DECC).

Habitat Protection During Construction

The following measures would be undertaken to ensure the protection of Broad-headed Snake habitat during construction (Biosis, 2007c):

- best practice sediment control measures would be adopted during clearing, and these measures must be devised by a suitably qualified hydrological engineer;
- the study area would be clearly marked by temporary fencing or flagging tape to prevent unnecessary clearing or access by construction vehicles and plant to surrounding potential habitat;
- construction materials and spoil must not be stored, dumped or stockpiled within surrounding habitat; and
- induction of all construction and site personnel would include information about the Broad-headed Snake and its habitat within the study area and subject site, along with protection measures that will be in place and enforced during the construction period.

Stage 3 – Monitoring and maintenance recommendations (post clearing)

ICHPL is responsible for the ongoing management and maintenance of the rehabilitation of the emplacement areas at West Cliff Colliery.

Post-clearing management and monitoring will be undertaken in consultation with a suitably qualified zoologist to ensure that measures are suitable for Broad-headed Snake.

Monitoring of relocated Broad-headed Snakes and translocated habitat would take place during winter during the day (to identify basking snakes) and at dusk (when the snakes are most active) to target rocky outcrops (Biosis, 2007c). During the summer, monitoring of relocated Broad-headed Snakes and translocated habitat would ideally consist of spotlighting hollow-bearing trees, logs and ground for foraging snakes (Biosis, 2007c). Monitoring of Broad-headed Snakes and their habitat would be continued for a minimum of three years post-clearance activities (Biosis, 2007c). The objectives of monitoring would be to determine the success of relocation, translocation and conservation of the Broad-headed Snake within the rehabilitated emplacement area and surrounding areas containing suitable habitat (Biosis, 2007c).

5.2.2 Southern Brown Bandicoot

The Southern Brown Bandicoot (*Isoodon obesulus obesulus*) was recorded by the Project surveys within and around the Stage 4 Coal Wash Emplacement (Table 7, Figure 5). The species is listed as Endangered on both the TSC and EPBC Acts. The Southern Brown Bandicoot is poorly understood in terms of its distribution and population size (DECC, 2007). Until recent records, it was uncertain as to whether the Southern Brown Bandicoot still existed in the Greater Southern Sydney Region. Section 6.5.1 provides information on the lifecycle, habitat and distribution of the Southern Brown Bandicoot, and evaluation of potential impacts on the species.

The persistence of this species in the local area is likely to rely on the availability of appropriate post fire successional habitat stages of sufficient area, habitat management and effective feral animal control aimed at foxes, dogs and cats in particular. Predation by the fox is recognised as a key threatening process for the Southern Brown Bandicoot (Lobert and Lee, 1990; Claridge and Barry, 2000; NPWS, 2001b; DEC, 2006a). The fox was recorded at most sites (including those sites at which the Southern Brown Bandicoot was recorded) and opportunistically across the whole study area. Potential predation by the fox is considered to represent a significant threat to the Southern Brown Bandicoot and is very likely a major factor in the relatively low numbers of the species in this area.

The Southern Brown Bandicoot habitat located on land to the north of Stage 4 has been subjected to historic and current disturbance and opportunities may exist for the regeneration of habitat (i.e. dense shrub and groundcover species that provide nesting and shelter sites and protection from predation) in this area in consultation with the landowner.

As part of the Biodiversity Management Plan, ICHPL propose to develop a specific management plan for the Southern Brown Bandicoot. The Southern Brown Bandicoot Management Plan (SBBMP) would be developed in consultation with DECC and SCA and to the satisfaction of the DoP. The aims of the SBBMP would be to:

1. Assist with the protection, rehabilitation and enhancement of known or potential Southern Brown Bandicoot habitats (i.e. land to the north of Stage 4, reserved land to the east [Dharawal State Conservation Area - DECC] and protected land to the south-east [Metropolitan Special Area – SCA]).
2. Collect information to better understand the extent, distribution, density and population dynamics of the local Southern Brown Bandicoot population.
3. Provide vegetation clearance measures to minimise impacts of the Project (particularly the Stage 4 Coal Wash Emplacement Area) on the local Southern Brown Bandicoot population.

Aim 1: Potential measures to protect, rehabilitate and/or enhance known or potential Southern Brown Bandicoot habitats would be developed and would include consideration of:

- erosion and sediment control works (e.g. at fire trail stream crossings) to improve known or potential Southern Brown Bandicoot habitat;
- implementation of feral animal control measures within and around known and potential Southern Brown Bandicoot habitats (consistent with a “Priority 1 Action” from the Southern Brown Bandicoot Recovery Plan [DEC, 2006a]);
- active revegetation/regeneration of appropriate shrub and groundcover species at known and potential Southern Brown Bandicoot habitat areas; and
- measures to reduce disturbances in known and potential Southern Brown Bandicoot habitat (e.g. reduce motorbike activity or rehabilitation of unnecessary tracks to limit feral animal access into Southern Brown Bandicoot habitats).

Aim 2: To assist with collecting information to better understand the extent, distribution and density of the local Southern Brown Bandicoot population, ICHPL would consider the following options in the SBBMP:

- undertake or sponsor targeted surveys for the Southern Brown Bandicoot (consistent with a “Priority 1 Action” from the Southern Brown Bandicoot Recovery Plan [DEC, 2006a]);

- sponsor a research program designed to collect information on habitat preference (e.g. preferred vegetative structure, species, position on slope, aspect etc.) to better understand what constitutes optimal habitat for the Southern Brown Bandicoot at the northern extremities of its range; and
- sponsor a research program designed to monitor the response of the Southern Brown Bandicoot to feral animal control (as recommended above) (consistent with a "Priority 1 Action" from the Southern Brown Bandicoot Recovery Plan [DEC, 2006a]).

Aim 3: Potential measures to minimise impacts of the Project (particularly the Stage 4 Coal Wash Emplacement Area) on the local Southern Brown Bandicoot population would be developed as part of the SBBMP, including:

- integration with the current and proposed vegetation clearance strategies;
- pre-clearance surveys (including trapping within the Stage 4 Coal Wash Emplacement) for the Southern Brown Bandicoot and subsequent relocation;
- identification of appropriate relocation sites prior to commencement of clearing activities in potential Southern Brown Bandicoot habitat within the Stage 4 Coal Wash Emplacement;
- consideration of potential Southern Brown Bandicoot habitat[4] components as part of the rehabilitation of coal wash emplacement areas; and
- consideration of placing captured animals from within the Stage 4 Coal Wash Emplacement Area to any relevant Southern Brown Bandicoot captive breeding program.

In addition to the above, ICHPL would consider in the SBBMP:

- opportunities and options available to inform local communities of the conservation significance of the Southern Brown Bandicoot (consistent with a "Priority 2 Action" from the Southern Brown Bandicoot Recovery Plan [DEC, 2006a]); and
- opportunities to involve local community groups in survey and monitoring for the Southern Brown Bandicoot (consistent with a "Priority 2 Action" from the Southern Brown Bandicoot Recovery Plan [DEC, 2006a]).

5.3 WEEDS

Potential weed management measures to be undertaken within ICHPL surface leases and/or other areas subject to Project related rehabilitation include the mechanical removal of weeds and application of approved herbicides, as well as the inspection of vehicles and mechanical equipment brought to site to avoid importation of foreign soil and organic matter.

Follow-up inspections would be conducted to assess the effectiveness of weed management measures and to determine the requirement for any supplementary management measures.

Further detail on the current weed management measures implemented by ICHPL is provided in the *West Cliff Colliery and Stage 3 Coal Wash Emplacement Vegetation and Fauna Management Plan* (Biosis Research, 2007d). Current weed management measures would continue to be implemented and would be detailed in the Biodiversity Management Plan.

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[4] For example, a dense and contiguous understorey of vegetation would be promoted to provide cover for the bandicoots to forage under and nesting materials for their shelter (NPWS, 2001). Bandicoots which shelter under very dense undergrowth appear to be less at risk of predation by foxes (Lobert and Lee, 1990).

5.4 INTRODUCED PEST SPECIES

Vegetation clearance associated with the Project has the potential to increase the occurrence of pest species. As described in Section 4.6, the proposed vegetation clearance would be progressive over the life of the Project. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project.

A clean, rubbish-free environment would be maintained in order to discourage scavenging and reduce the potential for colonisation of these areas by non-endemic fauna. Employees and contractors would not be permitted to take domestic pets into the Dharawal State Conservation Area or Metropolitan, O'Hares or Woronora Special Areas.

The Biodiversity Management Plan would describe management measures to be implemented to minimise the occurrence of pest fauna species. In addition to the measures described above, other management measures would include (DECC, 2007b):

- Reporting sightings of pest species to the DECC for inclusion in the Atlas of NSW Wildlife in order for the distribution and abundance of the pests to be better understood.
- Destruction of rabbit burrows within ICHPL surface leases.
- The inclusion of general pest awareness in ICHPL inductions, particularly for staff and contractors accessing the Metropolitan, O'Hares or Woronora Special Areas.
- Ongoing consultation with the SCA and the DECC in relation to the management of pest species.

5.5 FIRE

A range of management measures would be implemented for the Project to minimise the risk of bushfire. ICHPL's existing bushfire management measures would be reviewed and where appropriate revised for the Project.

5.6 AMPHIBIAN CHYTRID FUNGUS

To reduce the likelihood of spreading infection, personnel conducting amphibian surveys or surface water sampling for the Project would observe appropriate hygiene protocols in accordance with the NPWS (2001a) *Hygiene Protocols for the Control of Disease in Frogs*.

Hygiene protocols would be established for activities conducted in particular areas and movement between areas. Potential management measures include (NPWS, 2001a):

- The thorough cleaning and disinfecting of footwear.
- The thorough cleaning and disinfecting of equipment (such as nets, callipers, headlamps and waders).
- Restricting the movement of vehicles to formed tracks and pre-existing roads, where practicable.
- In the event the frog Chytrid fungus is known to be present at a site, that site would be the last site surveyed/sampled, where practicable.

5.7 FAUNA TRAPS

To minimise the potential for native fauna to become trapped, excavated holes in the ground (e.g. drill holes associated with groundwater monitoring bores, stream restoration activities or exploration activities) would be filled, capped and/or covered, where practicable.

5.8 FAUNA AND ROAD TRAFFIC

Speed limits would be imposed on fire trails and tracks to reduce the potential for vehicle strike on native fauna in the Metropolitan, O'Hares and Woronora Special Areas.

5.9 FAUNA AND NOISE

Noise mitigation and management measures would be implemented at the Project surface facilities as described in Appendix I of the EA.

6 THREATENED TERRESTRIAL FAUNA

This fauna impact assessment has been prepared in accordance with the Draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005), which identify important factors that must be considered when assessing potential impacts on threatened species, populations, or ecological communities, or their habitats for development applications assessed under Part 3A of the EP&A Act.

Threatened fauna species evaluations have been conducted and have included consideration of the following items:

- How is the proposal likely to affect the lifecycle of a threatened species and/or population?
- How is the proposal likely to affect the habitat of a threatened species, population or ecological community?
- Does the proposal affect any threatened species or populations that are at the limit of its known distribution?
- How is the proposal likely to affect current disturbance regimes?
- How is the proposal likely to affect habitat connectivity?
- How is the proposal likely to affect critical habitat?

Evaluations were conducted for threatened fauna that were recorded in the Project area and surrounds, as well as other threatened fauna that may possibly occur (based on distribution of the species and potential habitat resources available).

6.1 INVERTEBRATES

6.1.1 Cumberland Plain Land Snail

The Cumberland Plain Land Snail occurs in eucalypt woodland in areas associated with Wianamatta Shale and old Nepean river gravels (NSW Scientific Committee, 1997). It is found under logs and debris as well as around the base of trees and clumps of grass, where it burrows into loose soil (*ibid*.). The species has also been found in degraded environments provided that ground cover is available (e.g. rubbish, building materials, old car parts, etc.) (NPWS, 2000a). The Cumberland Plain Land Snail is hermaphroditic and lays clutches of small round white eggs in moist, dark areas (e.g. under logs) (NPWS, 2000b). The eggs take approximately 2 to 3 weeks to hatch and observations suggest the Cumberland Plain Land Snail reproduces throughout the year when conditions are suitable (*ibid*.). The Cumberland Plain Land Snail is generally active at night and forages on fungus (NPWS, 2000b).

Scientific studies have shown that populations of this narrow-range species are highly structured at very short distances (2 m) and that the radius of a genetic neighbourhood is approximately 350 m (Clark and Richardson, 2002). The genetic neighbourhood size gives an indication of the distances moved by individuals between birth and breeding and hence the size of gaps in distribution that can be filled within a generation (*ibid*.).

Threats relevant to this species include habitat removal or modification, weed invasion, inappropriate fire management and the removal of ground cover which provides shelter, foraging and breeding habitat (NPWS, 2000b).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by vegetation clearance/habitat removal, weed invasion and an increase in the frequency of bushfire.

Project infrastructure would be located to avoid vegetation clearance in areas of Cumberland Plain Woodland (vegetation communities p28 and p29) and River Flat Forest (vegetation community p33) (Appendix E of the EA) which provide potential habitat for this species and which are also listed as EEC's under the TSC Act. Vegetation clearance activities for the Project would be managed through the development and implementation of a Biodiversity Management Plan. A range of management protocols are proposed to be in place to manage the risk of bushfire and the spread or introduction of weeds in the Project area. Hence it is unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Cumberland Plain and Castlereagh Woodlands of Western Sydney and the fringes of River Flat Forest, particularly where it adjoins Cumberland Plain Woodland provide potential habitat for this species (NPWS, 2000a, 2000b). As described above, no vegetation clearance activities would occur in areas of Cumberland Plain Woodland (vegetation communities p28 and p29) or River Flat Forest (vegetation community p33) which provide potential habitat for this species. Further, given the range of management protocols proposed to be in place to manage the risk of bushfire and the spread or introduction of weeds, the Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Cumberland Plain Land Snail occurs within the Cumberland Plain region of Western Sydney, from Cattai in the north to Picton in the south, Prospect Reservoir in the east and Yarramundi to the west (NPWS, 2000a).

The Project is located within the known distribution of the Cumberland Plain Land Snail and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was clearing of the species habitats or a significant increase in fire frequency. Vegetation clearance for surface infrastructure would not take place in areas of Cumberland Plain Woodland (vegetation communities p28 and p29) or River Flat Forest (vegetation community p33) which provide habitat for this species. Given a range of management protocols are proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to significantly impact on habitat connectivity for the Cumberland Plain Land Snail.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Cumberland Plain Land Snail. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.2 AMPHIBIANS

6.2.1 Littlejohn's Tree Frog

The Littlejohn's Tree Frog occurs along permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops (DECC, 2009e). The Littlejohn's Tree Frog breeds mostly in autumn, but the species will also breed after heavy rainfall in spring and summer (NSW Scientific Committee, 2000c). Males have been found to call from elevated positions beside ponds and streams with breeding habitat not restricted to any particular type of water body having been found in streams, temporary pools and dams (Anstis, 2002; Lemckert, 2005). The Littlejohn's Tree Frog hunts either in shrubs or on the ground.

Threats relevant to the Littlejohn's Tree Frog include limited dispersal from small populations which increases the risk of local extinction; clearing of native vegetation and reduced habitat availability; and inappropriate fire practices (including pre- and post-logging burns and control burning) that disturb breeding habitat (NSW Scientific Committee, 2000a). Habitat alteration by longwall mining is also considered a threat to the Littlejohn's Tree Frog (NSW Scientific Committee, 2005a).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4.

Mine subsidence has the potential to impact marginally on populations through limited rock fall and surface tension cracks impacting on particular individuals but not at a level likely to have a negative impact on population dynamics.

Changes in surface hydrology have the potential to impact on habitat of the Littlejohn's Tree Frog. Within the Project area, known habitat for this species occurs in the south-east of North Cliff (Figure 4) while potential habitat is considered to also occur in intermittent and persistent lower order streams in the eastern portion of Appin Area 2 Extended. These areas are situated near areas of known habitat for this species in Dharawal Nature Reserve and the Darkes Forest area, located to the east and outside of the Project area.

Mine subsidence would result in cracking of the rock strata in streams which in some streams in the Project area is expected to result in conveyance of a portion of low flows via the fracture network, and a reduction in water level in pools as they become hydraulically connected with the fracture network (Section 4.5). There is also likely to be reduced continuity of flow between affected pools during dry weather. Gilbert and Associates (2009) indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows in streams. Only portions of streams considered known or potential habitat for this species are predicted to be subject to diversion of flows and drainage of pools during low flow events (MSEC, 2009; Gilbert and Associates, 2009). Experience has also shown that a range of different effects can occur in response to subsidence induced cracking with some pools retaining water through dry periods (Gilbert and Associates, 2009).

It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project. The West Cliff Stage 4 Coal Wash Emplacement has been comprehensively surveyed for threatened fauna species including the Littlejohn's Tree Frog and it has not been recorded despite numerous surveys in the location and surrounds.

An increase in fire frequency also has the potential to impact on the lifecycle of this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency resulting from the Project.

It is unlikely that the Project would adversely impact on the lifecycle of the Littlejohn's Tree Frog to the extent that a local population would be placed at risk of extinction.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Littlejohn's Tree Frog appears to be restricted to sandstone woodland and heath communities at mid to high altitude (NSW Scientific Committee, 2000c). There is the potential for relatively small components of each of the broad habitat types identified as being part of this species 'habitat' to be impacted by the Project via cliff face and rock-fall and sub surface and surface tension cracking. However the likely impacts of the potential changes in habitat described has been demonstrated to be relatively minor and localised.

In regard to breeding habitat, mine subsidence also has the potential to cause cracking and alter the availability of water. There is the potential for mine subsidence to convey a portion of low stream surface flows via fracture networks and reduce the water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather. During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network. Gilbert and Associates (2009) indicate that during periods of significant rainfall and runoff, the water level in subsidence impacted pools would be similar to pools unaffected by subsidence. Under these flow conditions pools and their downstream rock bars would become "drowned out". During dry periods when flows are in a low, recessionary regime the water level in pools affected by subsidence would recede much faster than is the case in unaffected pools (*ibid.*). As described above, MSEC (2009) and Gilbert and Associates (2009) indicate that these effects are predicted in portions of the streams considered to contain known or potential habitat for the Littlejohn's Tree Frog. In addition, experience has shown that a range of different effects can occur in response to subsidence induced cracking with some pools retaining water through dry periods (Gilbert and Associates, 2009).

Mine subsidence is also expected to result in localised changes in stream water quality. The effects of subsidence on water quality have been most noticeable as localised and transient changes (spikes or pulses) in iron and manganese and minor associated increases in electrical conductivity. Potential impacts on riparian vegetation would be localised and limited in extent.

As described in Section 4, the Project would involve some vegetation clearance for surface infrastructure (e.g. West Cliff Stage 4 Coal Wash Emplacement, exploration activities, ventilation shafts, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required.

Given the nature of the hydrological changes and other potential Project impacts, the Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Littlejohn's Tree Frog is distributed along the eastern slopes of the Great Dividing Range from Watagan State Forest near Wyong, south to Buchan in north-eastern Victoria (NSW Scientific Committee, 2000c). Within the Greater Southern Sydney Bioregion, the Woronora Plateau and the higher rainfall areas of the Blue Mountains are considered two key areas that are important to this species (DECC, 2007a). Littlejohn’s Tree Frog has been found to be common at Darkes Forest.

The Project is located within the known distribution of the Littlejohn's Tree Frog and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Disruption of existing habitat connectivity for existing populations would be possible following events such as significant habitat clearing, extensive rock falls or major surface cracking that created a barrier to movement, or the complete and permanent drying of streams that separated existing meta-populations. However, clearing of potential habitat for this species would occur at point scale rather than at landscape scale and rock fall and surface cracking are predicted to be relatively minor. Potential impacts along streams where the Littlejohn’s Tree Frog occurs is very unlikely to fragment existing populations. It is unlikely that habitat connectivity for the Littlejohn’s Tree Frog would be significantly affected by the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Littlejohn’s Tree. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.2.2 Giant Burrowing Frog

Much of the Giant Burrowing Frog’s existence is spent burrowed underground sometimes beneath deep leaf-litter or in earth-filled rock crevices interspersed with brief periods of activity throughout the year during rainy weather (NPWS, 2001c). Burrows are excavated into the earth around, or associated with rocks fissures or boulders (NPWS, 2001c). It has also been reported that yabbie holes are utilised along the beds and banks of drying streams (NPWS, 2001c). The Giant Burrowing Frog mainly breeds between mid summer and autumn (Cogger, 2000). Males call from within or adjacent to the breeding burrows or amongst accumulated vegetation debris (NPWS, 2001c). Tadpoles develop in three to six months (NPWS, 2001c). The diet of the Giant Burrowing Frog mainly consists of invertebrates including ants, beetles, cockroaches, spiders, centipedes and scorpions (NPWS, 2001c). The Giant Burrowing Frog is thought to have a large home range; having been recorded at considerable distances from suitable moist habitat (Hoser, 1989; Gillespie, 1990). Individuals have been recorded to move up to 200 to 300 m in a night (NPWS, 2001c).

Recent field studies by Penman *et al*. (2008) show that individuals spend only a few days near (i.e. <15 m) their breeding sites each year. Most time is spent in distinct non-breeding activity areas 20 to 250 m from the breeding sites (Penman *et al*., 2008). Within these non-breeding activity areas, individual frogs were observed to use one to 14 burrows repeatedly (*ibid.*).

Threats relevant to this species include vegetation clearance, habitat disturbance, erosion and sedimentation of headwater stream lines, high nutrient flows, predation by feral animals, fire and road mortality (NPWS, 2001c). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4.

Mine subsidence has the potential to impact marginally on populations through limited rock fall and surface tension cracks impacting on particular individuals but not at a level likely to have a negative impact on population dynamics.

As provided in the Upland Swamp Risk Assessment (Appendix O of the EA), only a small proportion of upland swamps are likely to be subject to significant negative consequences and ICHPL would develop and implement measures to mitigate and manage negative consequences in these few swamps. Further detail on these measures is provided in Section 5 in the Main Report and in the Upland Swamp Risk Assessment (Appendix O of the EA).

Changes in surface hydrology have the potential to impact on the habitats of the Giant Burrowing Frog including potential impacts on habitats likely to be important in the species' breeding. Mine subsidence would result in cracking of the rock strata in persistent and intermittent watercourses which is expected to result in conveyance of a portion of low flows via the fracture network, and a reduction in water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather. Gilbert and Associates (2009) indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows in streams. Mine subsidence has the potential to increase the rate of pool leakage (and consequently pool level recession). As described above, much of the Giant Burrowing Frog's existence is spent burrowed underground interspersed with brief periods of activity throughout the year during rainy weather (NPWS, 2001c). A number of streams provide potential habitat for the Giant Burrowing Frog (e.g. Four Mile Creek, Stokes Creek and Cobbong Creek). Only portions of streams considered known or potential habitat for this species are predicted to be subject to diversion of flows and drainage of pools during low flow events (MSEC, 2009; Gilbert and Associates, 2009). The Project stream impact minimisation criteria includes avoidance of significant cracking of rock bars that would result in surface flow diversion and draining of pools along a number of streams including Stokes Creek (downstream of Longwall 5a – refer to Appendix A of the EA). Experience has also shown that a range of different effects can occur in response to subsidence induced cracking with some pools retaining water through dry periods (Gilbert and Associates, 2009).

It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project.

An increase in fire frequency also has the potential to impact on the lifecycle of this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency resulting from the Project.

It is unlikely that the Project would adversely impact on the lifecycle of the Giant Burrowing Frog to the extent that a local population would be placed at risk of extinction.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The northern populations of the Giant Burrowing Frog are largely confined to sandstone ridgetop habitat and broader upland valleys, where the species is associated with small headwater streams and slow flowing to intermittent streams in undisturbed areas (NPWS, 2001c). The vegetation in these areas is typically woodland, open woodland and heath, with riparian components in and along the sides of early order streams. The species may also utilise upland swamps as a component of the range of habitats it is able to exploit.

There is the potential for relatively small components of each of the broad habitat types identified as being part of the Giant Burrowing Frog's 'habitat' to be impacted by the Project via cliff face and rock-fall and sub surface and surface tension cracking. However the likely impacts of the potential changes in habitat described has been demonstrated to be relatively minor and localised.

Mine subsidence also has the potential to cause cracking and alter the availability of water. The Giant Burrowing Frog is typically associated with small headwater streams and slow flowing to intermittent streams (NPWS, 2001c). Non-persistent sources of water (e.g. surface seeps, ponded water adjacent to fire trails and ephemeral streams) occur naturally and are generally available to terrestrial fauna including the Giant Burrowing Frog during and for a period following rain. The magnitude of surface cracking predicted by MSEC (2009) is considered unlikely to significantly influence the hydrological processes in these areas (Gilbert and Associates, 2009) and therefore significant changes to the availability of these sources of water to terrestrial fauna is not expected.

For some of the more persistent sources of water, there is the potential for mine subsidence to convey a portion of low stream surface flows via fracture networks and reduce the water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather. Gilbert and Associates (2009) indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows. During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network. Pool water levels would fluctuate in response to stream flow variability (i.e. increasing during periods of increasing flow and reducing with flow recession). Gilbert and Associates (2009) indicate that during periods of significant rainfall and runoff, the water level in subsidence impacted pools would be similar to pools unaffected by subsidence. Under these flow conditions pools and their downstream rock bars would become "drowned out". During dry periods when flows are in a low, recessionary regime the water level in pools affected by subsidence would recede much faster than is the case in unaffected pools (*ibid.*). As described above, MSEC (2009) and Gilbert and Associates (2009) indicate that these effects are predicted in only a portions of the streams considered potential habitat for this species. The Project stream impact minimisation criteria includes avoidance of significant cracking of rock bars that would result in surface flow diversion and draining of pools along a number of streams including Stokes Creek (downstream of Longwall 5a – refer to Appendix A of the EA). In addition, experience has shown that a range of different effects can occur in response to subsidence induced cracking with some pools retaining water through dry periods (Gilbert and Associates, 2009).

Mine subsidence is also expected to result in localised changes in stream water quality. The effects of subsidence on water quality have been most noticeable as localised and transient changes (spikes or pulses) in iron and manganese and minor associated increases in electrical conductivity. Potential impacts on riparian vegetation would be localised and limited in extent.

Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project. Surface works would be sited to minimise the amount of vegetation clearance required. It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas.

Given the nature of the hydrological changes and other potential Project impacts, the Project is unlikely to significantly reduce the quality or availability of habitat for the Giant Burrowing Frog.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Giant Burrowing Frog occurs in south-eastern NSW and Victoria (NPWS, 2001c). In the north of its distribution, this species is largely confined to the sandstone geology of the Sydney Basin extending as far south as Jervis Bay (Daly, 1996). In the south, this species occurs in disjunct 'pockets' from Narooma in NSW, south into eastern Victoria.

The Project is located within the known distribution of the Giant Burrowing Frog and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Disruption of existing habitat connectivity for existing populations would be possible following events such as significant habitat clearing, extensive rock falls or major surface cracking that created a barrier to movement, or the complete and permanent drying of streams that separated existing meta-populations. However, clearing of potential habitat for this species would occur at point scale rather than at landscape scale and rock fall and surface cracking are predicted to be relatively minor. Potential impacts along streams where the Giant Burrowing Frog occurs is very unlikely to fragment existing populations due to this species ability to move large distances over dry land (NPWS, 2001b). It is unlikely that habitat connectivity for the Giant Burrowing Frog would be significantly affected by the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Giant Burrowing Frog. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.2.3 Red-crowned Toadlet

The Red-crowned Toadlet is a relatively long-lived species (8-10 years) (NSW Scientific Committee, 2002) and is able to withstand prolonged periods of drought through its nocturnal, semi-fossorial lifestyle and use of moist microhabitat refugia (NPWS, 2001d).

The Red-crowned Toadlet has a unique terrestrial reproductive strategy: small nests are formed within decomposing accumulated leaf matter and clutch sizes are small, consisting of around 20-24 large eggs (NPWS, 2001d). The nests retain the eggs through the early stages of tadpole development; then rainfall events flush the embryos from the nest, and tadpoles complete development within transient pools (NPWS, 2001d). The timing of follow up rain events and duration of temporary pools is critical to reproductive success.

Many clutches are lost to desiccation through evaporation of the shallow pools and therefore recruitment is usually in low numbers (NPWS, 2001d). To offset this loss, females can lay multiple clutches and breed opportunistically when appropriate conditions prevail (*ibid.*).

The Red-crowned Toadlet has been recorded calling in all months of the year, including winter, and eggs have been found in all months (NPWS, 2001d). Midwinter breeding is infrequent and likely to occur during milder weather conditions that may prevail in the coastal part of its range in some years (*ibid*.). The Red-crowned Toadlet can also be found breeding along eroded gutters or the verges of unsealed fire trails (NPWS, 2001d). In these locations, accumulations of leaf-litter in association with temporary pools mimics natural feeder stream breeding habitat (*ibid*.).

When not breeding, Red-crowned Toadlets are thought to disperse over wider areas of its sandstone habitat and many individuals have been observed sheltering under cover that would be unsuitable for egg-laying (NPWS, 2001d). However, it is likely that such 'dispersion' is only in the order of a few tens of metres from suitable breeding areas (*ibid*.). Red-crowned Toadlets forage on ants, termites, mites, pseudo-scorpions, collembolans and small cockroaches (Rose, 1974; Webb, 1983).

Threats relevant to this species include habitat loss or degradation, high frequency fire, bush rock removal, Chytrid fungus disease, water pollution and changed hydrological regimes (NPWS, 2001d; NSW Scientific Committee, 2002). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4.

Mine subsidence has the potential to impact marginally on populations through limited rock fall and surface tension cracks impacting on particular individuals but not at a level likely to have a negative impact on population dynamics.

Changes in surface hydrology are likely to impact marginally, if at all, on the habitats, and as a result the lifecycle of the Red-crowned Toadlet. There is low potential for disruption to the Red-crowned Toadlet given its use of streams that are typically ephemeral in nature, as well eroded gutters or the verges of unsealed fire trails. These sources of water, which are generally available during and for a period following rain, would not be impacted by the Project. The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal stream flow.

It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project. The West Cliff Stage 4 Coal Wash Emplacement has been comprehensively surveyed for threatened fauna species including the Red-crowned Toadlet and has not been recorded despite numerous surveys in the location and surrounds.

An increase in fire frequency also has the potential to impact on the lifecycle of this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency resulting from the Project.

It is unlikely that the Project would adversely impact on the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Red-crowned Toadlet is known only from Triassic sandstones of the Sydney Basin, being found in steep escarpment areas and plateaus, as well as low undulating ranges with benched outcroppings (NPWS, 2001d). Within these geological formations, this species mainly occupies the upper parts of ridges, usually being restricted to within about 100 m of the ridgetop (*ibid.*). The Red-crowned Toadlet may also occur on plateaus or more level rock platforms along the ridgetop, however this area is usually less preferred than the first talus slope areas below the upper escarpment or just below benched rock platforms (NPWS, 2001d).

Favoured microhabitats for shelter sites are under flat sandstone rocks ('bush-rock') either resting on bare rock or damp loamy soils (NPWS, 2001d). Red-crowned Toadlets have also been found under logs on soil, beneath thick ground litter, particularly near large trees and in horizontal rock crevices near the ground (*ibid.*). Red-crowned Toadlets do not usually live along permanent flowing water courses occurring in gullies, instead preferring permanently moist soaks or areas of dense ground vegetation or litter along or near headwater stream beds (NPWS, 2001d). These are the non-perennial first or second order streams that are adjacent to ridges, are ephemeral in nature, and commonly called 'feeder-creeks' (*ibid.*). These streams channel water from the ridges, benches, cliffs and talus slopes to the perennial streams in the gullies below. Such watercourses are dry or reduced to scattered shallow pools or ponds for much of the year, and have sustained flow for only a few weeks following thunderstorms (NPWS, 2001d). Under natural conditions these feeder creeks have high water quality and low nutrient loads. The main vegetation communities found in association with this species are open woodland and heath communities that are typical for Hawkesbury and Narabeen geology (NPWS, 2001d). Tree cover, when present, is usually open and low (10 to 20 m) and with a xeromorphic understorey (*ibid.*).

There is the potential for relatively small components of the Red-crowned Toadlet's 'habitat' to be impacted by the Project via cliff face and rock-fall and sub surface and surface tension cracking. However the likely impacts of the potential changes in habitat described has been demonstrated to be relatively minor and localised.

Changes in surface hydrology are likely to impact marginally, if at all, on the habitats of the Red-crowned Toadlet. Non-persistent sources of water (e.g. surface seeps, ponded water adjacent to fire trails and ephemeral streams) occur naturally and are generally available to terrestrial fauna including the Red-crowned Toadlet during and for a period following rain. The magnitude of surface cracking predicted by MSEC (2009) is considered unlikely to significantly influence the hydrological processes in these areas (Gilbert and Associates, 2009). For some of the more persistent sources of water, there is the potential for mine subsidence to convey a portion of low stream surface flows via fracture networks and reduce the water level in pools as they become hydraulically connected with the fracture network. The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal stream flow. There is also likely to be reduced continuity of flow between affected pools during dry weather. Mine subsidence is also expected to result in localised changes in stream water quality. Potential impacts on riparian vegetation would be localised and limited in extent.

Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project. Surface works would be sited to minimise the amount of vegetation clearance required. It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required.

Given the nature of the hydrological changes and other potential Project impacts, the Project is unlikely to significantly reduce the quality or availability of habitat for the Red-crowned Toadlet.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Red-crowned Toadlet has a restricted distribution, known from a relatively small area of mid-eastern NSW (NPWS, 2001d). It is known from isolated portions of the Sydney Basin, from Pokolbin State Forest in the north to the Nowra district in the south, and Mt Victoria in the west.

The Project is located within the known distribution of the Red-crowned Toadlet and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Disruption of existing habitat connectivity for existing populations would be possible following events such as significant habitat clearing, extensive rock falls or major surface cracking that created a barrier to movement, or the complete and permanent drying of tributary streams that separated existing meta-populations. However, clearing of potential habitat for this species would occur at point scale rather than at landscape scale and rock fall and surface cracking are predicted to be relatively minor. Potential impacts along upland streams where the Red-crowned Toadlet occurs, is very unlikely to fragment existing populations. It is unlikely that habitat connectivity for the Red-crowned Toadlet would be significantly affected by the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Red-crowned Toadlet. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.2.4 Green and Golden Bell Frog

The Green and Golden Bell Frog breeds in summer (Cogger, 1992). Males call while floating in water and females produce a floating raft of eggs which gradually settle to the bottom (Harrison, 1922 in NPWS, 1999a). Tadpoles take around six weeks to develop depending on environmental conditions (e.g. temperature) (Pyke and White, 1996 in NPWS, 1999a). Adult male Green and Golden Bell Frogs may only live for around two years in difficult terrain (Goldingay and Newell, 2005) but life expectancy is likely to vary markedly according to the quality of the habitat.

The Green and Golden Bell Frog is active or basks by day but at night they forage on insects as well as other frogs (Cogger, 1992; NPWS, 1999a). Tadpoles feed on algae and other vegetative matter (NPWS, 1999a). The Green and Golden Bell Frog exhibits strong migration tendencies, including the ability to move several kilometres (DEC, 2005).

The home range of an individual Green and Golden Bell Frog may range from less than 100 square metres (m^2) to an area at least 700 m away (Pyke and White, 2001). Individuals have been observed sheltering in residential gardens located 200 to 300 m from their breeding site (*ibid*.). The Green and Golden Bell Frog feeds on a wide variety of prey including frogs, lizards, crickets, cockroaches, dragonflies, grasshoppers, caterpillars, slugs, earth-worms, molluscs, isopods, flies and tadpoles (Pyke and White, 2001).

The *Draft Recovery Plan for the Green and Golden Bell Frog* (Recovery Plan) (DEC, 2005) lists a number of threatening processes relevant to the Green and Golden Bell Frog, including habitat loss and/or modification and disturbance as well as fragmentation and isolation of habitat. The Recovery Plan also lists predation by introduced fish, disease and water quality and pollutant issues as threatening processes (DEC, 2005).

This species may also be sensitive to fertilisers. Historical and experimental evidence suggests that the elevated nitrate and phosphate concentrations in waterbodies in the 1970s may have contributed to the decline of the Green and Golden Bell Frog in its former range (Hamer *et al.,* 2003).

The Green and Golden Bell Frog was not recorded during the Project surveys Biosphere Environmental Consultants. However, this species has been previously recorded once in the Project area as well as several times to the south-east (DECC, 2009a). The nearest contemporary site known to contain Green and Golden Bell Frogs is at Darkes Forest, to the north-east of the Dharawal Nature Reserve.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The Green and Golden Bell Frog can be regarded as a ‘colonising’/’pioneering’ species as it is a habitat generalist, disperses widely and matures early (Hamer, 1998; Hamer *et al*., 2002). These characteristics (also known as ‘*r*’-selective characteristics) are an adaptation to living in an unpredictable environment (Begon *et al*., 1990).

Changes in surface hydrology have the potential to impact on the habitats of the Green and Golden Bell Frog including potential impacts on habitats likely to be important in the species' breeding. Mine subsidence would result in cracking of the rock strata in persistent and intermittent watercourses which is expected to result in conveyance of a portion of low flows via the fracture network, and a reduction in water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather. Gilbert and Associates (2009) indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows in streams. While mine subsidence has the potential to increase the rate of pool leakage (and consequently pool level recession), it is likely that a portion of the pools subject to mine subsidence effects will hold some water during prolonged dry periods (Gilbert and Associates, 2009). The Project stream impact minimisation criteria includes avoidance of impacts such as significant cracking of rock bars that would result in surface flow diversion and draining of pools along the Georges River, O'Hares Creek, Stokes Creek (downstream of Longwall 5a – refer to Appendix A of the EA), Nepean River, Cataract River and Lizard Creek. In addition, the Project avoids directly mining beneath the headwater reaches of Woronora River labelled as "perennial" on 1:25,000 topographic mapping (Lands Department, 2000) and therefore reduces potential impacts to this stream.

An increase in fire frequency also has the potential to impact on the lifecycle of this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency resulting from the Project.

It is estimated that the Project would disturb approximately 37 ha of remnant native vegetation in areas outside of the Stage 4 Coal Wash emplacement for ongoing surface exploration activities, the upgrade and extension of surface infrastructure (e.g. ventilation shafts), access tracks, environmental monitoring and management activities, potential stream restoration activities and other minor Project-related surface activities. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project.

It is unlikely that the Project would adversely impact on the lifecycle of the Green and Golden Bell Frog to the extent that a local population would be placed at risk of extinction.

2. *How is the proposal likely to affect the habitat of a threatened species, population or ecological community?*

The Green and Golden Bell Frog inhabits marshes, dams and stream sides and appears to prefer those waterbodies where bullrushes (*Typha* spp.) or spikerushes (*Eleocharis* spp.) grow (NPWS, 1999a). Optimum habitat for the Green and Golden Bell Frog is considered to be waterbodies which are unshaded, free of *Gambusia holbrooki* (an introduced predatory fish), have a grassy area nearby and diurnal sheltering sites (e.g. vegetation and/or rocks) (*ibid*.). Some Green and Golden Bell Frog populations, especially in the Greater Sydney region, exist in highly disturbed areas such as disused industrial sites, landfill areas and cleared land (*ibid*.). The Green and Golden Bell Frog also occasionally inhabit farm dams and ornamental ponds (Robinson, 1998).

A recent scientific study by Hamer *et al.* (2008) demonstrated high site fidelity of the Green and Golden Bell Frog to individual waterbodies and groups of neighbouring waterbodies. The Green and Golden Bell Frog tends to breed in more permanent waterbodies but also reproduce opportunistically in ephemeral waterbodies where recruitment is subsequently less successful (Hamer *et al.*, 2008).

For more persistent sources of water, there is the potential for mine subsidence to convey a portion of low stream surface flows via fracture networks and reduce the water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather. Gilbert and Associates (2009) indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows. During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network. Pool water levels would fluctuate in response to stream flow variability (i.e. increasing during periods of increasing flow and reducing with flow recession). Gilbert and Associates (2009) indicate that during periods of significant rainfall and runoff, the water level in subsidence impacted pools would be similar to pools unaffected by subsidence. Under these flow conditions pools and their downstream rock bars would become “drowned out”. During dry periods when flows are in a low, recessionary regime the water level in pools affected by subsidence would recede much faster than is the case in unaffected pools (*ibid.*). Despite prolonged dry periods, a number of small pools that create micro-habitat can remain which hold water (Gilbert and Associates, 2009).

Mine subsidence is also expected to result in localised changes in stream water quality. The effects of subsidence on water quality have been most noticeable as localised and transient changes (spikes or pulses) in iron and manganese and minor associated increases in electrical conductivity. Potential impacts on riparian vegetation would be localised and limited in extent.

Mining induced tilts has the potential to affect the water levels around the perimeters of farm dams (with the freeboard increasing on one side and decreasing on the other) and reduce the storage capacity of farm dams (MSEC, 2009). Farm dam walls subjected to higher strains may experience some minor cracking and leakage of water (MSEC, 2009). However, it is unlikely that these effects would have a material impact on water habitats available to the Green and Golden Bell Frog, particularly given that any such damage to landowner infrastructure would be repaired by the Mine Subsidence Board.

Minimal vegetation clearance for surface infrastructure would also be required throughout the Project area, however, this clearance would be progressive over the life of the mine and surface works would be situated to minimise vegetation clearance required where practicable. Vegetation clearance within riparian areas would be minor and limited to activities such as stream restoration works, if required.

Given the nature of the hydrological changes and other potential Project impacts, the Project is unlikely to significantly reduce the quality or availability of habitat for the Green and Golden Bell Frog.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Green and Golden Bell Frog is distributed in a series of isolated coastal populations within its former known range. Since 1990 there have been approximately 50 recorded locations in NSW, most of which are small, coastal, or near coastal populations (DECC, 2009f). Within the Sydney Basin, most of the remaining populations occur within a few kilometres of the coast (DECC, 2007a).

The Project is located within the known distribution of the Green and Golden Bell Frog and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Disruption of existing habitat connectivity for existing populations would be possible following events such as significant habitat clearing, or major surface cracking that created a barrier to movement, or the complete and permanent drying of tributary streams that separated existing meta-populations. However, clearing of potential habitat for this species would occur at point scale rather than at landscape scale and surface cracking is predicted to be relatively minor. It is unlikely that habitat connectivity for the Green and Golden Bell Frog would be significantly affected by the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Green and Golden Bell Frog. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.3 REPTILES

6.3.1 Broad-headed Snake

The Broad-headed Snake is found in rocky outcrops and adjacent sclerophyll forest and woodland (Cogger *et al*., 1993; NPWS, 2001e). Most suitable sites occur in sandstone ridgetops (Cogger *et al*., 1993). Suitable habitat is patchily distributed throughout the species range (Cogger *et al*., 1993). Adult snakes show a seasonal, temperature-induced shift in habitat use (Webb and Shine, 1998b). Adults use rocks and crevices as shelter sites in rocky outcrops in autumn, winter and early spring (Webb and Shine, 1994). Juvenile snakes remain in rocky habitat year round (Downes, 1999).

The Broad-headed Snake, like most small Australian elapid snakes, is nocturnal and rarely basks in the open and experimental field studies have shown that such behaviour may have evolved to minimise the risk of predation by diurnal predatory birds (Webb and Whiting, 2005). Snakes shelter under thin (<20 cm) rocks on exposed sites, which fit closely with a rocky substrate (Webb and Shine, 1994; Webb and Shine, 1998a). Occupied crevices have a sunny aspect (Webb and Shine, 1998a) and rocks used by snakes are those that receive the most warmth from the sun (Pringle *et al*., 2003). The majority of occupied retreat sites occur on exposed cliff edges (Webb and Shine, 1994). Thermally suitable microhabitat may be a limiting resource for the species (Pringle *et al*., 2003). Snakes often spend long periods of inactivity in a retreat site.

The Broad-headed Snake is nocturnal to crepuscular (active at dusk) and ambushes its prey (NPWS, 1999b). This species forages predominately on lizards (particularly Lesueur's Velvet Gecko) and frogs during winter, while the feeding preference shifts to mammals during the warmer months (Cogger, 2000; Webb and Shine, 1998c). Young are almost totally dependant on geckos as a source of food (Webb and Shine, 1998a). Individual Broad-headed Snakes have been recorded moving distances of up to 600 m (Ayers *et al*., 1996). This species is ovoviviparous giving birth to eight to 20 young (Cogger, 2000). Juveniles take four to six years to reach maturity (NPWS, 1999b).

Threats relevant to the Broad-headed Snake include the removal of bush rock (loss of shelter for this species and for its prey) (Shine *et al*., 1998), bushfire, fire suppression, forestry activities, impacts of feral animals such as Feral Goats, as well as illegal collection of the species (Green, 1997; Wilson and Swan, 2003; Pringle *et al*., 2003; Webb *et al*., 2005; NPWS, 1999b). Habitat alteration by longwall mining and removal of dead wood and dead trees are other threats relevant to this species (NSW Scientific Committee, 2003b; NSW Scientific Committee, 2005a) as is damage to fragile rock outcrops caused by humans (e.g. during bushwalking) (Goldingay and Newell, 2000; Webb *et al*., 2002) . In addition, the suggestion that vegetation encroachment over rock outcrops caused by European fire suppression practises might partly explain the recent decline of the Broad-headed Snake has been supported by an experimental field study (Webb *et al*., 2005) that has shown that modest canopy removal (similar to 15% increase in canopy openness) can restore habitat quality for nocturnal reptiles including the Broad-headed Snake and its prey, Lesueur's Velvet Gecko.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by vegetation clearance/habitat removal, an increase in the frequency of bushfire, an increase in exotic predator species and an increase in the rate of rock fall.

It is estimated that the Project would disturb approximately 65 ha of vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. It is unlikely that the Project vegetation clearance activities would impact on the lifecycle of this species to the extent that a local population of the Broad-headed Snake would be placed at risk of extinction. Vegetation clearance activities would be managed through the development and implementation of a Biodiversity Management Plan and would include pre-clearance surveys.

Given a range of management protocols are proposed to be in place to manage the risk of bushfire and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species, or an increase in feral exotic species. The Broad-headed Snake is well protected from predation because it is a top order predator but is likely to be more susceptible to predation in its juvenile phase, given its relatively limited home range within sandstone habitats and the protection offered by infinite nooks and crannies within sandstone habitats.

While rock falls occur naturally, subsidence has the potential to further reduce the stability of features (e.g. cliffs and overhangs) and thereby to increase the incidence of rock fall. Cliff instabilities are dependent on a number of factors such as jointing, weaknesses in the rockmass and seepage flow. In regard to the potential for subsidence to result in cliff falls, the DoP SCPR (DoP, 2008), states:

> *There is little to no evidence that vegetation or fauna habitats have been significantly altered as a result of cliff falls associated with subsidence.*

Given the predicted low incidence of rock falls (refer to Appendix R of the EA), it is considered that rock falls at the surface resulting from mine subsidence would likely have only small impacts, if any, on potential shelter or retreat sites for the Broad-headed Snake.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Broad-headed Snake favours habitat centered on the communities occurring on the Triassic sandstone of the Sydney Basin including exposed sandstone outcrops and benching in woodland, open woodland and/or heath (NPWS, 1999b). The Broad-headed Snake seasonally occupies distinctive microhabitats within these broader habitat types - rock crevices and exfoliating sheets of weathered sandstone during the cooler months and tree hollows during summer (Webb and Shine, 1998a). The rock crevice refuges commonly have a west to north-westerly aspect in order to maximise temperatures (Webb and Shine, 1998a).

Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Surface works would be sited to minimise the amount of vegetation clearance required. It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The Project is unlikely to significantly reduce the quality or availability of habitat for this species. A significant loss of shelter/retreat sites for the Broad-headed Snake due to subsidence is also unlikely based on the relatively low incidence of rock fall and cliff face collapse predicted to occur by MSEC (2009). Given a range of management protocols are proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in feral exotic species that could adversely impact habitat.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Broad-headed Snake is restricted to within a 200 km radius of Sydney, from Wollemi National Park in the north, south to the Clyde River Catchment, south-west of Nowra, west to the upper Blue Mountains and east to the Royal National Park (NPWS, 1999b). The current distribution of this species is focused in four key locations: the Blue Mountains, southern Sydney, an area north-west of the Cumberland Plains and the Nowra hinterland. Its eastern most distribution is within Royal National Park and the escarpment areas above the northern end of the Illawarra (NPWS, 1999b).

The Project is located within the known distribution of the Broad-headed Snake and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Habitat connectivity has the potential to be impacted by vegetation clearance/habitat removal. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale and is unlikely to be of a scale that could lead to the creation of two or more populations. It is unlikely that the Project would significantly impact on habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Broad-headed Snake. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.3.2 Heath Monitor

The Heath Monitor is mostly terrestrial and shelters in burrows (which it digs for itself), hollow logs and rock crevices (Wilson and Swan, 2003; Cogger, 2000). This species lays clutches of eggs in termite mounds (Wilson and Swan, 2003). The Heath Monitor forages on insects, small mammals, birds and other reptiles. This species is found in heath, open forest and woodland and individuals require large areas of habitat.

Threats to the Heath Monitor include habitat loss and fragmentation, removal of habitat elements such as termite mounds and fallen timber, vehicle strike and predation by Cats and Dogs (DECC, 2009g). Dog and Fox control programs may also impact on this species (DECC, 2007a). Habitat alteration by longwall mining and removal of dead wood and dead trees are other threats relevant to this species (NSW Scientific Committee, 2003b; NSW Scientific Committee, 2005a).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by vegetation clearance/habitat removal, an increase in the frequency of bushfire and an increase in exotic predator species.

It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. It is unlikely that the proposed vegetation clearance activities would impact on this species to the extent that a local population of the Heath Monitor would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species, or an increase in feral exotic species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Heath Monitor is known to associate with sandstone environments, occurring in open woodlands, heaths on sandy soil and in both wet and dry sclerophyll forests, where it shelters in burrows, hollow logs and rock crevices (Wilson and Swan, 2003; Cogger, 2000; DECC, 2007a).

Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project. Surface works would be sited to minimise the amount of vegetation clearance required. It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Reduction of potential habitat for the Heath Monitor due to surface infrastructure would be small compared to the amount of habitat available.

Given a range of management protocols are proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in feral exotic species that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Heath Monitor occurs on the Sydney Sandstone in Wollemi National Park to the north-west of Sydney, in the Goulburn and Australian Capital Territory (ACT) regions and near Cooma in the south (DECC, 2009g). There are also records for this species from the South West Slopes near Khancoban and Tooma River (*ibid.*).

The Heath Monitor has been recorded in the Metropolitan, O'Hares and Woronora Special Areas and the Woronora Plateau is considered to be one of the most important population centres in NSW for this species (DECC, 2007a).

The Project is located within the known distribution of the Heath Monitor and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Disruption of existing habitat connectivity for an existing population, would be possible following events such as extensive habitat clearing. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Given the nature of the vegetation clearance activities and the mobility of the species, it is unlikely that the Project would significantly impact on habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Heath Monitor. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4 BIRDS

6.4.1 Square-tailed Kite

The Square-tailed Kite breeds from July to December (Lindsey, 1992; Pizzey and Knight, 1999) and while little is known of its requirements for breeding in terms of habitat, it appears to need a large wooded area in the order of hundreds of hectares (Marchant and Higgins, 1993). Nests are constructed in a mature tree near an assured food supply and often within 100 m of a watercourse (Marchant and Higgins, 1993; Schodde and Tidemann, 1997). The nests of this species consist of large platforms made from sticks, which are lined with Eucalypt leaves. Square-tailed Kites may re-use nests in successive years (Lindsey, 1992; Schodde and Tidemann, 1997).

The Square-tailed Kite specialises in taking small prey from the tree canopy, such as birds (including nestlings), reptiles and insects (Schodde and Tidemann, 1997; Ayers *et al.,* 1996), and rarely, if ever, visits the ground (NPWS, 2000c). It hunts primarily over open forest, woodlands and mallee communities that are rich in passerines, as well as over adjacent heaths and other low scrubby habitats and in wooded towns (Storr, 1980; Debus and Czechura, 1989). Resident pairs have a large hunting range of at least 100 km^2 (NPWS, 2000c). Records suggest that this species moves north to tropical areas in winter (Blakers *et al*., 1984; Brouwer and Garnett, 1990), and Marchant and Higgins (1993) describe the species as migratory across much of its distribution.

The Square-tailed Kite is threatened by the removal, degradation and fragmentation of habitat, particularly of mature Eucalypts along watercourses (Ayers *et al*., 1996; NPWS, 1999c, 2000c). Other threats relevant to this species include inappropriate fire regimes, illegal shooting, and collection of eggs (Ayers *et al*., 1996; NPWS, 1999c, 2000c).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur: extensive clearing of habitat or an increase in fire frequency that result in a decline in prey species.

It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Any viable local population of the Square-tailed Kite is unlikely to be dependent upon the portion of habitat that would be removed or modified by the Project given the mobility of the species and the occurrence of habitat resources within the surrounding area and wider region. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency. Hence it is very unlikely that the Project would adversely impact on the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Square-tailed Kite inhabits dry woodland and open forest, while vegetation along major rivers and belts of trees in urban or semi-urban areas are favoured for hunting (NPWS, 2000c). Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact this species habitat.

It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The Project is unlikely to significantly reduce the quality or availability of habitat for the Square-tailed Kite.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Square-tailed Kite is uncommon, yet widespread, occurring across most parts of NSW (Marchant and Higgins, 1993; NPWS, 2000c). In NSW, scattered records of the species throughout the state indicate that the species is a regular resident in the north, north-east and along the major west-flowing river systems (DECC, 2009h). It is a summer breeding migrant to the south-east, including the NSW south coast, arriving in September and leaving by March (DECC, 2009h).

The Square-tailed Kite has been recorded in the Metropolitan, O'Hares and Woronora Special Areas, however is considered to be a rare summer migrant to the Greater Southern Sydney Region (DECC, 2007a). The Project is located within the known distribution of the Square-tailed Kite and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of the species habitats or a significant increase in fire frequency. Limited clearing of habitat would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to impact on habitat connectivity for the Square-tailed Kite.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Square-tailed Kite. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.2 Gang-gang Cockatoo

The Gang-gang Cockatoo breeds in hollows in the trunks or large limbs of large trees (Gibbons, 1999; Gibbons and Lindenmayer, 2000) from October to January (Pizzey and Knight, 2006). Nests are usually formed from decayed debris in a tree hollow (Pizzey and Knight, 2006). Breeding usually occurs in tall mature sclerophyll forests that have a dense understorey, and occasionally in coastal forests (NSW Scientific Committee, 2005b). Nests are most commonly recorded in eucalypt hollows in live trees close to water (Beruldsen, 1980). The species undertakes nomadic as well as seasonal movements (NSW Scientific Committee, 2005b; Pizzey and Knight, 2006) and may occur at apparently random points within its range (NSW Scientific Committee, 2005b). For example, in autumn and winter, the Gang-gang Cockatoo disperses widely from highlands through to the coast and sub-inland woodlands, farmlands and urban areas (Pizzey and Knight, 2006). This species is considered to be fairly common in suitable habitat (*ibid.*).

Threats to the Gang-gang Cockatoo include the removal or degradation of nesting or foraging habitat, Psittacine cirovirus disease and competition for hollows (NSW Scientific Committee, 2005b; Garnett and Crowley, 2000).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by vegetation clearance/habitat removal and an increase in the frequency of bushfire.

It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. It is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of this species to the extent that a local population of the Gang-gang Cockatoo would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire, it is unlikely that there would be an increase in fire frequency that would adversely impact on the lifecycle of the Gang-gang Cockatoo.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

In summer, the Gang-gang Cockatoo is generally found in tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests (NSW Scientific Committee, 2005b). The species may also occur in sub-alpine Snow Gum *Eucalyptus pauciflora* woodland and occasionally in temperate rainforests (Forshaw, 1989). In winter, the Gang-gang Cockatoo occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas (Shields and Crome, 1992). At this time the species may be observed in urban areas including parks and gardens (Morcombe, 1986).

Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Surface works would be sited to minimise the amount of vegetation clearance required. It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Any reduction of habitat for the Gang-gang Cockatoo due to surface infrastructure would be small compared to the amount of habitat available. Given a range of management protocols are proposed to be in place to manage the risk of bushfire, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

In NSW, the Gang-gang Cockatoo is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes (NSW Scientific Committee, 2005b).

The Project is located within the known distribution of the Gang-gang Cockatoo and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was extensive and widespread clearing of its habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to the Gang-gang Cockatoo would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for the Gang-gang Cockatoo.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Gang-gang Cockatoo. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.3 Glossy Black Cockatoo

The Glossy Black Cockatoo roosts communally in groves of trees in close proximity to stands of She-oaks (Pizzey and Knight, 1999). The species nests in hollow limbs or trunks of old or dead trees lined with woodchips, usually 15-30 m off the ground (Pizzey and Knight, 1999). Field studies have shown that the Glossy Black Cockatoo prefers to nest in vertical spouts in large trees and that nests are most often located relatively high in senescent trees or standing dead trees (Cameron, 2005a).

The Glossy Black Cockatoo forages for long hours each day to gain sufficient food, particularly during the breeding season and its diet is primarily restricted to the seeds of She-oaks (*Allocasuarina* spp. and *Casuarina* spp.), although Acacia, Angophora and Eucalypt seeds, Angophora fruit, sunflower seeds and grubs found in some *Allocasuarina* and *Acacia* species have occasionally been recorded as a food source (Higgins, 1999; Schodde and Tidemann, 1997; Barker and Vestjens, undated; Blakers *et al*., 1984). Older Glossy Black Cockatoos are able to process She-oak cones at a faster rate than younger birds (Cameron, 2005b).

Glossy Black Cockatoo group size increases when food resources are limited, perhaps because foraging efficiency is enhanced by associating with more experienced birds or by using the presence of feeding con-specifics to locate food (Cameron, 2005b). Populations of the Glossy Black Cockatoo are often sedentary so long as the requirement of an adequate supply of seed exists, however they are nomadic when supplies fail for any reason (Schodde and Tidemann, 1997).

Threats to the Glossy Black Cockatoo include the removal or degradation of nesting or foraging habitat, Psittacine cirovirus disease, competition for hollows and grazing of She-oak seedlings by Rabbits, Sheep and Goats (NSW Scientific Committee, 1999; NPWS, 1999d; Garnett and Crowley, 2000).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by vegetation clearance/habitat removal and an increase in the frequency of bushfire.

It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement (although *Allocasuarina* and *Casuarina* are not dominant canopy species in the emplacement area) and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. It is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of this species to the extent that a local population of the Glossy Black Cockatoo would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire, it is unlikely that there would be an increase in fire frequency that would adversely impact on the lifecycle of the Glossy Black Cockatoo.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Glossy Black Cockatoo inhabits coastal forests, open woodland, timbered watercourses or wherever Casuarinas are common (Schodde and Tidemann, 1997; Pizzey and Knight, 1999). However, not all apparently suitable habitats provide adequate food value to support the cockatoos (Crowley and Garnett, in press; Crowley *et al*., 1999; Clout, 1989). It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The Project has the potential to result in the removal/modification of habitat for this species, however the area to be disturbed would be small compared to the amount of habitat available for the Glossy Black Cockatoo. Further, given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Glossy Black Cockatoo is sparsely distributed along the east coast and immediate inland districts from western Victoria to Rockhampton in Queensland (Crome and Shields, 1992). In NSW the Glossy Black Cockatoo is found as far west as Cobar and Griffith in isolated mountain ranges (NPWS, 1999d).

The Project is located within the known distribution of the Glossy Black Cockatoo and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was extensive and widespread clearing of its habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to the Glossy Black Cockatoo would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species which travels widely in search of fruiting Casuarinas. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for the Glossy Black Cockatoo.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Glossy Black Cockatoo. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.4 Powerful Owl, Masked Owl, Barking Owl and Sooty Owl

Nests of the Powerful Owl are located in large hollow tree limbs or trunks (Schodde and Tidemann, 1997). The Powerful Owl roosts by day on the branches of relatively open trees, usually within dense foliage along streams amid Eucalypt forest (Ayers *et al.*, 1999). Each pair has a number of roosting trees (Schodde and Tidemann, 1997). The Powerful Owl is a sedentary species that lives singly or in pairs within permanent territories (300 to 1,000 ha depending on habitat productivity) (Schodde and Tidemann, 1997; Ayers *et al.*, 1999).

A recent scientific study has shown that on average 5-12% of the home-range of a Powerful Owl is used during a single night (Soderquist and Gibbons, 2007). Core foraging areas for individuals in the study comprised many, typically small, patches scattered across the entire home-range (*ibid.*). Soderquist and Gibbons (2007) also found that selection of roosting sites was flexible with 96% of roosts in very small to medium-sized trees. The Powerful Owl hunts nocturnally for primary prey items such as arboreal and semi-arboreal mammals, birds, insects and terrestrial mammals (*ibid.*).

A field study by Cooke *et al*. (2006) found that Powerful Owls in the Yarra Valley Corridor are reliant almost exclusively on arboreal marsupial prey as their preferred diet, however, there was a strong positive relationship with the presence of these species in the diet and their site-specific availability, indicating that the powerful owl is a generalist hunter (i.e. preying on the most available prey at a given site in a given season).The Masked Owl, in forested environments, is a highly cryptic species, except for short periods early in the breeding season when individuals typically become more vocal and their presence is readily detectable (Kavanagh and Murray, 1996a; 1996b).

The Masked Owl roosts communally within a diverse range of wooded habitats that provide large hollow-bearing trees, often in riparian forests (Garnett and Crowley, 2000). The species nests on decayed debris in hollow Eucalypts 12 to 20 m high, bare sand or earth of cave (Pizzey and Knight, 1999). During the non-breeding season, roosting may occur among dense foliage of trees (Kavanagh and Murray, 1996a).The Masked Owl forages in nearby open areas (Kavanagh and Murray, 1996a; Higgins, 1999) and its diet mainly consists of possums, rabbits, currawongs, gliders, bats, birds and lizards (Pizzey and Knight, 1999; Garnett and Crowley, 2000) but can also consist largely of introduced mammals (e.g. rats), if available (Kavanagh and Murray, 1996a; 1996b). This species keeps to the same territory all year round (Schodde and Tidemann, 1997). Kavanagh and Murray (1996a; 1996b) radio-tagged and tracked an adult female Masked Owl over several weeks and estimated her home range as 1,017 to 1,178 ha.

The Barking Owl roosts by day in dense streamside galleries and thickets of Acacia, Casuarina and Eucalypts, and forages in adjacent woodland (Ayers *et al.,* 1996). Breeding takes place in traditional territories, in large hollows in old Eucalypts (Ayers *et al.,* 1996), which may be used year after year. Nest entrances are typically 2 to 35 m above the ground (Higgins, 1998). The Barking Owl hunts nocturnally for a variety of small to medium-sized mammals, birds and large insects within woodland and forest habitats (Higgins, 1998). The species is assumed to be sedentary, living singly, in pairs, or in family groups of 3 to 5 in permanent territories containing several roost sites (Ayers *et al.*, 1996).

The Sooty Owl inhabits dimly lit rainforests and rainforest gullies overtopped by eucalypts (Schodde and Tidemann, 1997). Nests are typically a 40 to 500 cm deep hollow in a tall eucalypt in or on the edge of rainforest. The Sooty Owl is thought to pair permanently and hold the same territory (approximately 200 to 800 ha) each year. The Sooty Owl roosts by day in one of a number of set perches (e.g. a deep hollow, on the stems of a giant fig or a crevice under a bank or cliff) and hunts through the forest and along its edge for prey items such as possums, glider, rats, bandicoots and birds. A field study by Bilney *et al*. (2006) that arboreal prey constitutes 81% of the diet of Sooty Owls in the area investigated.

Threats relevant to the Powerful Owl, Masked Owl, Barking Owl and/or Sooty Owl include clearing of vegetation and consequently foraging and breeding habitat (Debus and Chafer, 1994; Garnett and Crowley, 2000; NPWS, 2000c, 2003a), as well as timber harvesting, inappropriate fire regimes and predation by foxes on fledgling owls (Debus and Chafer, 1994; McNabb, 1996; Debus, 1997; NPWS, 2003a).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of these four owl species has the potential to be impacted by vegetation clearance/habitat removal and an increase in the frequency of bushfire. It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. However, it is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of these species to the extent that a local population would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire, it is unlikely that there would be an increase in fire frequency that would adversely impact the lifecycle of these four species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Powerful Owl occurs in open forest and tall open forest, particularly in wet and dry sclerophyll forest, as well as in gully rainforest and in woodland (NPWS, undated a). The Masked Owl inhabits forests, woodlands and nearby clearings (Flegg, 2002), while the Barking Owl primarily inhabits open forest and woodland in warm lowland areas on gentle terrain (Ayers *et al.*, 1996), avoiding high altitudes and dense, wet escarpment forests (Debus, 1997). The Sooty Owl is associated with rainforests and eucalypt rainforest gullies (Schodde and Tidemann, 1997).

Where practicable, surface works would be sited to minimise the amount of vegetation clearance required, particularly clearance of large hollow-bearing trees. It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Clearing of vegetation and consequently foraging and breeding habitat for these four species due to surface infrastructure would be small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for the Powerful Owl, Masked Owl, Barking Owl or Sooty Owl.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Powerful Owl is primarily distributed from the Clarke Range in Queensland to the Mount Burr region of south-eastern South Australia, primarily on the coastal side of the Great Dividing Range (Ayers *et al.*, 1999).

The main distribution of the Masked Owl is located along the coast (NPWS, undated b), however this species is also sparsely distributed through sub-coastal mainland Australia from Fraser Island to Carnarvon (Western Australia) including the Nullarbor Plain and inland of the Great Dividing Range (Schodde and Mason, 1980; Smith *et al.*, 1995; Higgins, 1999).

The Barking Owl is found throughout most of NSW, with the main part of the distribution being west of the Great Dividing Range (Debus, 1997).

The Sooty Owl is distributed in south-eastern Australia, along the eastern scarp of the Great Dividing Range, north to the Conondale-Blackall Ranges in Queensland, and south to the Dandenong Ranges in Victoria (Schodde and Tidemann, 1997).

The Project is located within the known distribution of the Powerful Owl, Masked Owl, Barking Owl and Sooty Owl and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these four owl species within the Project area would only be likely if there was extensive and widespread clearing of their habitats or a significant increase in fire frequency. Limited clearing of habitat potentially of benefit to these species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these four vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for these four owl species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Powerful Owl, Masked Owl, Barking Owl or Sooty Owl. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.5 Bush Stone-curlew

In NSW, Bush Stone-curlews occur in lowland grassy woodland and open forest, much of which has been cleared for agriculture and urban development (Johnson and Baker-Gabb, 1994). Bush Stone-curlew habitat is described by broad ground and understorey structural features and is not necessarily associated with any particular vegetation communities. In general, habitat occurs in open woodlands with few, if any, shrubs, and short, sparse grasses of less than 15 cm in height, with scattered fallen timber, leaf litter and bare ground present. In coastal areas, structurally similar elements of tidal and estuarine communities provide suitable habitat. Bush Stone-curlews are recorded within Casuarina woodlands, salt marsh and mangroves (Price, 2004). In general, Bush Stone-curlews are not found on the escarpments but in lower elevation grassy woodlands of the coast or west of the divide throughout the sheep-wheat belt (DEC, 2006b).

Bush Stone-curlew nests consist of a slight depression in the ground usually near dead timber where they roost during the day relying on camouflage to hide them from predators (NPWS, 1999e; Pizzey and Knight, 1999; DEC, 2006b). Breeding occurs in spring with both parents caring for and actively defending their young (Marchant and Higgins, 1993). Bush Stone-curlews are nocturnal and forage on invertebrates (molluscs, centipedes, crustaceans, spiders, grasshoppers, moths, etc.), small fauna (frogs, lizards, snakes, small rodents) and some vegetation (NPWS, 1999e; DEC, 2006b). This species is mainly sedentary although is known to be locally dispersive outside breeding periods, occurring singly or in pairs (NPWS, 1999e).

Threats relevant to the Bush Stone-curlew include removal of dead timber, cultivation, grazing, predation by Foxes, Pigs, Dogs and Cats, and disturbance by human activities (especially during nesting) (NPWS, 1999e; 2003b).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur: extensive clearing of habitat or an increase in fire frequency that result in a decline in prey species. Any viable local population of the Bush Stone-curlew is unlikely to be dependent upon the portion of habitat that would be removed or modified by the Project given the occurrence of nearby habitat resources within the surrounding area and wider region. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency. Hence it is very unlikely that the Project would adversely impact on the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

In NSW, Bush Stone-curlews occur in lowland grassy woodland and open forest, much of which has been cleared for agriculture and urban development (Johnson and Baker-Gabb, 1994). Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact this species habitat. As described in Section 4, the Project would involve some vegetation clearance for surface infrastructure (e.g. West Cliff Stage 4 Coal Wash Emplacement, exploration activities, ventilation shafts, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. The Project is unlikely to significantly reduce the quality or availability of habitat for the Bush Stone-curlew.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Bush Stone-curlew is distributed throughout mainland Australia, except in the most arid areas and offshore islands (Garnett and Crowley, 2000). Once widespread along the east coast of NSW, recent records indicate that the distribution of the Bush Stone-curlew is now limited to areas of the NSW central and north coast (NPWS, 1999e; DEC, 2006b).

The Project is located within the known distribution of the Bush Stone-curlew and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was extensive and widespread clearing of its habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to the Bush Stone-curlew would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for the Bush Stone-curlew.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Bush Stone-curlew. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.6 Turquoise Parrot

The Turquoise Parrot lives on the edge of eucalypt woodlands adjoining clearings, timbered ridges and streams in farmland. The Turquoise Parrot breeds between August and December, often-producing two broods (Schodde and Tidemann, 1997). . Pizzey and Knight (2006) report that this species may also breed between April and May. Nests are built in hollows and cavities, which occur in stumps, fence posts and live trees (e.g. spout of a eucalypt) close (usually <2 m) to the ground (Forshaw, 1981; Lindsey, 1992; Ayers *et al.,* 1996; Pizzey and Knight, 2006). Logs on the ground are also used for nesting (Quinn and Baker-Gabb, 1993). Females are responsible for incubation, which lasts approximately 18 days. Birds fledge at four weeks, after which young birds are dependent on the parents for a few months (Schodde and Tidemann, 1997). Turquoise Parrots generally occur as pairs or small flocks (Pizzey and Knight, 2006). Foraging is almost entirely on the ground (Higgins, 1999) on introduced and native grasses and herbs (Ayers *et al.,* 1996; Pizzey and Knight, 2006) such as the Parrot Pea (*Dillwynia* spp.), Barley Grass (*Hordeum murinum*), Mustard (*Sisymbrium* sp.), Wallaby Grass (*Austrodanthonia* spp.), Stinging Nettle (*Urtica urens*) and Saffron Thistle (*Carthamus lanatus*) (Crome and Shields, 1992). In addition, a reliable water source is an essential component of the habitat requirements of this species (Higgins, 1999). The Turquoise Parrot is partly nomadic (Ayers *et al.*, 1996; Pizzey and Knight, 2006).

Threats to this species include habitat loss and fragmentation, timber cutting, inappropriate fire regimes removing understorey vegetation, grazing, and predation by Cats and Foxes (NPWS, 1999f; Garnett and Crowley, 2000). This species is considered to be consolidating after decades of decline (Pizzey and Knight, 2006).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by vegetation clearance/habitat removal and an increase in the frequency of bushfire.

It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. It is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of this species to the extent that a local population of the Turquoise Parrot would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire, it is unlikely that there would be an increase in fire frequency that would adversely impact on the lifecycle of the Turquoise Parrot.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Turquoise Parrot favours eucalypt woodlands and open forests that have a ground cover of grasses (DECC, 2007a). Open grassy woodlands near permanent water that contain dead trees and forested hills are particularly preferred by this species (Morris in Pizzey and Knight, 2006). Other suitable habitat includes coastal heaths, pastures containing exotic grasses, roadsides and orchards (Pizzey and Knight, 2006). It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The Project has the potential to result in the removal/modification of habitat for this species, however the area to be disturbed would be small compared to the amount of habitat available for the Turquoise Parrot. Further, given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Turquoise Parrot occurs along the eastern and western scarps of the Great Dividing Range, south to Nowra and Benalla (NSW), north to Maryborough and Taroom (Queensland), and west to Griffith (Schodde and Tidemann, 1997).

The Project is located within the known distribution of the Turquoise Parrot and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was extensive and widespread clearing of its habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to the Turquoise Parrot would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for the Turquoise Parrot.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Turquoise Parrot. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.7 Eastern Ground Parrot

The Eastern Ground Parrot lives in low heathland and sedgeland (Meredith, 1984; Meredith *et al*., 1984, McFarland, 1989) as well as drier ridges and nearby grasslands (Pizzey and Knight, 2006). This shy species occurs as singles, pairs or open companies (Pizzey and Knight, 2006). Breeding takes place between September and December as well as in autumn in north-east NSW (*ibid*.). Nests, generally made into a cup shape with an entrance tunnel from bitten-off stems, are made on the ground beneath dense vegetation (e.g. tussock or stunted bush) and the clutch size averages 3 to 4 (McFarland, 1991a; Pizzey and Knight, 2006). The Eastern Ground Parrot feeds on the ground (Pizzey and Knight, 2006) and eats seeds from a wide range of herbs, graminoids and heath, the diet generally reflecting the range of available plants, but excludes seeds that need processing to remove woody husks (McFarland, 1991b). This species climbs low plants (Pizzey and Knight, 2006). The Eastern Ground Parrot is considered to be sedentary but undertakes local seasonal movements (*ibid*.).

Threats relevant to this species include habitat loss and fragmentation (Higgins, 1999), however inappropriate fire regimes are considered to be the main threat (DECC, 2007a). The principal management action for this species on the Woronora Plateau is the maintenance of a mosaic of burn ages within suitable habitat (*ibid*.).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; changed surface hydrological conditions leading to a reduced availability of habitat and resources; and clearing of vegetation. Vegetation clearance for surface infrastructure would not take place in upland swamps except for very minor clearing for environmental monitoring purposes.

As provided in the Upland Swamp Risk Assessment (Appendix O of the EA), only a small proportion of upland swamps are likely to be subject to significant negative consequences and ICHPL would develop and implement measures to mitigate and manage negative consequences in these few swamps. Further detail on these measures is provided in Section 5 in the Main Report and in the Upland Swamp Risk Assessment (Appendix O of the EA).

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Eastern Ground Parrot lives in low heathland and sedgeland. Heathland becomes unsuitable immediately after fire (Meredith et al., 1984, McFarland, 1993), in some cases, for a further four years (Jordan, 1987; Baker and Whelan, 1994), but suitability may decline if left unburnt for more than 15 years (McFarland, 1989). In sedgeland and gramminoid heathlands, Ground Parrots persist for many more years after fire (Meredith *et al*., 1984; Baker and Whelan, 1994). A mosaic of burning that allows movement between patches of different post-fire recovery is considered likely to be important to ensure rapid recolonisation of recently burnt areas.

An imposed fire regime is required to maintain the integrity of habitat with a mosaic of fire ages being used to ensure refugia in time of fire, rapid recolonisation of habitat that has recovered after fire, and recovery of habitat that has become unsuitable through being unburnt for too long (Meredith, 1984; McFarland, 1993).

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat of this species. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation. It is unlikely that clearing activities would have a significant impact on the habitat of this species. Vegetation clearance for surface infrastructure would not take place in upland swamps except for very minor clearing for environmental monitoring purposes. As a result, the Project is unlikely to significantly reduce the quality or availability of habitat for the Eastern Ground Parrot.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The eastern subspecies of the Eastern Ground Parrot (*Pezoporus wallicus wallicus*) inhabits south-eastern Australia from southern Queensland through NSW to western Victoria (DECC, 2009i). The upland swamps of the Woronora Plateau once supported many populations of this parrot, however they were thought to have disappeared following a period of frequent burning after the extensive 1968 bushfires (C. Chafer pers. comm. in DECC, 2007a). However, recent targeted surveys by Western Research Institute and Biosphere Environmental Consultants (2008) recorded the Eastern Ground Parrot in upland swamp habitat at the nearby Metropolitan Colliery.

The Project is located within the known distribution of the Eastern Ground Parrot and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of the species habitats, a significant increase in fire frequency or if changes in surface hydrology impacted adversely and at landscape scale on upland swamp and heathland habitats. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Changes in surface hydrology are unlikely to adversely impact habitat connectivity for this species. Hence the Project is very unlikely to adversely impact habitat connectivity for the Eastern Ground Parrot.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Eastern Ground Parrot. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.8 Eastern Bristlebird

The Eastern Bristlebird has been split into two subspecies (Schodde and Mason, 1999), *Dasyornis brachypterus monoides* (northern subspecies) and *Dasyornis brachypterus brachypterus* (southern subspecies) (NSW Scientific Committee, 2008a, 2008b). Current Preliminary Determinations by the NSW Scientific Committee propose to list the northern subspecies as a Critically Endangered species and the southern subspecies as an Endangered species under the TSC Act.

The northern subspecies of the Eastern Bristlebird inhabits thick, moist undergrowth which provides a refuge from fire (NSW Scientific Committee, 2008a). The primary habitat is grass tussocks (mainly Wild Sorghum) in open forest and woodland close to rainforest (*ibid.*). The southern subspecies inhabits thick undergrowth; dense, low vegetation including heathland, sedgeland, shrubland (often riparian or on swamp fringes), forest or woodland with a dense shrub layer, and temperate rainforest (NSW Scientific Committee, 2008b).

The Eastern Bristlebird is considered to be a cover-dependent and fire-sensitive species (NPWS, 1999g). Age of habitat since fires is of particular importance with unburnt periods of 15 years or more necessary to optimise population density. Eastern Bristlebirds have low fecundity; generally laying a clutch of two eggs and raising only one fledgling (NPWS, 1999g). Eastern Bristlebird nests are elliptical domes constructed in low dense vegetation, usually in tufted plants (NPWS, 1999g). The diet of the Eastern Bristlebird includes ants, beetles and weevils (Baker, 1998). Individuals have a home range of more than 10 ha and are presumed to be sedentary (Baker, 1998).

Potential threats to this species are thought to include loss of habitat (including indirect loss due to too frequent fires), predation by native and introduced predators, road-kills (known to occur in the Jervis Bay area), grazing by livestock and trampling of habitat (northern populations), off-road vehicle damage to habitat and invasion of habitat by weeds (NPWS, 1999g). Fragmentation and isolation characteristic of the Eastern Bristlebird populations may also be adversely affecting the species (*ibid.*).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by an increase in fire frequency impacting the species habitat, an increase in exotic pest species, changed surface hydrological conditions leading to a reduced availability of habitat and resources, and clearing of vegetation.

The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project. As provided in the Upland Swamp Risk Assessment (Appendix O of the EA), only a small proportion of upland swamps are likely to be subject to significant negative consequences. These swamps would have detailed Risk Management Plans prepared which would include detailed mitigation, remediation and monitoring measures (Appendix O of the EA). Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation. The Biodiversity Management Plan would describe measures to be implemented to minimise soil disturbance and the spread of weeds or feral species.

Within the Greater Southern Sydney Region, the Eastern Bristlebird historically occurred along and below the Illawarra Escarpment, however is now thought to be locally extinct (DECC, 2007a; NSW Scientific Committee, 2008b). Given the absence of records and known distribution of this species, the Project is unlikely to impact on the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Eastern Bristlebird inhabits a wide range of vegetation communities including rainforest, eucalypt forest, woodland, mallee, shrubland, swamp, heathland and sedgeland where there is low dense cover (Baker, in press). The Eastern Bristlebird is considered to be a cover-dependent and fire-sensitive species (NPWS, 1999g).

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat of this species. It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Surface works would be sited to minimise the amount of vegetation clearance required. Given the absence of records and known distribution of this species, the Project is unlikely to impact on the habitat of the Eastern Bristlebird.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The southern subspecies of Eastern Bristlebird is disjunct from the northern subspecies by approximately 700 km (NSW Scientific Committee, 2008a, 2008b). The northern subspecies is confined to the Conondale Range and Border Ranges of southeast Queensland and north-east NSW (NSW Scientific Committee, 2008a). While the southern subspecies of Eastern Bristlebird formerly occurred around Sydney and north to the Myall Lakes, its distribution has now contracted 300 km to south of Wollongong (NSW Scientific Committee, 2008b). It is known to occur as four disjunct populations in NSW, *viz*. Budderoo National Park and Barren Grounds Nature Reserve, Jervis Bay/Booderee National Parks, Nadgee Nature Reserve and Beecroft Peninsula (where it has been translocated (*ibid.*).

The Project is not located within the known distribution of the Eastern Bristlebird.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Vegetation clearance activities associated with the Project have the potential to impact on habitat connectivity for this species. However, the absence of records and known distribution of this species suggest that this is unlikely.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Eastern Bristlebird. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.9 Regent Honeyeater and Swift Parrot

The Regent Honeyeater usually nests in isolated pairs, although they sometimes breed in loose colonies (NPWS, 1999h). Successful nesting has been known to occur in remnant trees in paddocks (Geering and French, 1998). The nest is a thick walled cup of bark strips bound with cobwebs and lined with dry grass and bark shreds (Geering and French, 1998). There are only a small number of known breeding sites in NSW, the most important being in the Capertee Valley (DEC, 2004b) although other important breeding areas are situated in Warrumbungle National Park, Pilliga Nature Reserve, Barraba district, the central coast around Gosford, and the Hunter Valley (Ayers *et al.,* 1996; NPWS, 1999h). Although nectar is their main food source, Regent Honeyeaters also eat insects, lerps and fruit (Ayers *et al.,* 1996). In fact, field studies of the Regent Honeyeater show that the species has a more generalised diet, and is less nectar-dependent, than previously suggested (Oliver, 2000). For example, Regent Honeyeaters have been observed to spend up to 90%; of their foraging time feeding on lerp, honeydew and insects when nectar is scarce (*ibid.*). The Regent Honeyeater has demonstrated a preference for larger trees to forage and the preference for particular species may be related to the timing of flowering (DEC, 2004b). The Regent Honeyeater is regarded as a single population (DEC, 2004b). The birds are partly migratory, shifting generally northwards in autumn and winter and returning south to breed in spring (Schodde and Tidemann, 1997). Individuals have been found to travel over 350 km between the Capertee Valley and Canberra (David Geering pers. comm., 2004b). The movements of the Regent Honeyeater are related to the regional patterns of flowering of the key forage species (DEC, 2004b).

The Swift Parrot only breeds in Tasmania, always within 8 km of the coast (Brereton, 1998) and nests in tree cavities or hollows, usually high in a Eucalypt (Lindsey, 1992; Pizzey and Knight, 1999). The Swift Parrot migrates to mainland Australia from May to August (NSW Scientific Committee, 2000d; Swift Parrot Recovery Team, 2001). Non-breeding birds are highly mobile and their movements vary between years (Hindwood and Sharland, 1964; Brown, 1989). Generally a canopy feeder, the Swift Parrot congregates where there is profuse flowering of Eucalypts (Blakers *et al*., 1984; Brouwer and Garnett, 1990). *Eucalyptus globulus* ssp. *globulus* is the favoured foraging tree in Tasmania (Hingston *et al*., 2004; Brereton *et al*., 2004) while *Eucalyptus robusta*, *Corymbia maculata* and Red Bloodwood (*C. gummifera*) are utilised by this species on the coast of NSW (Swift Parrot Recovery Team, 2001). A study conducted in Tasmania found that Swift Parrots prefer to forage in taller trees (Brereton *et al*., 2004). If sufficient food is available this species will remain in an area and return to the same tree to roost (Pizzey and Doyle, 1980). A recent five-year study by Saunders and Heinsohn (2008) found that the abundance of Swift Parrots in NSW fluctuated significantly between years and regions, with coastal areas providing important drought-refuge habitats for a substantial proportion of the population. The incidence of Swift Parrots at foraging sites was chiefly associated with the abundance of lerp, nectar and non-aggressive competitors (Saunders and Heinsohn, 2008). Remnant vegetation as small as 10 ha are used by Swift Parrots (MacNally and Horrocks, 2000).

Threats to the Regent Honeyeater include the removal of foraging habitat (Ayers *et al*., 1996; Garnett and Crowley, 2000; DEC, 2004b), firewood collection (Garnett and Crowley, 2000) and lack of water and degradation of Riparian habitat through over-utilised or diverted stream flows (DEC, 2004b). Threats to the Swift Parrot include the removal of foraging habitat (NSW Scientific Committee, 2000d; Ayers *et al*., 1996; Garnett and Crowley, 2000; DEC, 2004b), firewood collection (Garnett and Crowley, 2000) and lack of water and degradation of Riparian habitat through over-utilised or diverted stream flows (DEC, 2004b).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of these species has the potential to be impacted by vegetation clearance/habitat removal and an increase in the frequency of bushfire. It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. However, it is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of these species to the extent that a local population would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire, it is unlikely that there would be an increase in fire frequency that could adversely impact the lifecycle of these species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

In NSW the Swift Parrot inhabits Box-Ironbark forests and woodlands (Swift Parrot Recovery Team, 2001). The Regent Honeyeater occurs in a wide variety of habitats including Swamp Mahogany forest, Spotted Gum, riverine She-oak woodlands, remnant stands of timber, roadside reserves and travelling stock routes (DEC, 2004b), however it is most commonly found in Box-Ironbark woodlands (NPWS, 1999h; DEC, 2004b).

Surface works would be sited to minimise the amount of vegetation clearance required. It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Clearing of vegetation and consequently foraging and breeding habitat for these species due to surface infrastructure would be small in comparison with the amount of habitat available in the surrounds and wider region. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to have a significant impact on the available habitat of these species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Swift Parrot breeds in Tasmania and typically migrates to mainland Australia to over-winter on the inland slopes of the Great Dividing Range in Victoria and central and eastern NSW, with smaller numbers reaching south-east Queensland and south-east South Australia (Swift Parrot Recovery Team, 2001; Garnett and Crowley, 2000).

The Regent Honeyeater is distributed from the Great Dividing Range, north to Brisbane in Queensland and south to Bendigo in Victoria, with outliers in the Mount Lofty Ranges and Kangaroo Island in South Australia (Schodde and Tidemann, 1997). On the western-edge of its range in NSW, this species occurs as far inland as Narrabri, Warrumbungle National Park, Dubbo, Parkes and Finley (DEC, 2004b).

The Project is located within the known distribution of the Swift Parrot and Regent Honeyeater and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Given the nature of the vegetation clearance activities, it is unlikely that the Project would significantly impact on habitat connectivity for these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Swift Parrot or Regent Honeyeater. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.10 Brown Treecreeper (eastern subspecies), Speckled Warbler, Diamond Firetail, Hooded Robin and Black-chinned Honeyeater (eastern subspecies)

The Brown Treecreeper (eastern subspecies), Speckled Warbler, Diamond Firetail and Hooded Robin inhabit a range of Eucalypt dominated vegetation communities, as well as drier open forests (Brown Treecreeper [eastern subspecies] and Hooded Robin), Cypress dominated vegetation (Speckled Warbler) and Acacia scrubland (Hooded Robin); typically with a grassy understorey. In NSW, the Black-chinned Honeyeater (eastern subspecies) is mainly found in woodlands containing Box-Ironbark woodland associations and River Red Gum.

The Brown Treecreeper (eastern subspecies), Speckled Warbler, Diamond Firetail and Black-chinned Honeyeater (eastern subspecies) occur predominantly on the western side of the Great Dividing Range, although scattered populations also exist on the east of the Divide in drier areas. The Hooded Robin is distributed throughout south-eastern Australia, from central Queensland to the Spencer Gulf in South Australia.

The Brown Treecreeper (eastern subspecies) builds cup nests, which are made from dried grass, bark and dung; usually lined with fur, feathers or plant down (Schodde and Tidemann, 1997). Nests are often built in the hollows of trees, on branches or fence posts, 1 to 3 m above the ground (NSW Scientific Committee, 2001a). This species is insectivorous, and forages on tree trunks and the ground for ants, beetles and larvae (Garnett and Crowley, 2000) and is sedentary, often occurring in pairs or small groups (NSW Scientific Committee, 2001a). Pairs or groups of three to six hold to the same large territory of about 5 to 10 ha year round (Schodde and Tidemann, 1997).

Domed nests of the Speckled Warbler are made from grass and bark shreds and are lined with fur and feathers (Schodde and Tidemann, 1997). The nest is usually hidden in a slight hollow predominantly on the ground (Gardner, 2002), however it can also be placed in a low shrub or tree trunk (Schodde and Tidemann, 1997; Pizzey and Knight, 1998).

The Speckled Warbler forages on the ground for arthropods and seeds (Blakers *et al*., 1984; Ford *et al*., 1986). Preferred foraging habitat of the Speckled Warbler includes areas with a combination of open grassy patches, leaf litter and shrub cover (NSW Scientific Committee, 2001b). The Speckled Warbler is sedentary, living in pairs or trios and the home range of this species can vary from 6 to 12 ha (NSW Scientific Committee, 2001b).

Nests of the Diamond Firetail are placed in the thick foliage of mistletoe clumps, Eucalypt tree or shrub, up to 10 m above the ground (Schodde and Tidemann, 1997). A field study by Cooney and Watson (2005) found that Diamond Firetails preferentially nest in mistletoe. The nests are bulky and bottle-shaped and are made from grass (Pizzey and Knight, 1998) and often have flowers woven into the entrances (McGuire and Kleindorfer, 2007). After fledging, young birds spend about a week in the breeding area before joining a larger flock to forage wherever food sources are abundant (Schodde and Tidemann, 1997). Diamond Firetails drink frequently throughout the day. The main food source of this species is seed, mostly from grasses (Read, 1994), however their diet can also include insects (Blakers *et al*., 1984, Read, 1994). At dusk, feeding flocks disperse to dense shrubbery or to specifically build nests to roost (Schodde and Tidemann, 1997). Roosting nests are made of coarse green and dry grasses and are smaller and built lower to the ground than breeding nests (*ibid.*).

The nest of the Hooded Robin is an open cup made from bark-strips, rootlets, grass and/or spiders web. The nest is built in a tree fork, crevice or hollow on or near dead wood, approximately 1 to 6 m above the ground (Pizzey and Knight, 1999; Schodde and Tidemann, 1997). The Hooded Robin feeds on the ground on insects and small lizards in areas with a mix of bare ground, ground cover and leaf litter (Garnett and Crowley, 2000; NSW Scientific Committee, 2001c). This species is often observed in small family groups and sometimes in isolated pairs (NSW Scientific Committee, 2001c). The species is typically territorial and has a home range of approximately 10 to 20 ha (Schodde and Tidemann, 1997). Juveniles of this species are dispersive (Pizzey and Knight, 1999).

Nests of the Black-chinned Honeyeater (eastern subspecies) are a fragile cup made of bark-shreds, grass, wool and/or spiders web (Pizzey and Knight, 1997). This species typically nests high (approximately 3 to 15 m) in outer foliage (Schodde and Tidemann, 1997). Breeding can be communal, with additional members of the colony helping the senior parental pair feed their young (*ibid.*). The Black-chinned Honeyeater (eastern subspecies) feeds on insects, nectar and lerp (Blakers *et al*., 1984). The Black-chinned Honeyeater has a large feeding territory and as a result, often appears locally and is seasonally nomadic (Pizzey and Knight, 1997; Schodde and Tidemann, 1997).

Threats relevant to the Brown Treecreeper (eastern subspecies), Speckled Warbler, Diamond Firetail, Hooded Robin and/or Black-chinned Honeyeater (eastern subspecies) include the clearance and fragmentation of woodland habitat, removal of dead timber, loss of hollow bearing trees, grazing by stock in woodland areas and predation (NSW Scientific Committee, 2001a, 2001b, 2001c, 2001d, 2001e; Gardner, 2002).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of these species has the potential to be impacted by vegetation clearance/habitat removal and an increase in the frequency of bushfire. It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. However, it is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of these species to the extent that a local population would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire, it is unlikely that there would be an increase in fire frequency that could adversely impact the lifecycle of these five species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Brown Treecreeper (eastern subspecies), Speckled Warbler, Diamond Firetail and Hooded Robin inhabit a range of Eucalypt dominated vegetation communities, as well as drier open forests (Brown Treecreeper [eastern subspecies] and Hooded Robin), Cypress dominated vegetation (Speckled Warbler) and Acacia scrubland (Hooded Robin); typically with a grassy understorey. In NSW, the Black-chinned Honeyeater (eastern subspecies) is mainly found in woodlands containing Box-Ironbark woodland associations and River Red Gum.

Surface works would be sited to minimise the amount of vegetation clearance required. It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Clearing of vegetation and consequently foraging and breeding habitat for these five species due to surface infrastructure would be small in comparison with the amount of habitat available in the surrounds and wider region. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to have a significant impact on the available habitat of these five species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Brown Treecreeper (eastern subspecies), Speckled Warbler, Diamond Firetail and Black-chinned Honeyeater (eastern subspecies) occur predominantly on the western side of the Great Dividing Range, although scattered populations also exist on the east of the Divide in drier areas. The Hooded Robin is distributed throughout south-eastern Australia, from central Queensland to the Spencer Gulf in South Australia.

The Project is located within the known distribution of the Brown Treecreeper (eastern subspecies), Speckled Warbler, Diamond Firetail, Hooded Robin and Black-chinned Honeyeater (eastern subspecies) and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Given the nature of the vegetation clearance activities, it is unlikely that the Project would significantly impact on habitat connectivity for these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Brown Treecreeper (eastern subspecies), Speckled Warbler, Diamond Firetail, Hooded Robin or Black-chinned Honeyeater (eastern subspecies). There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.11 Pink Robin and Olive Whistler

The Pink Robin inhabits rainforest and tall, open eucalypt forest, particularly in densely vegetated gullies (DECC, 2009j). On the mainland, the species disperses north and west and into more open habitats in winter, regularly as far north as the ACT area, and sometimes being found as far north as the central coast of NSW (DECC, 2009j). The Pink Robin occurs as singles or pairs (Pizzey and Knight, 2006). Breeding takes place between September and January (*ibid.*). The nest of the Pink Robin is a deep, spherical cup made of green moss bound with cobweb and adorned with camouflaging lichen and lined with fur and plant down (DECC, 2009j). The nest is placed in an upright or oblique fork, from 30 cm to 6 m above the ground, in deep undergrowth (*ibid.*). Females do most or all of the nest building and incubate unaided, however both adults feed the nestlings (DECC, 2009j). Insects and spiders are the main dietary items of the Pink Robin.

The Olive Whistler inhabits the wet forests on the ranges of the east coast (DECC, 2009k). The Olive Whistler has a disjunct distribution in NSW chiefly occupying the beech forests around Barrington Tops and the MacPherson Ranges in the north and wet forests from Illawarra south to Victoria (*ibid.*). In the south it is found inland to the Snowy Mountains and the Brindabella Range. This elusive species occurs as singles or pairs and often mixes with scrubwrens and robins (Pizzey and Knight, 2006). The Olive Whistler breeds between September to January and makes a nest from twigs and grass which is placed in dense shrubs, trees, bracken or sword grass (*ibid.*). The Olive Whistler forages in trees and shrubs and on the ground, feeding on berries and insects (DECC, 2009k). This species is considered to be mostly sedentary in mountain forests but is also an altitudinal migrant (Pizzey and Knight, 2006). For example, the Olive Whistler is a migrant to the Snowy Mountains area (Green and Sanecki (2006).

Threats relevant to the Pink Robin and Olive Whistler include the clearing of rainforest and tall, wet forest habitat, particularly near gullies. These two avian species have not been located within the Project area and it is unlikely that a viable population(s) of these species are present.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of these two species has the potential to be impacted by vegetation clearance/habitat removal and an increase in the frequency of bushfire. It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. However, it is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of these species to the extent that a local population would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire, it is unlikely that there would be an increase in fire frequency that would adversely impact the lifecycle of these two species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Pink Robin inhabits rainforest and tall, open eucalypt forest, particularly in densely vegetated gullies (DECC, 2009j) as well as open forests, woodlands and scrublands (Pizzey and Knight, 2006). Gardens, plantations and golf courses may also provide habitat (Pizzey and Knight, 2006). The Olive Whistler inhabits mostly wet forests above 500 m, however, may move to lower altitudes during the winter months (DECC, 2009k). Other suitable habitat for the Olive Whistler includes watercourse vegetation, coastal tea-tree/paperbark scrubs and heaths, blackberry bushes and gardens (Pizzey and Knight, 2006). Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Clearing of vegetation and consequently foraging and breeding habitat for these two species due to surface infrastructure would be small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for the Pink Robin and Olive Whistler.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Pink Robin is found in Tasmania and the uplands of eastern Victoria and far south-eastern NSW, almost as far north as Bombala. On the mainland, the species disperses north and west and into more open habitats in winter, regularly as far north as the ACT area, and sometimes being found as far north as the central coast of NSW (DECC, 2009j).

The Olive Whistler inhabits the wet forests on the ranges of the east coast (DECC, 2009k). The Olive Whistler has a disjunct distribution in NSW chiefly occupying the beech forests around Barrington Tops and the MacPherson Ranges in the north and wet forests from Illawarra south to Victoria (*ibid.*). In the south it is found inland to the Snowy Mountains and the Brindabella Range.

The Project is considered to be located within the known distribution of the Pink Robin and to the west of the known distribution for the Olive Whistler.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Given the nature of the vegetation clearance activities, it is unlikely that the Project would significantly impact on habitat connectivity for these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Pink Robin or Olive Whistler. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.12 Australasian Bittern and Black Bittern

The Australasian Bittern is a shy and cryptic bird which breeds using nests made from a well-constructed platform of broken and trampled weeds, rushes and Cumbungi (Marchant and Higgins, 1990). The nest is generally located approximately 30 cm above water level in heavy vegetation fringing freshwater pools (*ibid.*). Breeding takes place between September and December (Pizzey and Knight, 2006). This partly nocturnal species typically occurs on its own but may form loose companies in areas of particularly suitable habitat (*ibid.*). The Australasian Bittern forages in shallows or hunts in deeper water from bent-over reeds or other platforms (Morcombe, 2004). The species appears to be sedentary in permanent habitat but may move short distances during winter and in response to years with high rainfall (Marchant and Higgins, 1990).

The Black Bittern is a secretive species which may occur as solitary individuals or in pairs (Pizzey and Knight, 2006). The preferred habitat of the Black Bittern consists of areas with shadowy, leafy waterside trees (including but not limited to Callistemons, Paperbarks and Mangroves) as well as sheltered mudflats and oyster-slats (*ibid*). Breeding occurs between September and April and nests take the form of a shallow saucer in a platform of trampled water plants over water in reeds (*ibid.*). The Black Bittern is generally sedentary but may be irruptive in response to heavy rains and floods or drought elsewhere (*ibid.*)

Threats to the Australasian Bittern include drainage of wetlands for agriculture, salinisation of wetlands and overgrazing of wetland vegetation (Garnett and Crowley, 2000; Garnett, 1992 in Smith *et al.*, 1995). Recognised threats to the Black Bittern include clearing of riparian vegetation, grazing and trampling of riparian vegetation by livestock and predation by foxes and cats (DECC, 2009l).

The Australasian Bittern and Black Bittern were not recorded during the recent terrestrial fauna surveys of the Project area. It is unlikely that a viable population(s) of these species is/are present within the Project area.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of these species has the potential to be impacted by vegetation clearance/habitat removal and an increase in the frequency of bushfire. It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. However, it is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of these species to the extent that a local population would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire, it is unlikely that there would be an increase in fire frequency that could adversely impact the lifecycle of these species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Good habitat for the Australasian Bittern includes in or over water in tall reedbeds, rushes, sedges, lignum as well as rice fields, drains in tussocky paddocks (Pizzey and Knight, 2006). The preferred habitat of the Black Bittern consists of areas with shadowy, leafy waterside trees (including but not limited to Callistemons, Paperbarks and Mangroves) as well as sheltered mudflats and oyster-slats (Pizzey and Knight, 2006).

Mine subsidence has the potential to cause cracking and alter the availability of water in streams, however the changes described would not be of an extent that would significantly affect the availability of habitat resources for these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for the Australasian Bittern or Black Bittern.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The national distribution of the Australasian Bittern is from southern Queensland to Tasmania and south eastern South Australia (including most of NSW and Victoria) and the south-western corner of Western Australia (Marchant and Higgins, 1990). The distribution of the Black Bittern ranges from the Pilbara in Western Australia to far eastern Victoria although is considered rare south of Sydney (Pizzey and Knight, 2006).

The Project is considered to be located within the known distribution of the Australasian Bittern and Black Bittern.

4. How is the proposal likely to affect current disturbance regimes?

How the Project is likely to affect the current disturbance regimes operating within the Project area (including fire, flood and drought) are discussed in Section 5. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Given the nature of the vegetation clearance activities, it is unlikely that the Project would significantly impact on habitat connectivity for these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Australasian Bittern and Black Bittern. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.4.13 Blue-billed Duck and Freckled Duck

Blue-billed Ducks roost usually on open water or in a small, concealed bay (Marchant and Higgins, 1990). Breeding can either be seasonal or opportunistic depending on water levels prevailing in an area (*ibid.*) but typically occurs between September and March (Pizzey and Knight, 2006). Blue-billed Ducks disperse to well-vegetated freshwater swamps and lakes to breed (Slater *et al.*, 1986 in Ayers *et al.*, 1996). Nests are usually constructed in dense vegetation including Cumbungi (*Typha*), Lignum sedges, Canegrass (*Eragrostris*), Spike-rush or Nitre-bush (*Chenopodium*) (Ayers *et al.*, 1996). The Blue-billed Duck obtains food such as aquatic insects by diving in deep water as well as foraging for seeds and leaves of freshwater plants (Marchant and Higgins, 1990).

Young Blue-billed Ducks (yearlings and sub-adults) in particular are regionally and seasonally nomadic where they migrate each year from the natal swamps of inland NSW to non-breeding areas on the Murray River system and coastal lakes of Victoria and South Australia (Frith, 1977; Serventy, 1985). The Blue-billed Duck readily colonises new areas of habitat following floods (Frith, 1977 in Ayers *et al.*, 1996).

During the day, the Freckled Duck congregate in small or large groups on permanent open waterbodies, frequently roosting on fallen trees and sand spits (Ayers *et al.*, 1996; Simpson and Day, 1999). The Freckled Duck breeds on densely vegetated freshwater swamps, streams or temporary floodwaters (Morcombe, 2004), often breeding prolifically after very wet years (Garnett and Crowley, 2000). Otherwise, breeding typically occurs between September and December (Pizzey and Knight, 2006). Freckled Ducks construct a bowl-shaped nest from sticks and stems in lignum, an overhanging tea-tree branch or flood debris (*ibid.*).

The Freckled Duck forages at wetland edges or by dabbling in shallow water (Ayers *et al.*, 1996; Morcombe, 2004). Preferred food includes algae, seeds of aquatic grasses and sedges, small invertebrates, small fish and the vegetative parts of aquatic plants (Ayers *et al.*, 1996). The Freckled Duck is nomadic between ephemeral inland wetlands, although during the driest years, they congregate on permanent wetlands (Garnett and Crowley, 2000). Aerial bird surveys conducted between 1987 and 1989 found that perhaps over half of the population of Freckled Ducks were present on Lake Wyara and Lake Numalla in arid Australia (Kingsford and Porter (1994).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of these species has the potential to be impacted by vegetation clearance/habitat removal, a reduction in the availability of water habitat and an increase in the frequency of bushfire.

It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. However, it is unlikely that the proposed vegetation clearance activities or predicted changes in availability of water sources (Section 4.5) would impact on the lifecycle of these species to the extent that a local population would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire, it is unlikely that there would be an increase in fire frequency that could adversely impact the lifecycle of these species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The preferred habitat of the Blue-billed Duck includes well-vegetated freshwater swamps as well as large dams and lakes (Pizzey and Knight, 2006). During winter, the Blue-billed Duck favours more open waters (*ibid.*). The Freckled Duck inhabits large, well-vegetated swamps, moving to open lakes during dry periods (*ibid.*).

Mine subsidence has the potential to cause cracking and alter the availability of water in streams, however the changes described would not be of an extent that would significantly affect the availability of habitat resources for these species. It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for the Blue-billed Duck or Freckled Duck.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The distribution of the Blue-billed Duck is widespread within NSW, but most common in the southern Murray-Darling Basin area (NPWS, 1999i). Birds disperse during the breeding season to deep swamps up to 300 km away (*ibid.*). It is generally only during summer or in drier years that they are seen in coastal areas (*ibid.*). The Freckled Duck is found primarily in south-eastern and south-western Australia, occurring as a vagrant elsewhere (NPWS, 1999j). It breeds in large temporary swamps created by floods in the Bulloo and Lake Eyre basins and the Murray-Darling system, particularly along the Paroo and Lachlan Rivers, and other rivers within the Riverina (*ibid.*). The duck is forced to disperse during extensive inland droughts when wetlands in the Murray River basin provide important habitat (*ibid.*). The species may also occur as far as coastal NSW and Victoria during such times (*ibid.*).

The Project is considered to be located at the eastern margin of the distribution of the Blue-billed Duck and Freckled Duck.

4. How is the proposal likely to affect current disturbance regimes?

How the Project is likely to affect the current disturbance regimes operating within the Project area (including fire, flood and drought) are discussed in Section 5. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these species within the Project area would only be likely if there was widespread restriction of water habitats. Given the nature of the potential impacts on water habitats, it is unlikely that the Project would significantly impact on habitat connectivity for these species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Freckled and Blue-billed Ducks. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.5 MAMMALS

6.5.1 Southern Brown Bandicoot (eastern)

The Southern Brown Bandicoot (eastern) occurs in a variety of habitats including heathland, shrubland, dry sclerophyll forest with heathy understorey, sedgeland and woodland (Hocking, 1990; Kemper, 1990; Menkhorst and Seebeck, 1990; Rounsevell *et al.*, 1991). However the Southern Brown Bandicoot prefers sandy soil with scrubby vegetation in areas with low ground cover that are burnt out from time to time (Van Dyk and Strahan, 2008). Many of the habitats occupied by the Southern Brown Bandicoot are prone to fire and some authors have suggested that the species prefers to occupy early seral stages following disturbance (NPWS, 2001b).

The Southern Brown Bandicoot is nocturnal and prefers to stay close to cover when in search of food on the surface of the ground, and in the shallow, conical holes that it digs with its foreclaws. It is omnivorous, feeding on earthworms, other invertebrates, insects (both adult and larval), fungi and other subterranean plant material (NPWS, 2001b; Van Dyk & Strahan, 2008) including blackberries (Sanderson and Kraehenbuehl, 2006). The Southern Brown Bandicoot usually nests during the day in shallow depressions in the ground covered by leaf litter, grass or other plant material (NPWS, 2001b; DECC, 2008). Breeding begins in winter and usually lasts six to eight months; under favourable conditions reproduction is high producing up to six young per litter (Van Dyk and Strahan, 2008; Braithwaite, 1983). Field studies in Belair National Park have found that mean litter size was 1.8 young per mother (Sanderson and Kraehenbuehl, 2006). Individuals are often solitary in the wild and survival is dependent on possession and defence of a suitable home range of up to 5 ha (Van Dyk and Strahan, 2008).

Threats to this species include predation by feral carnivores, habitat loss, inappropriate fire regimes leading to degradation of habitat and road-kill from vehicular traffic (NPWS, 2001b). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a). Feral predators including foxes, dogs and cats are considered to pose a significant threat to the Southern Brown Bandicoot (Lobert and Lee, 1990; Claridge and Barry, 2000; DEC, 2006a). Southern Brown Bandicoot populations have increased following fox baiting in some areas (Sanderson and Kraehenbuehl, 2006).

One adult male Southern Brown Bandicoot was trapped during the Project surveys by Biosphere Environmental Consultants in the proposed West Cliff Stage 4 Coal Wash Emplacement Area (Figure 5). Further targeted trapping, use of hair tubes and use of infrared motion sensing cameras was conducted, however no further animals were captured, photographed or hair traces found. However, numerous Southern Brown Bandicoot diggings were located outside of the Stage 4 Coal Wash Emplacement Area (including within land to the north, in the Dharawal State Conservation Area to the east and in the Metropolitan Special Area to the south). In addition, some other bandicoot diggings were recorded however could not be distinguished between the Long-nosed Bandicoot and the Southern Brown Bandicoot. A bandicoot skull was found within the Metropolitan Special Area and was subsequently identified as belonging to a Southern Brown Bandicoot by palaeontologist Henk Godthelp from the University of NSW.

Further to the above, Southern Brown Bandicoot diggings have previously been tentatively recorded on the eastern extent of the Project as part of the Metropolitan Coal Project Terrestrial Vertebrate Fauna Survey (Western Research Institute and Biosphere Environmental Consultants Pty Ltd, 2008). Some bandicoot diggings were considered most likely to belong to the Southern Brown Bandicoot (D. Goldney, pers. comm., 2009), however, given the difficulty in digging confirmation and feedback from the DECC, diggings were recorded as potentially belonging to the Southern Brown Bandicoot, Long-nosed Bandicoot or Long-nosed Potaroo and assessed accordingly.

It is considered likely that a viable population of the Southern Brown Bandicoot exists, made up of meta populations. The Southern Brown Bandicoot is probably best described as present but rare.

The proposed Stage 4 Coal Wash Emplacement area and surrounds provide habitat for the Southern Brown Bandicoot, resulting in part from the 2001 bushfires creating habitat mosaics in early to mid-succession phase at the time of the Project surveys. Conversely, the greater the time lapse since the last landscape-scale bushfire, the greater the possibility that some early successional habitats may become sub-optimal for the species. It is likely that well managed cool mosaic burnings between well spaced landscape-wide bushfires may be required as part of a management mix to maintain optimal habitat outcomes for the Southern Brown Bandicoot.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by vegetation clearance/habitat removal, an increase in the frequency of bushfire and an increase in exotic predator species. Management measures for the Southern Brown Bandicoot are provided in Section 5.

It is estimated that the Project would disturb approximately 65 ha of remnant vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project.

Potential habitat resources required to support stages of the lifecycle of the Southern Brown Bandicoot (e.g. suitable vegetation types that have been recently burnt) would remain in parts of the Project area that would not be affected by the proposed vegetation clearance. It is very likely that available habitat and niche space is significantly underutilised by the Southern Brown Bandicoot because of its very likely rare occurrence in this landscape. Furthermore, it is very likely that a meta-population (i.e. part of a local population) rather than a complete local population of Southern Brown Bandicoot would utilise habitats available in the Stage 4 Coal Wash Emplacement area. Little is known about how this species responds to clearing albeit carried out progressively in discrete stages adjacent to other available habitat, nor whether the species is strongly site attached. However the potential is present for individual animals to either self relocate (into nearby under-utilised available habitat and niche space) as emplacement clearing progresses or to be trapped and relocated during the implementation of the vegetation clearing strategies. Vegetation clearance activities would be managed through the development and implementation of a Biodiversity Management Plan and would include pre-clearance surveys. Monitoring of the status of the species in the proposed Stage 4 Coal Wash Emplacement area, would also be included in the Biodiversity Management Plan to be developed for the Project.

Given a range of management protocols are proposed to be in place to manage the risk of bushfire and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species, or an increase in feral exotic species. The Biodiversity Management Plan would include protocols to manage the behaviour of people to reduce the risk of unplanned bushfire as well as measures to reduce the number of introduced fauna (e.g. foxes, dogs and cats) that may prey on threatened fauna such as the Southern Brown Bandicoot.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

There is a degree of uncertainty surrounding the preferred habitat for the Southern Brown Bandicoot (Southwell *et al.*, 2008). The Southern Brown Bandicoot occurs in a variety of habitats including heathland, shrubland, dry sclerophyll forest with heathy understorey, sedgeland and woodland (Hocking, 1990; Kemper, 1990; Menkhorst and Seebeck, 1990; Rounsevell *et al.*, 1991). However the species is thought to prefer sandy soil with scrubby vegetation in areas with low ground cover that are burnt out from time to time (Van Dyk & Strahan, 2008). The habitats occupied by the Southern Brown Bandicoot are prone to fire disturbance and some authors have suggested that the species prefers to occupy early seral stages following disturbance (NPWS, 2001b), for example, regrowth areas that have been recently burnt or cleared (Cockburn, 1990).

During a field study by Sanderson and Kraehenbuehl (2006), Southern Brown Bandicoots were captured most commonly in close proximity to watercourses and usually in areas with thick groundcover. Bandicoots which shelter under very dense undergrowth appear to be less at risk of predation by foxes (Lobert and Lee, 1990). Individuals were commonly trapped in areas containing Blackberry and the fruit of this introduced weed was found in the scats of the Southern Brown Bandicoot (Sanderson and Kraehenbuehl, 2006). This species can also coexist with people close to their houses (Sanderson and Kraehenbuehl, 2006; Dowle and Deane, 2009).

Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project. Surface works would be sited to minimise the amount of vegetation clearance required. It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Potential habitat resources required to support stages of the lifecycle of the Southern Brown Bandicoot (e.g. suitable vegetation types that have been recently burnt) would remain in parts of the Project area that would not be affected by the proposed vegetation clearance. It is very likely that available habitat and niche space is significantly underutilised by the Southern Brown Bandicoot because of its very likely rare occurrence in this landscape. Habitat resources for the Southern Brown Bandicoot (including suitable vegetation types that were burnt in 2001) also exist adjacent to the Stage 4 Coal Wash Emplacement within Dharawal State Conservation Area and in the Woronora and Metropolitan Special Areas.

A high intensity bushfire or too-frequent bushfires would very likely reduce habitat quality for this species, however, a range of management protocols would be in place to manage the behaviour of people in the Project area to lessen this risk.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Southern Brown Bandicoot is found in the south-east and south of mainland Australia, Tasmania, Cape York Peninsula and a few islands off the coast of South Australia (NPWS, 2001b). In NSW, this species is thought to be restricted to the coastal fringe, from the southern side of the Hawkesbury River in the north to the Victorian border.

The Southern Brown Bandicoot was recorded during recent targeted surveys within the Project area and surrounds. The Project is located within the known distribution of the Southern Brown Bandicoot.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires in unlikely to be altered by the Project. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Habitat connectivity has the potential to be impacted by vegetation clearance/habitat removal. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale. It is considered unlikely that the vegetation clearance proposed would result in the isolation of nearby areas of habitat for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Southern Brown Bandicoot. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009a) located in the Project area or surrounds.

6.5.2 Eastern Pygmy-possum

The Eastern Pygmy-possum inhabits a wide range of habitats including rainforest, wet and dry sclerophyll forest, subalpine woodland, coastal banksia woodland and wet heath (Turner and Ward, 1998; Menkhorst and Knight, 2001). In drier habitats banksias and myrtaceous shrubs and trees are favoured as food sources and nesting sites (Turner and Ward, 1998). The Eastern Pygmy-possum is sparse to locally common in a wide range of vegetation on the Great Dividing Range, including the western slopes and coastal plains from south-east Queensland to south-east South Australia, extending into Victoria (Menkhorst and Knight, 2001; Turner and Ward, 1998). The Eastern Pygmy Possum is also found in Tasmania (Menkhorst and Knight, 2001; Turner and Ward, 1998). In particular, a field investigation by Tulloch and Dickman (2006) found that the Eastern Pygmy-possum prefers *Banksia* spp. (probably for food) and *Eucalyptus* spp. and *Xanthorrhoea* spp. (probably for shelter).

The Eastern Pygmy-possum is nocturnal, becoming active shortly after dusk (Turner and Ward, 1998). An agile climber, the Eastern Pygmy-possum predominantly feeds on nectar and pollen, which it gathers, from banksias, eucalypts and bottlebrushes (*ibid.*). This species has also been known to feed on soft fruits and insects (Menkhorst and Knight, 2001). An experimental field study by Tulloch and Dickman (2007) found that the Eastern Pygmy-possums monitor shifts in the resource base continuously, allowing them to exploit local or ephemeral changes in floral resources. The activity of the Eastern Pygmy-possum is reduced in winter when time is spent in torpor (Turner and Ward, 1998). However, this species is also considered to be an opportunistic non-seasonal hibernator (Geiser, 2007).

Tree hollows are favoured nesting sites however, small spherical nests have been found between the wood and bark of eucalypts (Turner and Ward, 1998). Abandoned birds nests and shredded bark in the forks of tea-trees have also been used as nests (*ibid.*). The Eastern Pygmy-possum appears to be mainly solitary and each individual uses several nests (Turner and Ward, 1998). On mainland Australia, births may occur any time of year if food supplies are abundant; however most occur in late spring to early autumn. The young remain in the pouch for 30 days, after which they are left in a nest and weaned when 65 days old. Two litters are usually produced per season. The home range of the males of this species (about 0.68 ha) is larger than that of females (about 0.35ha) and is not exclusive (Turner and Ward, 1998).

Threats to this species include habitat fragmentation and loss, inappropriate fire regimes that affect understorey plants, the loss of nest sites and predation by Foxes and Cats (NSW Scientific Committee, 2001f). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by vegetation clearance/habitat removal, an increase in the frequency of bushfire and an increase in exotic predator species.

It is estimated that the Project would disturb approximately 65 ha of remnant vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation.

Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Given the extent of remnant vegetation and known Eastern Pygmy-possum records in the area, it is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of this species to the extent that a local population of the Eastern Pygmy-possum would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species, or an increase in feral species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Eastern Pygmy-possum inhabits a wide range of habitats including rainforest, wet and dry sclerophyll forest, subalpine woodland, coastal banksia woodland and wet heath (Turner and Ward, 1998; Menkhorst and Knight, 2001). In drier habitats banksias and myrtaceous shrubs and trees are favoured as food sources and nesting sites (Turner and Ward, 1998).

It is estimated that the Project would disturb approximately 65 ha of remnant vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Eastern Pygmy-possum due to surface infrastructure would be small compared to the amount of habitat available.

Given a range of management protocols are proposed to be in place to manage the behaviour of people, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Eastern Pygmy-possum is sparse to locally common in a wide range of vegetation on the Great Dividing Range, including the western slopes and coastal plains from south-east Queensland to south-east South Australia, extending into Victoria (Menkhorst and Knight, 2001; Turner and Ward, 1998). The Eastern Pygmy Possum is also found in Tasmania (Menkhorst and Knight, 2001; Turner and Ward, 1998).

The Project is located within the known distribution of the Eastern Pygmy-possum and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Disruption of existing habitat connectivity for an existing population would be possible following events such as extensive habitat clearing. It is considered unlikely however that the vegetation clearance proposed would result in the isolation of nearby areas of habitat for this species. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Given the nature and extent of the vegetation clearance activities, it is unlikely that the Project would significantly impact on habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Eastern Pygmy-possum. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.5.3 Koala

The Koala occurs in certain Eucalypt forest and woodland depending on a number of factors including the size and species of trees, soil nutrients, climate, rainfall and amount of past disturbance (NPWS, 1999k). The Koala is nocturnal, rests in tree forks during the day and breeds in summer (Martin and Handasyde, 1998).

Tree species preferred by Koalas in NSW as their principal food source include *Eucalyptus punctata, E. tereticornis, E. robusta, E. microcorys, E. viminalis, E. camaldulensis, E. haemastoma, E. signata, E. albens* and *E. populnea* (SEPP, 1995). Koalas have however been observed to feed on the leaves of approximately 70 species of Eucalypt and 30 non-Eucalypt species (Phillips, 1990). Field studies have shown that *E. punctata and E. agglomerata* are most preferred by Koalas in the Campbelltown area (south west of Sydney), but only when growing on shale-based substrates (Phillips and Callaghan, 2000). Their preferred use by Koalas was probably influenced by the increased nutrient status in shale substrates compared to sandstone substrates (*ibid*.). Furthermore, Phillips and Callaghan (2000) suggest that the presence of *E. punctata* and *E. agglomerata* and their occurrence in conjunction with shale-based substrates are considered to be important limiting factors affecting the present-day distribution and abundance of Koalas in the Campbelltown area. A field study by Matthews *et al*. (2007) found that Koalas preferred trees of larger diameter (i.e. greater than 30 cm) and used significantly taller trees during summer.

The Koala is regarded as a solitary species that spends most of its time in defined home ranges (Martin and Handasyde, 1998; Ayers *et al.,* 1996) although individuals have overlapping home range areas (Martin and Handasyde, 1998). Dispersal distances generally range from 1 to 11 km, although movements in excess of 50 km have been recorded (NPWS, 1999k).

Threats to the Koala include loss or modification of habitat (e.g. fire, weed invasion, climate change), road mortalities, Dog attacks, fire and disease (NPWS, 1999k, 2003c). Resource depletion from intense wildfire is likely to be short-term for Koalas because they have been observed to use burnt trees (presenting epicormic growth) within months of the fire for both food and shelter (Matthews *et al*., 2007).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species may be impacted by vegetation clearance/habitat removal, increases in fire frequency impacting the species habitat and increases in exotic predator species.

It is estimated that the Project would disturb approximately 65 ha of remnant vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas.

The West Cliff Stage 4 Coal Wash Emplacement has been comprehensively surveyed for the Koala. No evidence of the presence of Koalas (e.g. sightings or characteristic scratches or faecal pellets) has been observed. The proposed vegetation clearance would be progressive over the life of the mine. Given the extent of remnant vegetation and known Koala records in the area (DECC, 2009a), it is unlikely that the proposed vegetation clearance activities would impact on this species to the extent that a local population of the Koala would be placed at risk of extinction.

Vegetation clearance activities would be managed through the development and implementation of a Biodiversity Management Plan and would include pre-clearance surveys. As described in Section 4.7, to minimise impacts on koala habitat, the location of surface activities requiring clearing would avoid core koala habitat and SEPP 44 Schedule 2 Feed Tree Species wherever feasible and practicable. In addition, the pre-clearance surveys would include targeted searches for koalas and evidence of koala activity (e.g. koala scratches). Clearing activities would be located away from identified koalas and evidence of koala activity.

Given a range of management protocols are proposed to be in place to manage the risk of bushfire and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species, or an increase in feral species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

It is estimated that the Project would disturb approximately 65 ha of remnant vegetation for the West Cliff Stage 4 Coal Wash Emplacement. Potential and core Koala habitat occurs within the study area outside of the extent of longwall mining to the north of the West Cliff Area 5 domain and west of the North Cliff domain, approximately 7 to 8 km north of the proposed Stage 4 Coal Wash Emplacement. However, the Stage 4 Coal Wash Emplacement does not fall within the definition of either core or potential koala habitat. There was no evidence of the presence of Koalas within the emplacement area during the surveys. No characteristic scratches or faecal pellets were observed, despite searching smooth-barked trees and the base of trees. One SEPP 44 Schedule 2 Feed Tree Species occurs within the proposed Stage 4 Coal Wash Emplacement Area (i.e. Grey Gum, *Eucalyptus punctata*) (FloraSearch, 2009). However, this species was only recorded in two of 23 samples within the Stage 4 Coal Wash Emplacement Area (scattered occurrences in low numbers) and does not constitute 15% of the upper or lower strata of the tree component (FloraSearch, 2009).

It is estimated that the Project would also disturb less than 37 ha of remnant native vegetation in other areas. Surface works would be sited to minimise the amount of vegetation clearance required. To minimise impacts on terrestrial vegetation, vegetation clearance would be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of trees. Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project.

Given a range of management protocols are proposed to be in place to manage the behaviour of people, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat.

The Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Koala has a fragmented distribution throughout eastern Australia, from north-east Queensland to the Eyre Peninsula in South Australia (Martin and Handasyde, 1998). In NSW, the Koala mainly occurs on the central and north coasts (NPWS, 1999k).

The Project is located within the known distribution of the Koala and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

Issues pertaining to human-related disturbance are discussed in Questions 1 and 2.

5. How is the proposal likely to affect habitat connectivity?

The vegetation clearance proposed is unlikely to result in the isolation of areas of habitat for the Koala. Vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is unlikely to impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Koala. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.5.4 Spotted-tailed Quoll

The Spotted-tailed Quoll occurs in a range of habitats that include sclerophyll forests and woodlands, rainforests and coastal heathlands (NPWS, 1999l). This species has also been observed in treeless areas including grazing lands, open country and rocky outcrops but they do require large areas of relatively intact vegetation for foraging as well as hollow logs, tree hollows, rock outcrops and caves to use as den sites (*ibid.*).

Individual quolls use multiple dens and, with the exception of maternal dens, rarely shelter in the same location on successive days (Glen and Dickman, 2006). A field study by Belcher and Darrant (2006) found that rock dens are preferred over log dens. The same study showed that habitat use was significantly related with prey densities at most sites (Belcher and Darrant, 2006). Both sexes of the Spotted-tailed Quoll become sexually mature when they reach about one year old (Edgar and Belcher, 1998). The Spotted-tailed Quoll requires an abundance of food (such as birds and small mammals) and field studies have found that medium-sized mammals, in particular, are important prey for the Spotted-tailed Quolls (Belcher *et al.*, 2007; Dawson *et al.*, 2007; Glen and Dickman, 2008). Notwithstanding, this species is adaptable in its utilisation of available food, even after fire (Dawson *et al.*, 2007).

This species is primarily solitary and nocturnal, although it may forage during the day (NPWS, 1999l). Prey items of this carnivore include birds, reptiles, small mammals (e.g. gliders, possums, rats and small macropods), arthropods and carrion (Edgar and Belcher, 1998; Ayers *et al.*, 1996; NPWS, 1999l). This species is thought to occupy large home ranges (between 800 ha and 2,000 ha) and has been known to move several kilometres overnight (NPWS, 1999l). A field study by Kortner *et al.* (2004) found that home ranges of males overlapped substantially, whereas those of females appeared to be exclusive.

Threats relevant to the Spotted-tailed Quoll include loss of habitat through clearing, logging and frequent fire and loss of potential den sites including hollow logs (NPWS, 1999l). Other threats include competition for food and predation by Foxes and Cats as well as people shooting them as agricultural pests (*ibid.*). For example, Glen and Dickman (2008) found a high degree of dietary overlap between Spotted-tailed Quolls, Foxes and wild Dogs.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by vegetation clearance/habitat removal, an increase in the frequency of bushfire and an increase in exotic predator species.

It is estimated that the Project would disturb approximately 65 ha of remnant vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Given the extent of remnant vegetation and known Spotted-tailed Quoll records in the area, it is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of this species to the extent that a local population of the Spotted-tailed Quoll would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species, or an increase in feral species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

It is estimated that the Project would disturb approximately 65 ha of remnant vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project.

Surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Spotted-tailed Quoll due to surface infrastructure would be small compared to the amount of habitat available. Given a range of management protocols are proposed to be in place to manage the behaviour of people, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

In NSW, the Spotted-tailed Quoll occurs on both sides of the Great Dividing Range (NPWS, 1999l). The Spotted-tailed Quoll is mainly distributed towards the coast in the NSW Sydney Basin Bioregion (*ibid.*).

The Project is located within the known distribution of the Spotted-tailed Quoll and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Disruption of existing habitat connectivity for an existing population would be possible following events such as extensive habitat clearing. It is considered unlikely however that the vegetation clearance proposed would result in the isolation of nearby areas of habitat for this species. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Given the nature and extent of the vegetation clearance activities, it is unlikely that the Project would significantly impact on habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Spotted-tailed Quoll. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.5.5 Long-nosed Potoroo

The Long-nosed Potoroo inhabits coastal heaths and dry and wet sclerophyll forests. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. The use of such vegetation mosaics or ecotones appears to be characteristic of potoroids in temperate environments (Bennett, 1993). Dense ground cover provides diurnal shelter and protection from predators, however, food resources are often most abundant in adjacent more open areas (*ibid.*). A sandy loam soil is also a common feature (DECC, 2009m). The Long-nosed Potoroo is mainly nocturnal and hides by day in dense vegetation, however during the winter months animals may forage during daylight hours (DECC, 2009m). The Long-nosed Potoroo often digs small holes in the ground in a similar way to bandicoots and the fruit-bodies of hypogenous (underground-fruiting) fungi are a large component of their diet. The Long-nosed Potoroo also eats roots, tubers, insects and their larvae and other soft-bodied animals in the soil. Breeding peaks typically occur in late winter to early summer and adults are capable of two reproductive bouts per year. Individuals of the Long-nosed Potoroo are mainly solitary, non-territorial and have home range sizes ranging between 2 to 5 ha (DECC, 2009m).

Threats relevant to the Long-nosed Potoroo include habitat loss and fragmentation, predation from Foxes, Dogs and Cats and too frequent fires or grazing by stock that reduce the density and floristic diversity of understorey vegetation (DECC, 2009m). Habitat alteration by longwall mining is also considered a threat to the Long-nosed Potoroo (NSW Scientific Committee, 2005a).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be impacted by vegetation clearance/habitat removal, an increase in the frequency of bushfire and an increase in exotic predator species.

It is estimated that the Project would disturb approximately 65 ha of remnant vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Given the extent of remnant vegetation and lack of Long-nosed Potoroo records in the study area, it is unlikely that the proposed vegetation clearance activities would impact on the lifecycle of this species to the extent that a local population of the Long-nosed Potoroo would be placed at risk of extinction. Given a range of management protocols are proposed to be in place to manage the risk of bushfire and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species, or an increase in feral species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Long-nosed Potoroo inhabits coastal heaths and dry and wet sclerophyll forests. This species is also associated with upland swamps (DECC, 2007a). Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature (DECC, 2009m).

It is estimated that the Project would disturb approximately 65 ha of remnant vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Vegetation clearance would be progressive over the life of the mine and natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Long-nosed Potoroo due to surface infrastructure would be small compared to the amount of habitat available. Given a range of management protocols are proposed to be in place to manage the behaviour of people, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

In NSW, the Long-nosed Potoroo is generally restricted to coastal heaths and forests east of the Great Dividing Range, with an annual rainfall exceeding 760 mm (DECC, 2009m).

The Project is located within the known distribution of the Long-nosed Potoroo and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Disruption of existing habitat connectivity for an existing population would be possible following events such as extensive habitat clearing. It is considered unlikely however that the vegetation clearance proposed would result in the isolation of nearby areas of habitat for this species. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Given the nature and extent of the vegetation clearance activities, it is unlikely that the Project would significantly impact on habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Long-nosed Potoroo. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.5.6 Squirrel Glider and Yellow-bellied Glider

The Squirrel Glider is distributed widely in eastern Australia, from northern Queensland, through eastern NSW to Victoria (NPWS, 2000c). The Squirrel Glider inhabits dry sclerophyll forests and woodland where it lives in family groups of up to ten animals (NPWS, 1999m). This species utilises tree hollows for sheltering and breeding (Suckling, 1998), and a number of tree cavities are often used within a home range (Quin, 1993). A field study by Crane *et al.* (2008) found that the Squirrel Glider favoured particular Eucalyptus species and some broader eucalypt groups probably due to inter-specific differences in hollow development and dieback among the various groups (rather than bark type, a factor previously claimed to be an important determinant of den tree usage). Both living and dead trees that contain hollows are used (Beyer *et al*., 2008). Two offspring are produced, twice a year, which remain in the pouch for around 30 days (Suckling, 1998). The diet of the Squirrel Glider consists of insects, acacia gum, eucalypt sap, nectar and pollen (Suckling, 1998). At sites of lower floristic diversity, exudates associated with homopterous insects have been found to be the primary food items consumed throughout the year (Holland *et al*., 2007). Squirrel Glider's forage in the upper and lower forest canopies and in the shrub understorey (NPWS, 1999m). Squirrel Gliders appear to be restricted to stands of mixed forest that contain at least one species of winter-flowering eucalypt or banksia that can contribute to a reliable, year-round food supply (NPWS, 2000c). The estimated home range size for this species varies from 2 to 13 ha, with densities from 0.4 to 3 individuals per ha (Quin, 1993; Suckling, 1998). The home-range of a family group is likely to vary according to habitat quality and availability of resources (Quin, 1995). For example, a field study by van der Ree and Bennett (2003) found that the home ranges of the Squirrel Glider in a linear network (a highly modified landscape) were smaller than those estimated from other studies of this species in continuous habitat. The apparent high quality of the linear habitats investigated was attributed to the density of large old trees, which provide foraging and breeding resources, and the productivity of the environment (van der Ree and Bennett, 2003).

Within its range, the Yellow-bellied Glider is restricted to tall, mature forests in regions of high rainfall (NPWS, 1999n). This species favours productive, tall open sclerophyll forests with mature trees, which provide shelter and nesting hollows and year round forage resources (NPWS, 1999n; 2002b). Essential elements of habitat include sap-site trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of forest types (Tanton, 1994).

The Yellow-bellied Glider is gregarious, living in family groups of between three and six individuals (NPWS, 1999n). A single young is born between May and September and remains in the pouch for up to 100 days (NPWS, 1999n). This species has a large home range of between 30 and 65 ha and usually occurs in densities of 0.05 to 0.14 individuals per ha (NPWS, 1999n). For example, field studies at Kioloa in NSW found that the home ranges of Yellow-bellied Glider groups were exclusive and averaged 34 ha while glider density averaged 0.10 to 0.16 individuals per ha (Goldingay, 1992). The diet of the Yellow-bellied Glider predominantly consists of plant and insect exudates, such as nectar, sap, honeydew and manna and invertebrates found under decorticating bark (NPWS, 1999n, 2002b). A characteristic habit of the species involves incising the bark of eucalypts, which often leaves a triangular or v-shaped mark at the sap site (*ibid*.). Yellow-bellied Gliders also make small incisions on trees, apparently to test their suitability for sap feeding and field observations have shown that gliders actively check sap trees and non-sap trees (Goldingay, 2000).

Loss, fragmentation and degradation of habitat, the removal of hollow bearing trees, inappropriate fire regimes, and competition and predation by Foxes and Cats are relevant threats to the Squirrel Glider (NPWS, 1999m). Threats relevant to the Yellow-bellied Glider include habitat loss and fragmentation, logging of old growth trees, which remove the number of hollow bearing trees available for nesting, inappropriate fire regimes and predation by Cats and Foxes (NPWS, 1999n).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of these species has the potential to be adversely impacted if one or more of the following were to occur: extensive clearing of habitat or an increase in the frequency of bushfire.

It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Any local population of these two species are unlikely to be dependent upon the portion of habitat that would be removed or modified by the Project given the mobility of the species and the occurrence of nearby habitat resources within the surrounding area and wider region. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency. Hence it is very unlikely that the Project would impact on the lifecycle of these species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Squirrel Glider requires hollow bearing trees and a mix of eucalypts, acacias and banksias within dry sclerophyll forests and woodland. Within its range, the Yellow-bellied Glider is restricted to tall, mature forests in regions of high rainfall (NPWS, 1999n). This species favours productive, tall open sclerophyll forests with mature trees, which provide shelter and nesting hollows and year round forage resources (NPWS, 1999n, 2002b). Essential elements of habitat include sap-site trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of forest types (Tanton, 1994).

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact these two species habitat. It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The Project is unlikely to significantly reduce the quality or availability of habitat for the Squirrel Glider or Yellow-bellied Glider.

3. *Does the proposal affect any threatened species or populations that are at the limit of its known distribution?*

The Squirrel Glider is distributed widely in eastern Australia, from northern Queensland, through eastern NSW to Victoria (NPWS, 2000c). The Yellow-bellied Glider has a patchy distribution along the east coast and adjacent ranges of Australia from south-eastern South Australia to North Queensland (NPWS, 1999n). In NSW, the distribution of the Yellow-bellied Glider is essentially coastal, extending inland to adjacent ranges (NPWS, 2002b).

The Project is located within the known distribution of the Squirrel Glider and Yellow-bellied Glider and does not represent a distributional limit for this species.

4. *How is the proposal likely to affect current disturbance regimes?*

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. *How is the proposal likely to affect habitat connectivity?*

Loss of habitat connectivity for these species within the Project area would only be likely if there was widespread clearing of their habitat or a significant increase in fire frequency. Limited clearing of habitat potentially of benefit to these species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for the Squirrel Glider and Yellow-bellied Glider.

6. *How is the proposal likely to affect critical habitat?*

Critical habitat, as defined by the TSC Act, has not been declared for the Squirrel Glider or Yellow-bellied Glider. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.5.7 Grey-headed Flying Fox

The Grey-headed Flying Fox inhabits rainforests, open forests, closed and open woodlands, *Melaleuca* swamps, *Banksia* woodlands, as well as mangroves (Churchill, 1998; Duncan *et al.*, 1999a). The Grey-headed Flying Fox is distributed in coastal south-eastern Australia, from Victoria to Miriam Vale in Queensland and inland to the western slopes (Hall and Richards, 2000).

The Grey-headed Flying Fox is an obligate nectarivore and frugivore (Eby, 2000). This species feeds on a wide variety of flowering and fruiting plants and is responsible for the seed dispersal of many rainforest trees, such as native figs and palms (Tidemann, 1998). The Grey-headed Flying Fox also feeds extensively on the blossoms of eucalypts, angophoras, tea-trees and banksias, as well as in introduced tree species in urban areas and in commercial fruit crops (Tidemann, 1998; Duncan *et al.*, 1999a).

Roost sites of the Grey-headed Flying Fox (known as camps) are commonly formed in gullies, typically not far from water and usually in vegetation with a dense canopy (Tidemann, 1998). Mating, birth and the rearing of young occur at the roost sites (*ibid.*). Mating occurs at any time of the year, however most conceptions occur in March or April (Tidemann, 1998). The majority of reproductively mature females give birth to a single young each October/November (NPWS, 2001f).

Colonies of bats leave their camps according to the time of sunset and cloud cover, however, emergence has been observed to be delayed when diurnal avian predators are present (Welbergen, 2006). In contrast, emergence is typically earlier during lactation when energetic demands are higher (*ibid.*). The Grey-headed Flying Fox commutes daily to foraging areas, usually within 15 km of the day roost, while a few individuals may travel up to 50 km (Tidemann, 1998). The Grey-headed Flying Fox responds to changes in the amount and location of available food by migrating in irregular patterns (Eby, 2000). Migration patterns vary between years in association with the changing location of flowering trees (*ibid.*). It has been suggested that the Grey-headed Flying Fox uses winds to facilitate long-distance movements (Tidemann and Nelson, 2004).

Loss of foraging habitat, disturbance at roosting sites, unregulated shooting, electrocution on power lines and competition and hybridisation with the Black Flying Fox (*Pteropous alecto*) are threats to this species (NPWS, 2001f). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a). In addition, temperature extremes (e.g. greater than 42^{o}C) have caused mass deaths of this species (e.g. Welbergen *et al.*, 2006). Welbergen *et al.* (2006) report that since 1994, at least 24,500 Grey-headed Flying Foxes have been killed during 19 extreme temperature events and that it is reasonable to conclude that such die-offs may become more frequent as a result of climate change.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur: extensive clearing of habitat or an increase in the frequency of bushfire.

It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Any local population of the Grey-headed Flying Fox is unlikely to be dependent upon the portion of habitat that would be removed or modified by the Project given the mobility of the species and the occurrence of nearby habitat resources within the surrounding area and wider region. A Grey-headed Flying Fox camp is known to occur at Menangle at the western side of the Nepean River in Appin Area 7 (DECC, 2009n). Vegetation clearance activities for the Project will avoid this camp site. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency. Hence it is very unlikely that the Project would impact on the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Grey-headed Flying Fox inhabits rainforests, open forests, closed and open woodlands, *Melaleuca* swamps, *Banksia* woodlands, as well as mangroves (Churchill, 1998; Duncan *et al.*, 1999a). Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact this species habitat. It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Vegetation clearance activities will avoid the Grey-headed Flying Fox camp site located at Menangle at the western side of the Nepean River. The Project is unlikely to significantly reduce the quality or availability of habitat for the Grey-headed Flying Fox.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Grey-headed Flying Fox is distributed in coastal south-eastern Australia, from Victoria to Miriam Vale in Queensland and inland to the western slopes (Hall and Richards, 2000). The Project is located within the known distribution of the Grey-headed Flying Fox and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of its habitat or a significant increase in fire frequency. Limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Grey-headed Flying Fox. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.5.8 Eastern Bentwing Bat

The Eastern Bentwing Bat occupies a range of habitat types including rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grasslands (Churchill, 1998).

The Eastern Bentwing Bat is distributed in Northern Australia from the Kimberley through the Top End to the western Gulf of Carpentaria (Churchill, 1998; Dwyer, 1998). In eastern Australia, the Eastern Bentwing Bat is distributed from north Queensland to far south-east South Australia (*ibid.*). In NSW, the Eastern Bentwing Bat is found along the coast and western slopes, including high altitude elevations of the Great Dividing Range (NPWS, 2000c).

The Eastern Bentwing Bat is an obligate cave dweller, however it also uses cave substitutes such as mine adits and road culverts (Churchill, 1998). The maternity cave is used annually for the birth and development of young (Churchill, 1998). In temperate regions mating takes place during May to June. In October, adult females congregate in maternity colonies and give birth to their single young in December to mid January (Churchill, 1998). Once the young have been weaned, the mothers disperse to their winter roosts. There is a mass exodus of juveniles a few weeks thereafter and the maternity colony is deserted by April (*ibid.*). This species forages in forested areas, catching moths and other flying insects above the tree tops (DECC, 2009o).

Disturbance to colonies (particularly in maternity or hibernating caves), destruction or modification of caves, rehabilitation of derelict mines, changes to habitat (particularly surrounding maternity caves) and insecticide use are relevant threats to this species (NPWS, 2000c).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat, an increase in the rate of rock fall and/or cliff face collapse with associated caves, and clearing of vegetation.

It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project. Any local population of the Eastern Bentwing Bat is unlikely to be dependent upon the portion of habitat that would be removed or modified by the Project given the mobility of the species and the occurrence of nearby habitat resources within the surrounding area and wider region. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency. MSEC (2009) and Appendix R of the EA have predicted only minor increases in rock fall and cliff face collapse. Subsequently, there is likely to be only small impacts, if any, on potential roosting or breeding habitat for the Eastern Bentwing Bat. Hence it is unlikely that the Project would impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Eastern Bentwing Bat utilises a range of habitat types including rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grasslands (Churchill, 1998). Furthermore it is an obligate cave dweller or uses appropriate substitutes.

It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Eastern Bentwing Bat due to surface infrastructure would be small compared to the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. A significant loss of cave habitats due to mine subsidence associated with the Project is unlikely based on the relatively small predicted increase in rock fall and cliff face collapse (MSEC, 2009 and Appendix R of the EA). The Project is unlikely to significantly reduce the quality or availability of habitat for the Eastern Bentwing Bat.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Eastern Bentwing Bat is distributed in Northern Australia from the Kimberley through the Top End to the western Gulf of Carpentaria (Churchill, 1998; Dwyer, 1998). In eastern Australia, the Eastern Bentwing Bat is distributed from north Queensland to far south-east South Australia (*ibid.*). In NSW, the Eastern Bentwing Bat is found along the coast and western slopes, including high altitude elevations of the Great Dividing Range (NPWS, 2000c).

The Project is located within the known distribution of the Eastern Bentwing Bat and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of its habitat or a significant increase in fire frequency. Clearing of potential habitat of this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Eastern Bentwing Bat. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.5.9 Large-footed Myotis

The Large-footed Myotis will live in most habitat types (including mangroves, paperbark swamps, riverine monsoon rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland), as long as they are close to water (ranging from rainforest streams to large lakes and reservoirs) (Richards, 1998; Churchill, 1998; NPWS, 2000c). Riparian habitat is thought to be preferred (Duncan *et al.*, 1999b).

The Large-footed Myotis was previously considered to only occur disjunctly along the coast of Australia from Victoria to south-east Queensland and inland along waterways (Duncan *et al.*, 1999b). However, a recent taxonomic assessment of the Australian *Myotis* group (*M. adversus, M. macropus* and *M. moluccarum*) showed that these taxa form a monophyletic group that was given the name *M. macropus* (Cooper *et al.*, 2004). Hence, the general distributional range is now considered to be across northern Australia, coastally to Victoria (DECC, 2009p).

Colonies of the Large-footed Myotis roost during the day, predominantly in caves or their substitutes (such as mines and tunnels), however have also been known to roost in tree hollows and disused bird nests (NPWS, 2000c). In cooler regions this species hibernates in winter, remaining in roosts, which are separate from the maternity sites (Richards, 1998). Within breeding colonies, males establish a territory, excluding other males and form a harem of females during the breeding periods (Richards, 1998). When not breeding, males roost alone (*ibid.*). In NSW, females of this species give birth to one young each year, usually in November or December (Richards, 1998). The Large-footed Myotis forage most commonly over water, raking its surface with the sharp claws of their large feet to catch aquatic insects and small fish, which make up most of their diet (Richards, 1998; Churchill, 1998; NPWS, 2000c). The Large-footed Myotis may also forage aerially and may forage individually or hunt together (*ibid.*).

Threats to the Large-footed Myotis are currently poorly known but possible threats are suggested to include sensitivity to changes in water quality caused by sedimentation, eutrophication, alteration of flow regimes and other pollution (Duncan *et al*., 1999b) as well as disturbance to roosting sites by activities such as recreational caving and/or roadworks, particularly during the colder months when the species is hibernating (Ayers *et* al., 1996; Duncan *et al*., 1999b; Gilmore and Parnaby, 1994).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat, changed surface hydrological conditions leading to a reduced availability of habitat and resources, an increase in the rate of rock fall and/or cliff face collapse with associated caves, and clearing of vegetation.

It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project. Changes in surface hydrology are likely to impact marginally on the habitat of this species.

The Project stream impact minimisation criteria includes avoidance of impacts such as significant cracking of rock bars that would result in surface flow diversion and draining of pools along the Georges River, O'Hares Creek, Stokes Creek (downstream of Longwall 5a – refer to Appendix A of the EA), Nepean River, Cataract River and Lizard Creek. In addition, the Project avoids directly mining beneath the headwater reaches of Woronora River labelled as "perennial" on 1:250,000 topographic mapping (Lands Department, 2000) and therefore reduces potential impacts to this stream.

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency. MSEC (2009) and Appendix R of the EA (Major Cliff Line Risk Assessment) have predicted only minor increases in rock fall and cliff face collapse. Subsequently, there is likely to be only small impacts, if any, on potential roosting or breeding habitat for the Large-footed Myotis. Hence it is unlikely that the Project would impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Large-footed Myotis will live in most habitat types (including mangroves, paperbark swamps, riverine monsoon rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland), as long as they are close to water (ranging from rainforest streams to large lakes and reservoirs) (Richards, 1998; Churchill, 1998; NPWS, 2000c). Riparian habitat is thought to be preferred (Duncan *et al*., 1999b).

It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Large-footed Myotis due to surface infrastructure would be small compared to the amount of habitat available. Mine subsidence also has the potential to cause cracking and alter the availability of water in streams, however the changes described would not be of an extent that would significantly affect the availability of habitat resources for this species.

Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. A significant loss of cave habitats due to mine subsidence is unlikely based on the relatively small increase in rock fall and cliff face collapse predicted to occur by MSEC (2009) and Appendix R of the EA. The Project is unlikely to significantly reduce the quality or availability of habitat for the Large-footed Myotis.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Large-footed Myotis was previously considered to only occur disjunctly along the coast of Australia from Victoria to south-east Queensland and inland along waterways (Duncan *et al.*, 1999b). However, a recent taxonomic assessment of the Australian *Myotis* group (*M. adversus, M. macropus* and *M. moluccarum*) showed that these taxa form a monophyletic group that was given the name *M. macropus* (Cooper *et al.*, 2004). Hence, the general distributional range is now considered to be across northern Australia, coastally to Victoria (DECC, 2009p).

The Large-footed Myotis has been recorded in the Metropolitan, O'Hares and Woronora Special Areas (DECC, 2009a) and is considered to be a species of high regional priority (DECC, 2007a). The Project is located within the known distribution of the Large-footed Myotis and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of its habitat or a significant increase in fire frequency. Clearing of potential habitat of this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Large-footed Myotis. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

6.5.10 Other Bat Fauna: Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and Large-eared Pied Bat

The Yellow-bellied Sheathtail Bat inhabits a wide range of habitats including wet and dry sclerophyll forest, open woodland, Acacia shrubland, mallee, grasslands and desert (Churchill, 1998). The distribution of the Yellow-bellied Sheathtail Bat includes the eastern coast of NSW. The Yellow-bellied Sheathtail Bat roosts in tree hollows in a wide range of habitats and has been found to utilise multiple roost sites. This species has also been found in the abandoned nests of Sugar Gliders (Richards, 1995). The Yellow-bellied Sheathtail Bat is insectivorous and forages above the tree canopy. A variety of prey items are eaten including long-horned grasshoppers, shield bugs and flying ants, while beetles comprise up to 90% of this species' diet (Churchill, 1998). This species is likely to be migratory in southern Australia (Richards, 1995).

The Eastern Freetail Bat mainly roosts in tree hollows, however has also been recorded roosting under bark or in man-made structures (DECC, 2009q). Little is known about the reproduction and diet of the Eastern Freetail Bat. However, some data suggests the males and females of this species separate at certain times of the year possibly for birth and raising of young (Allison and Hoye, 1998).

The Eastern False Pipistrelle predominantly roosts in tree hollows, as well as abandoned buildings (Parnaby, 1983), and there is also one record from the Jenolan Caves. Breeding occurs in late spring and early summer (Churchill, 1998). This species forages within or just below the tree canopy (Churchill, 1998). The diet of mainland bats consists of moths, beetles, weevils, bugs, flies and ants (Menkhorst and Lumsden, 1995). The Eastern False Pipistrelle has been recorded travelling 12 km from foraging areas to roosting sites (Churchill, 1998). Given the size and shape of the wings of this species, it is likely that Eastern False Pipistrelles are highly mobile (Phillips, 1995). During winter, some populations of the Eastern False Pipistrelle may migrate from highland to coastal areas, while others may hibernate (Parnaby, 1983).

The Greater Broad-nosed Bat is thought to be highly mobile with a large foraging range (Phillips, 1998). This species flies slowly at a height of approximately 3 to 6 m (Hoye and Richards, 1995). Natural and human-made openings are used as movement corridors in the more congested environments of the wetter forests (*ibid.*). The diet of the Greater Broad-nosed Bat consists of insects including moths, beetles and chafers, while this species has also been known to eat other bat species (Churchill, 1998). This species roosts in tree hollows, however may occasionally be found in buildings (Churchill, 1998). Females congregate in maternity colonies and single young are born in January (Churchill, 1998).

The Large-eared Pied Bat roosts in caves, mine tunnels and the abandoned mud nests of Fairy Martins (Hoye and Dwyer, 1998; Schulz, 1998). Females give birth in November and young are independent by late February (Hoye and Dwyer, 1998). Young leave the cave soon after, while the females remain another month before abandoning the roost in late March for winter (Churchill, 1998). This species is thought to spend the coldest months in hibernation (Hoye and Dwyer, 1998). The Large-eared Pied Bat forages for small flying insects below the forest canopy (Hoye and Dwyer, 1998; Churchill, 1998).

Threats relevant to the Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and/or Large-eared Pied Bat include loss of roost or maternity sites (e.g. hollow-bearing trees and caves), loss of foraging habitat and application of pesticides in or adjacent to foraging areas.

1. *How is the proposal likely to affect the lifecycle of a threatened species and/or population?*

Potential impacts of the Project on terrestrial fauna are summarised in Section 4. The lifecycle of these species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species' habitat, an increase in the rate of rock fall and/or cliff face collapse with associated caves, and clearing of vegetation.

It is estimated that the Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some areas are likely to be disturbed, while other areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active revegetation undertaken in areas disturbed by the Project. Any local population of these five species is unlikely to be dependent upon the portion of habitat that would be removed or modified by the Project given the mobility of the species' and the occurrence of nearby habitat resources within the surrounding area and wider region.

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency. MSEC (2009) and Appendix R of the EA (Major Cliff Line Risk Assessment) have predicted only minor increases in rock fall and cliff face collapse. Subsequently, there is likely to be only small impacts, if any, on potential roosting or breeding habitat for these five species. Hence it is unlikely that the Project would impact the lifecycle of the Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and Large-eared Pied Bat.

2. *How is the proposal likely to affect the habitat of a threatened species, population or ecological community?*

The Yellow-bellied Sheathtail Bat inhabits a wide range of habitats including wet and dry sclerophyll forest, open woodland, Acacia shrubland, mallee, grasslands and desert (Churchill, 1998). The Eastern Freetail Bat inhabits dry sclerophyll forest, woodland and coastal dune vegetation. The Eastern False Pipistrelle prefers moist habitats, with a canopy height exceeding 20 m (DECC, 2009q). The Greater Broad-nosed Bat prefers moist gullies in mature coastal forest or rainforest between the Great Dividing Range and the coast, however, has also been recorded in open woodland and wet and dry sclerophyll forest (Churchill, 1998). The Large-eared Pied Bat occurs in moderately well wooded habitats (Ayers *et al*., 1996).

It is estimated that the Project would disturb approximately 65 ha for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for these five species due to surface infrastructure would be small compared to the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. A significant loss of cave habitats due to mine subsidence associated with the Project is unlikely based on the relatively small predicted increase in rock fall and cliff face collapse. The Project is unlikely to significantly reduce the quality or availability of habitat for these five species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The distribution of the Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and Large-eared Pied Bat includes the eastern coast of NSW.

The Project is located within the known distribution of the Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and Large-eared Pied Bat and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. Given a range of management protocols are proposed to be in place to manage the risk of fire, it is unlikely that there would be an increase in fire frequency as a result of the Project.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these species within the Project area would only be likely if there was widespread clearing of their habitat or a significant increase in fire frequency. Clearing of potential habitat of these species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these five vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for these five species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat or Large-eared Pied Bat. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2009) or DEWHA Register of Critical Habitat (2009b) located in the Project area or surrounds.

7 CONCLUSIONS

The following are the conclusions from the study:

- Nine broad habitat types were identified in the study area, namely Dry Rainforest, Tall Forest, Open Woodland, Gully Forest, Riparian, Low Woodland Heath, Upland Swamp, Cleared Agricultural Land and Water. Open Woodland, Gully Forest, Riparian and Low Woodland Heath were also associated with various rock formations that added to the habitat complexity of these major habitat types. The majority of these habitat types on the Woronora Plateau were in mid-succession recovery following the 2000/2001 bushfires.
- The habitat throughout the study area is variable and reflects the different landscape and geological domains. The higher parts of the Woronora Plateau are dominated by Low Woodland and Low Woodland Heath across the higher parts. The incised gullies provide more sheltered habitat for Gully Forest and Riparian scrub. Upland swamps are confined to the eastern and southern portions of the study area; some of these swamps are dry underfoot for most of the year while others have wet or damp areas within them. The most restricted habitat is Dry Rainforest which only occurs in isolated pockets in the western portion of the study area; these pockets are invariably heavily weed infested and bear little resemblance to the original vegetation community that existed there prior to land clearing and settlement.
- The range of habitats present across the study site also demonstrate a high level of functional integrity and system resilience.
- A total of 236 species were identified in the study area (including 222 native and 14 introduced species, consisting of 19 amphibian species, 30 reptile species, 151 bird species and 36 mammal species).
- The species diversity recorded was considered to be a very representative subset of the species that could be potentially located within the region.
- Seventeen threatened species were located within the study area, namely the Giant Burrowing Frog, Red-crowned Toadlet, Littlejohn's Tree Frog, Heath Monitor, Broad-headed Snake, Square-tailed Kite, Eastern Ground Parrot, Gang-gang Cockatoo, Powerful Owl, Black-chinned Honeyeater (eastern subspecies), Spotted-tail Quoll, Southern Brown Bandicoot (eastern), Koala, Eastern Pygmy-possum, Grey-headed Flying-fox, Eastern Bentwing-bat and Large-footed Myotis.
- Portions of the study area fall within the definition of core Koala habitat under SEPP 44.

Potential adverse impacts of the Project on terrestrial fauna and their habitats have been assessed and include:

- Surface cracking, changes in pool levels, flooding or scouring, changes in stream alignments, changes in the availability of water due to cracking of rock strata in watercourses, changes in water quality, strata gas emissions and rock falls as a result of mine subsidence.
- Other direct and indirect impacts, including vegetation clearance/habitat disturbance (associated with the Stage 4 Coal Wash Emplacement and other Project related activities), fire, weeds and exotic pests, the plant pathogen *Phytophthora cinnamomi*, amphibian Chytrid fungus, dust, noise, fauna traps, road traffic, artificial lighting and greenhouse gas emissions/climate change effects.

In summary the following conclusions can be made:

- The Project would disturb approximately 65 ha of remnant native vegetation for the West Cliff Stage 4 Coal Wash Emplacement and less than 37 ha of remnant native vegetation in other areas of the approximated 9,845 ha of remnant native vegetation across the study area.
- Project related vegetation clearance would be progressive over the life of the mine.
- The Project stream impact minimisation criteria includes avoidance of impacts such as significant cracking of rock bars that would result in surface flow diversion and draining of pools along the Cataract River, Georges River (in West Cliff Area 5), Lizard Creek, Nepean River, O'Hares Creek and Stokes Creek (downstream of Longwall 5a – refer to Appendix A of the EA).
- The Project would avoid directly mining beneath the headwater reaches of the Georges and Woronora Rivers lablled as "perennial" on 1:25,000 topographic mapping (Lands Department, 2000), and therefore reduce potential impacts to these streams.
- The Project would include a range of measures to mitigate, manage and monitor potential impacts on terrestrial fauna.

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NSW Scientific Committee (2001d) *Final Determination for Black-chinned Honeyeater (Eastern form) (Melithreptus gularis gularis).*

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ATTACHMENT A

THREATENED SPECIES DATABASE SEARCH RESULTS

Table A1
Threatened Species Database Search Results

Scientific Name	Common Name	Conservation Status		Species Records							
				DECC List		EPBC Act Protected Matters Search[5]	NPWS Atlas of NSW Wildlife[6]	Australian Museum[7]	Birds Australia[8]	BHPIC Previous Survey Records[9]	Considered to Potentially Occur in the Study Area or Immediate Surrounds
		TSC Act[1]	EPBC Act[2]	Sydney Cataract sub-region[3]	Cumberland sub-region[4]						
Amphibians											
Litoria aurea	Green and Golden Bell Frog	E	V	●	●	●	●	●			✓
Litoria brevipalmata	Green-thighed Frog	V	-					●			X
Litoria littlejohni	Littlejohn's Tree Frog	V	V	●		●	●	●			✓
Mixophyes balbus	Stuttering Frog	E	V	●		●		●			X
Heleioporus australiacus	Giant Burrowing Frog	V	V	●	●	●	●	●			✓
Pseudophryne australis	Red-crowned Toadlet	V	-	●	●		●	●			✓
Reptiles											
Caretta caretta	Loggerhead Turtle	E	E	●							X
Chelonia mydas	Green Turtle	V	V	●			●				X
Dermochelys coriacea	Leathery Turtle	V	E	●							X
Hoplocephalus bungaroides	Broad-headed Snake	E	V	●	●	●	●	●		●	✓
Varanus rosenbergi	Heath Monitor	V	-	●	●		●	●		●	✓
Birds											
Anthochaera phrygia	Regent Honeyeater	E	E	●	●	●	●	●	●		✓
Botaurus poiciloptilus	Australasian Bittern	V	-		●		●		●		✓

Table A1 (Continued)
Threatened Species Database Search Results

Scientific Name	Common Name	Conservation Status		Species Records							
				DECC List							
		TSC Act[1]	EPBC Act[2]	Sydney Cataract sub-region[3]	Cumberland sub-region[4]	EPBC Act Protected Matters Search[5]	NPWS Atlas of NSW Wildlife[6]	Australian Museum[7]	Birds Australia[8]	BHPIC Previous Survey Records[9]	Considered to Potentially Occur in the Study Area or Immediate Surrounds
Burhinus grallarius	Bush Stone-curlew	E	-	●	●		●	●			✓
Calidris alba	Sanderling	V	-				●		●		X
Calidris tenuirostris	Great Knot	V	-						●		X
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	●	●		●	●	●	●	✓
Calyptorhynchus banksii	Red-tailed Black Cockatoo	V	-					●			X
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-	●	●		●	●	●	●	✓
Charadrius mongolus	Lesser Sand Plover	V	-						●		X
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	-		●		●		●		✓
Coracina lineata	Barred Cuckoo-shrike	V	-				●		●		X
Dasyornis brachypterus	Eastern Bristlebird	E	E	●			●	●			✓
Diomedea antipodensis	Antipodean Albatross	V	V				●				X
Diomedea exulans	Wandering Albatross	E	V				●	●	●		X
Diomedea gibsoni	Gibson's Albatross	V	V				●		●		X
Ephippiorhynchus asiaticus	Black-necked Stork	E	-				●				✓[10]

Table A1 (Continued)
Threatened Species Database Search Results

Scientific Name	Common Name	Conservation Status		Species Records							
				DECC List							
		TSC Act[1]	EPBC Act[2]	Sydney Cataract sub-region[3]	Cumberland sub-region[4]	EPBC Act Protected Matters Search[5]	NPWS Atlas of NSW Wildlife[6]	Australian Museum[7]	Birds Australia[8]	BHPIC Previous Survey Records[9]	Considered to Potentially Occur in the Study Area or Immediate Surrounds
Esacus neglectus	Beach Stone-curlew	E	-				●				X
Fregetta grallaria	White-bellied Storm-Petrel	V	-				●				X
Grantiella picta	Painted Honeyeater	V	-		●		●				X
Gygis alba	White Tern	V	-				●				X
Haematopus fuliginosus	Sooty Oystercatcher	V	-	●			●	●	●		X
Haematopus longirostris	Pied Oystercatcher	V	-	●			●		●		X
Halobaena caerulea	Blue Petrel	-	V					●			X
Irediparra gallinacea	Comb-crested Jacana	V	-		●						X
Ixobrychus flavicollis	Black Bittern	V	-		●		●	●	●		✓
Lathamus discolor	Swift Parrot	E	E	●	●	●	●	●	●		✓
Limicola falcinellus	Broad-billed Sandpiper	V	-				●				X
Limosa limosa	Black-tailed Godwit	V	-		●		●				X
Lophoictinia isura	Square-tailed Kite	V	-	●	●		●		●		✓
Macronectes giganteus	Southern Giant Petrel	E	E				●		●		X
Macronectes halli	Northern Giant-Petrel	V	V				●		●		X

Table A1 (Continued)
Threatened Species Database Search Results

Scientific Name	Common Name	Conservation Status		Species Records							
				DECC List							
		TSC Act[1]	EPBC Act[2]	Sydney Cataract sub-region[3]	Cumberland sub-region[4]	EPBC Act Protected Matters Search[5]	NPWS Atlas of NSW Wildlife[6]	Australian Museum[7]	Birds Australia[8]	BHPIC Previous Survey Records[9]	Considered to Potentially Occur in the Study Area or Immediate Surrounds
Melanodryas cucullata	Hooded Robin	V	-		●		●		●		✓
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	-	●	●		●		●		✓
Neophema chrysogaster	Orange-bellied Parrot	CE	CE			●					X
Neophema pulchella	Turquoise Parrot	V	-	●	●		●	●	●		✓
Ninox connivens	Barking Owl	V	-		●		●				✓
Ninox strenua	Powerful Owl	V	-	●	●		●	●	●	●	✓
Oxyura australis	Blue-billed Duck	V	-				●				✓
Pachycephala olivacea	Olive Whistler	V	-				●		●		✓
Petroica rodinogaster	Pink Robin	V	-				●				✓
Pezoporus wallicus wallicus	Eastern Ground Parrot	V	-	●				●			✓
Phaethon rubricauda	Red-tailed Tropicbird	V	-				●				X
Phoebetria fusca	Sooty Albatross	V	V				●	●			X
Polytelis anthopeplus monarchoides	Regent Parrot (eastern subsp.)	E	V				●				X
Polytelis swainsonii	Superb Parrot	V	V				●				X
Procelsterna cerulea	Grey Ternlet	V	-				●				X

Table A1 (Continued)
Threatened Species Database Search Results

Scientific Name	Common Name	Conservation Status		Species Records							
				DECC List							
		TSC Act[1]	EPBC Act[2]	Sydney Cataract sub-region[3]	Cumberland sub-region[4]	EPBC Act Protected Matters Search[5]	NPWS Atlas of NSW Wildlife[6]	Australian Museum[7]	Birds Australia[8]	BHPIC Previous Survey Records[9]	Considered to Potentially Occur in the Study Area or Immediate Surrounds
Pterodroma leucoptera leucoptera	Gould's Petrel	E	E				●	●			X
Pterodroma neglecta neglecta	Kermadec Petrel (west Pacific subspecies)	V	V				●				X
Pterodroma nigripennis	Black-winged Petrel	V	-				●				X
Pterodroma solandri	Providence Petrel	V	-				●	●	●		X
Ptilinopus magnificus	Wompoo Fruit-Dove	V	-				●				X
Ptilinopus regina	Rose-crowned Fruit-Dove	V	-				●				X
Ptilinopus superbus	Superb Fruit-Dove	V	-		●		●	●	●		X
Puffinus assimilis	Little Shearwater	V	-	●			●	●	●		X
Puffinus carneipes	Flesh-footed Shearwater	V	-				●		●		X
Pyrrholaemus saggitatus	Speckled Warbler	V	-		●		●				✓
Rostratula australis	Australian Painted Snipe	E	V		●	●		●			X
Stagonopleura guttata	Diamond Firetail	V	-		●		●	●	●		✓
Sterna albifrons	Little Tern	E	-	●			●		●		X
Sterna fuscata	Sooty Tern	V	-				●	●			X
Stictonetta naevosa	Freckled Duck	V	-		●		●		●		✓

Table A1 (Continued)
Threatened Species Database Search Results

Scientific Name	Common Name	Conservation Status		Species Records							
				DECC List		EPBC Act Protected Matters Search[5]	NPWS Atlas of NSW Wildlife[6]	Australian Museum[7]	Birds Australia[8]	BHPIC Previous Survey Records[9]	Considered to Potentially Occur in the Study Area or Immediate Surrounds
		TSC Act[1]	EPBC Act[2]	Sydney Cataract sub-region[3]	Cumberland sub-region[4]						
Thalassarche bulleri	Buller's Albatross	-	V				•		•		X
Thalassarche cauta	Shy Albatross	V	V				•		•		X
Thalassarche cauta salvini	Salvin's Albatross	V	V				•				X
Thalassarche cauta steadi	White-capped Albatross	-	V				•				X
Thalassarche chrysostoma	Grey-headed Albatross	-	V				•		•		X
Thalassarche melanophris	Black-browed Albatross	V	V				•		•		X
Thalassarche melanophris impavida		V	V				•				X
Thinornis rubricollis	Hooded Plover	E	-				•				X
Turnix maculosa	Red-backed Button-quail	V						•			X
Tyto novaehollandiae	Masked Owl	V	-	•	•		•		•		✓
Tyto tenebricosa	Sooty Owl	V	-	•	•		•	•	•		✓
Mammals											
Aepyprymnus rufescens	Rufous Bettong	V	-					•			X
Arctocephalus forsteri	New Zealand Fur-seal	V	-				•				X

Table A1 (Continued)
Threatened Species Database Search Results

Scientific Name	Common Name	Conservation Status		Species Records							
				DECC List		EPBC Act Protected Matters Search[5]	NPWS Atlas of NSW Wildlife[6]	Australian Museum[7]	Birds Australia[8]	BHPIC Previous Survey Records[9]	Considered to Potentially Occur in the Study Area or Immediate Surrounds
		TSC Act[1]	EPBC Act[2]	Sydney Cataract sub-region[3]	Cumberland sub-region[4]						
Arctocephalus pusillus doriferus	Australian Fur-seal	V	-				•				X
Arctocephalus tropicalis	Sub-antarctic Fur-seal	-	V					•			X
Bettongia penicillata penicillata	Brush-tailed Bettong (South-East Mainland)	EXT	EXT				•	•			X
Cercartetus nanus	Eastern Pygmy-possum	V	-	•	•		•	•			✓
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	•		•	•				✓
Dasyurus maculatus	Spotted-tailed Quoll	V	E	•	•	•	•	•			✓
Dasyurus viverrinus	Eastern Quoll	E	-				•	•			X
Dugong dugon	Dugong	E	-				•				X
Eubalaena australis	Southern Right Whale	V	E				•				X
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	-	•	•		•				✓
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E	E			•	•				✓
Macropus parma	Parma Wallaby	V	-								X
Megaptera novaeangliae	Humpback Whale	V	V				•				X

Table A1 (Continued)
Threatened Species Database Search Results

Scientific Name	Common Name	Conservation Status		Species Records							
				DECC List							
		TSC Act[1]	EPBC Act[2]	Sydney Cataract sub-region[3]	Cumberland sub-region[4]	EPBC Act Protected Matters Search[5]	NPWS Atlas of NSW Wildlife[6]	Australian Museum[7]	Birds Australia[8]	BHPIC Previous Survey Records[9]	Considered to Potentially Occur in the Study Area or Immediate Surrounds
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	-	●	●		●			●	✓
Mormopterus norfolkensis	Eastern Freetail-bat	V	-	●	●		●				✓
Myotis macropus	Large-footed Myotis	V	-	●	●		●			●	✓
Petaurus australis	Yellow-bellied Glider	V	-				●	●			✓
Petaurus norfolcensis	Squirrel Glider	V	-	●	●		●				✓
Petrogale penicillata	Brush-tailed Rock-wallaby	E	V			●	●				X
Phascogale tapoatafa	Brush-tailed Phascogale	V	-					●			X
Phascolarctos cinereus	Koala	V	-	●	●		●	●		●	✓
Physeter macrocephalus	Sperm Whale	V	-				●				X
Potorous tridactylus tridactylus	Long-nosed Potoroo	V	V			●					✓
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	●	●	●	●			●	✓
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	-	●	●		●	●			✓
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-	●	●		●				✓

Table A1 (Continued)
Threatened Species Database Search Results

Scientific Name	Common Name	Conservation Status		Species Records							
				DECC List							
		TSC Act[1]	EPBC Act[2]	Sydney Cataract sub-region[3]	Cumberland sub-region[4]	EPBC Act Protected Matters Search[5]	NPWS Atlas of NSW Wildlife[6]	Australian Museum[7]	Birds Australia[8]	BHPIC Previous Survey Records[9]	Considered to Potentially Occur in the Study Area or Immediate Surrounds
Gastropods											
Meridolum corneovirens	Cumberland Plain Land Snail	E	-	●	●		●	●		●	✓

1 Threatened species status under the NSW *Threatened Species Conservation Act, 1995* (current as at 11 May 2009).

2 Threatened species status under the Commonwealth *Environment Protection and Biodiversity Conservatin Act, 1999* (current as at 11 May 2009).

3 DECC (2009) *List of Threatened Species Known or Predicted to occur in the Sydney Cataract CMA Sub-region*. Date Accessed: 17 February 2009.

4 DECC (2009) *List of Threatened Species Known or Predicted to occur in the Cumberland CMA Sub-region*. Date Accessed: 17 February 2009.

5 Department of Environment and Water Resources (DEWR) (2008) *EPBC Act Protected Matters Search.* Search for co-ordinates: -34.27027,150.9147, -34.11638,150.9197, -34.11166,150.6352, -34.26138,150.6269.

6 NPWS (2009) *Threatened Species - DECC Atlas database records for the Wollongong 1:100, 000 map sheet*. Date Received: 3 February 2009.

7 Australian Museum (2009) *Database records within the following search area: (MGA Zone 56) 270000E, 6235000N; 319000E, 6235000N; 270000E, 6195000N; 319000E, 6195000N*. Data received January 2009.

8 Birds Australia (2008) *Database records within the following search area: (MGA Zone 56) 270000E, 6235000N; 319000E, 6235000N; 270000E, 6195000N; 319000E, 6195000N.* Data received December 2008.

9 Biosis Research (2007) *West Cliff Colliery Area 5 – Longwalls 34-36 Impacts of Subsidence on Terrestrial Flora and Fauna*; Biosis Research (2007) *West Cliff Colliery – Stage 3 Coal Wash Emplacement Application – Volume 3 Species Impact Statement*; and Biosis Research (2008) *Appin Colliery Area 7 – Longwalls 705-710 Impacts of Subsidence on Terrestrial Flora and Fauna.*

E - Endangered V – Vulnerable CE EXT

10 The Black-necked Stork is known only as a vagrant and considered to be a very rare visitor in the area (DECC, 2007a). This species is therefore not assessed any further in this report.

ATTACHMENT B

SURVEY EFFORT

Table B1
Survey Effort

Method	Site Effort	Total Effort
Anabat detectors	1 Anabat detector for 2 nights at Sites 1 to 54 and T1, T2, T3, T5, T9, T10, T11, T12, T13, T14, T15, T17, T18, T35, T36.	138 Anabat detector nights
Hair tubes	At least 5 large ground hair tubes at Sites 1 to 54, T3 and T37 to T53 for a minimum of four nights. 5 arboreal hair tubes at Sites 1 to 54 and T3 for a minimum of four nights.	3, 150 large ground hair tube nights 1,100 arboreal hair tube nights
Spotlighting	Up to 2 person hours per site (i.e. Sites 1 to 54 and T1, T2, T3, T5, T9, T10, T11, T12, T13, T14, T15, T17, T18, T35 to T46).	154 person hours
Diurnal herpetological searches	Up to 1 person hour per site on two days at Sites 1 to 54 and T1, T2, T3, T4, T6, T7, T8, T11, T12, T15, T17, T18, T20, T21, T22, T23, T24, T25, T27, T29, T31 to T46.	172 person hours
Nocturnal amphibian searches	1 person hour per site on two nights at Sites 1 to 54 and T3, T5, T9. T10, T11, T12, T13, T14, T15, T16, T20, T21, T25, T28, T29, T30, T31, T32, T33, T34, T35.	150 person hours
Bird surveys	30-minutes on two days at each site (i.e. Sites 1 to 54 and T1, T2, T3,T11, T12, T15, T16, T17, T18, T20, T22, T23, T24, T25, T26, T29, T31, T32, T33, T34, T36.	75 person hours
Call playback	Up to 20 mins at each site for two nights (i.e. Sites 1 to 54 and T1, T2, T3, T5, T9, T10, T11, T12, T13, T14, T15, T17, T18, T35, T36.	46 hours
Elliott A traps	20 Elliott A traps at Sites 1 to 54 for a minimum of four nights. 25 Elliott A traps at Sites 51 to 54 for five nights.	4,820 trap nights
Elliott B traps	5 Elliott B traps at Sites 1 to 54 for a minimum of four nights.	1,180 trap nights
Arboreal Elliott traps	5 arboreal Elliott traps at Sites 1 to 54 for a minimum of four nights.	1,180 trap nights
Standard cage traps	5 traps at Sites 1 to 54 for a minimum of four nights. 10 traps at Sites T37 to T46 for seven nights.	1,880 trap nights
Platypus surveys	Up to 6 hours of observation at Sites 5, 6, 9, 20,T6, T14, T19, T28, T30.	Up to 54 hours
Opportunistic observations	*Ad lib* across the study area.	*Ad lib*
Tracks and traces	*Ad lib* or when engaged in other activities above.	*Ad lib*
Motion sensing cameras	Recording 24 hours per day for a period of 11 days at Sites 54 and T47 to T53.	88 days/nights

ATTACHMENT C

FAUNA SPECIES RECORDED DURING THE SURVEYS

Table C1
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Amphibians						
MYOBATRACHIDAE						
Common Eastern Froglet	*Crinia signifera*	-	-	1, 3, 5, 6, 9, 11, 14, 17, 20, 24, 25, 27, 28, 33, 34, 35, 36, 37, 38, 41, 43, 45, 47, 50, 51, 53, 54, T3, T5, T9, T13, T15, T16, T29, T30, T31, T33, T34, T35.	C	X,H
Giant Burrowing Frog	*Heleioporous australiacus*	V	V	T18	U	X
Eastern Banjo Frog	*Limnodynastes dumerilii*	-	-	54, T5, T16, T18	C	X
Brown-striped Frog	*Limnodynastes peronii*	-	-	24, 45, 51, 54, T9, T13, T16, T31, T32, T33	C	X,H
Spotted Grass Frog	*Limnodynastes tasmaniensis*	-	-	11, 17, 48, 49, T9, T13, T31, T33	C	X,H
Haswell's Frog	*Paracrinia haswelli*	-	-	54, T5, T16	C	X,H
Red-crowned Toadlet	*Pseudophryne australis*	V	-	11, 26, Opp (X 3)	C	X,H
Brown Toadlet	*Pseudophryne bibronii*	-	-	Opp	U	X,H
Smooth Toadlet	*Uperoleia laeviagata*	-	-	T5, T35	U	X,H
HYLIDAE						
Blue Mountains Tree Frog	*Litoria citropa*	-	-	5, 6, 11, 27, 30, 31	C	X,H
Bleating Tree Frog	*Litoria dentata*	-	-	1, 3, 9, 10, 11, 20, 24, 25, 28, 33, 34, 36, 38, 43, 45, 48, T13, T31	C	X,H
Eastern Dwarf Tree Frog	*Litoria fallax*	-	-	1, 3 ,6, 11, 24, 33, 45, 47, 50, 51, 54, T3, T5, T9, T15, T18, T20, T31, T33	C	X,H
Freycinet's Frog	*Litoria freycineti*	-	-	1, 3, T18, T36.	C	X,H
Broad-palmed Frog	*Litoria latopalmata*	-	-	42	U	X,H
Lesueurs Frog	*Litoria lesueuri*	-	-	5, 6, 11, 20, 25, 45, 47, 50, 53, T5, T11, T15, T28, T34	C	X,H
Littlejohn's Tree Frog	*Litoria littlejohni*	V	V	Opp	U	X,H
Leaf Green River Tree Frog	*Litoria nudidigita*	-	-	5, 6, 9, 11, 25, 50, T15	C	X,H
Peron's Tree Frog	*Litoria peronii*	-	-	5, 6, 9, 11, 17, 24, 27, 45,51, T9, T36.	C	X,H
Verreaux's Tree Frog	*Litoria verreauxii*	-	-	18, 24, 44, T3, T5, T9, T16, T30	C	X,H
Reptiles						
CHELIDAE						
Snake-necked Turtle	*Chelodina longicollis*	-	-	21, 43, 50, T18, T31, Opp	C	X
Macquarie Turtle	*Emydura macquarii*	-	-	T28, T30	U	X

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Reptiles (Continued)						
GEKKONIDAE						
Wood Gecko	*Diplodactylus vittatus*	-	-	42, Opp	U	X
Lesueur's Velvet Gecko	*Oedura lesueurii*	-	-	5, 20, 26, 29, 31, 36, 37, 40, 43, T6, T11	C	X
Broad-tailed Gecko	*Phyllurus platurus*	-	-	17, 27, 31, 36, 43, T24, T36	C	X
SCINCIDAE						
Red-throated Skink	*Acritoscincus platynota*	-	-	10, 17, 32, 35, 37, 39, 40, 43,53, T34, T36.	C	X
Cream-striped Shining-skink	*Cryptoblepharus virgatus*	-	-	28, 33, 38, 41, 44, 45, 48, 50, T1, T6, T33, T35	C	X
Copper-tailed Skink	*Ctenotus taeniolatus*	-	-	5, 16, 22, 23, 26, 27, 29, 31, 33, 34, 38, 40, 41, 43, 44, 48, 51, 52, T6, T24, T35, T36	C	X
Cunningham's Skink	*Egernia cunninghami*	-	-	37	U	X
White's Skink	*Egernia whitii*	-	-	36, 37, 40	C	X
Eastern Water-skink	*Eulamprus quoyii*	-	-	5, 6, 9, 11, 14, 16, 20, 24, 26, 27, 28, 33, 35, 38, 43, 45, 51, 54, T6, T11, T15, T30, T31, T33, T35	C	X
Barred-sided Skink	*Eulamprus tenuis*	-	-	6, 31, 43, 48	C	X
Dark-flecked Garden Sunskink	*Lampropholis delicata*	-	-	2, 3, 7, 8, 9, 10, 12, 14, 15, 16, 19, 20, 21, 23, 25, 28, 29, 30, 31, 32, 34, 35, 36, 37, 38, 39, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54,T1, T3, T33, T34, T36	C	X
Pale-flecked Garden Sunskink	*Lampropholis guichenoti*	-	-	3, 7, 14, 17, 19, 21, 23, 25, 27, 31, 32, 39, 42, 43, 46, 48, 50, T24, T33, T34, T35, T36	C	X
Three-toed Skink	*Saiphos equalis*	-	-	23, 28, 33	C	X
Eastern Blue-tongue	*Tiliqua scincoides*	-	-	48	U	X
AGAMIDAE						
Jacky Lizard	*Amphibolurus muricatus*	-	-	3, 10, 16, 27, 28, 31, 32, 35, 36, 40, 41, 44, 46, 48, 52	C	X
Water Dragon	*Physignathus lesueurii*	-	-	5, 27, 45, 47, 50, T11, T28	C	X
Bearded Dragon	*Pogona barbata*	-	-	49	U	X
Mountain Dragon	*Rankinia diemensis*	-	-	36, 37, 52, 52, T22	C	X

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Reptiles (Continued)						
VARANIDAE						
Heath Monitor	*Varanus rosenbergi*	V	-	23	I	X
Lace Monitor	*Varanus varius*	-	-	9, 29, 39, 46, 49, 54	C	X
BOIDAE						
Diamond Python	*Morelia spilota*	-	-	5	I	X
ELAPIDAE						
Golden-crowned Snake	*Cacophis squamulosus*	-	-	26, 53, T6	C	X
Yellow-faced Whipsnake	*Demansia psammophis*	-	-	5, 17, 28, 40	C	X
Black-bellied Swamp Snake	*Hemiaspis signata*	-	-	28, 54	C	X
Broad-headed Snake	*Hoplocephalus bungaroides*	E	V	T4, Opp	U	X, T
Red-bellied Black Snake	*Pseudechis porphyriacus*	-	-	28, 37, 45, 46, 47, 54 T31, T32	C	X
Eastern Brown Snake	*Pseudonaja textilis*	-	-	17^, 26, 29, 45	C	X
Eastern Small-eyed Snake	*Rhinoplocephalus nigrescens*	-	-	4, 28, 51, T36	C	X
Birds						
ANATIDAE						
Black Swan	*Cygnus atratus*	-	-	T16, T31, Opp	C	X
Australian Wood Duck	*Chenonetta jubata*	-	-	T5, T13, T16, T20, T26, T33	C	X
Pacific Black Duck	*Anas superciliosa*	-	-	45, T5, T16, T31, Opp	C	X
Grey Teal	*Anas gracilis*	-	-	T16, T20, Opp	C	X
Chestnut Teal	*Anas castanea*	-	-	43, T16	C	X
Hardhead	*Aythya australis*	-	-	T16, T31, Opp	C	X
PODICIPEDIDAE						
Australasian Grebe	*Tachybaptus novaehollandiae*	-	-	T16, T26, T31, Opp	C	X
THRESKIORNITHIDAE						
Australian White Ibis	*Threskiornis molucca*	-	-	T14, T33, Opp	C	X
Royal Spoonbill	*Platalea regia*	-	-	T16	U	X
Yellow-billed Spoonbill	*Platelea flavipes*	-	-	T16, Opp	C	X
ARDEIDAE						
Cattle Egret	*Bubulcus ibis*	-	-	47, 49, Opp	C	X
White-necked Heron	*Ardea pacifica*	-	-	Opp	C	X
Great Egret	*Ardea alba*	-	-	T16	U	X
White-faced Heron	*Egretta novaehollandiae*	-	-	T33, T36, Opp	C	X
PHALACROCORACIDAE						
Little Pied Cormorant	*Phalacrocorax melanoleucos*	-	-	T16	C	X
Little Black Cormorant	*Phalacrocorax sulcirostris*	-	-	49, T16, Opp	C	X
Pied Cormorant	*Phalacrocorax varius*	-	-	T16	C	X
Great Cormorant	*Phalacrocorax carbo*	-	-	T16	C	X

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Birds (Continued)						
ANHINGIDAE						
Darter	*Anhinga melanogaster*	-	-	45, T15	C	X
FALCONIDAE						
Australian Kestrel	*Falco cenchroides*	-	-	T16, Opp	C	X
Australian Hobby	*Falco longipennis*	-	-	Opp	U	X
Brown Falcon	*Falco berigora*	-	-	T15, Opp	C	X
Peregrine Falcon	*Falco peregrinus*	-	-	31, Opp	C	X
ACCIPITRIDAE						
Pacific Baza	*Aviceda subcristata*	-	-	Opp	U	X
Square-tailed Kite	*Lophoictinia isura*	V	-	Opp	U	X
Black-shouldered Kite	*Elanus axillaris*	-	-	Opp	C	X
Whistling Kite	*Haliastur sphenurus*	-	-	Opp	U	X
Brown Goshawk	*Accipiter fasciatus*	-	-	Opp	C	X
Collared Sparrowhawk	*Accipiter cirrhocephalus*	-	-	43, 47, Opp	C	X
Wedge-tailed Eagle	*Aquilia audax*	-	-	47, 50, Opp	C	X
Little Eagle	*Hieraaetus morphnoides*	-	-	48, Opp	C	X
RALLIDAE						
Purple Swamphen	*Porphyrio porphyrio*	-	-	45, T5, T16, T26	C	X
Dusky Moorhen	*Gallinula tenebrosa*	-	-	T16, T33,Opp	C	X
Eurasian Coot	*Fulcia atra*	-	-	T16	C	X
TURNICIDAE						
Painted Button-quail	*Turnix varius*	-	-	Opp	U	X
RECURVIROSTRIDAE						
Black-winged Stilt	*Himantopus himantopus*	-	-	T16, T31	C	X
CHARADRIIDAE						
Masked Lapwing	*Vanellus miles*	-	-	52, T15, T16, T33, T34	C	X
LARIDAE						
Silver Gull	*Larus novaehollandiae*	-	-	T12	C	X
COLUMBIDAE						
White-headed Pigeon	*Columba leucomela*	-	-	T14	U	X
Spotted Turtle-Dove*	*Streptopelia chinensis*	-	-	19, 21, T14	C	X
Crested Pigeon	*Ocyphaps lophotes*	-	-	12, 22, T1, T12, Opp	C	X
Wonga Pigeon	*Leucosarcia melanoleuca*	-	-	18, 45, 48, Opp	C	X,H
Peaceful Dove	*Geopelia placida*	-	-	46, 48	C	X
PSITTACIDAE						
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*	-	-	1, 4, 7, 8, 13, 15, 18, 19, 21, 23, 37, 39, 42, 52, T36, Opp	C	X,H
Gang-gang Cockatoo	*Callocephalon fimbriatum*	V	-	24, Opp	C	X
Galah	*Eolophus roseicapilla*	-	-	19, T26, T33, Opp	C	X
Long-billed Corella	*Cacatua tenuirostris*	-	-	19, T16	C	X

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Birds (Continued)						
Little Corella	*Cacatua sanguinea*	-	-	18, 19, 45, 48, T16, T20, T26, Opp	C	X
Sulphur-crested Cockatoo	*Cacatua galerita*	-	-	4, 11, 16, 18, 19, 21, 26, 39, 43, 45, 46, 47, T1, T20	C	X,H
Rainbow Lorikeet	*Trichyglossus haematodus*	-	-	2, 6, 10, 11, 12, 13, 17, 21, 23, 53, T2, T15, T18, T34, T36	C	X
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*	-	-	T15	U	X
Musk Lorikeet	*Glossopsitta concinna*	-	-	T26, Opp	C	X
Crimson Rosella	*Platycercus elegans*	-	-	5, 9, 11, 12, 22, 23, 26, 31, 32, 36, 37, 51, T1, T7, T11, T34	C	X
Eastern Rosella	*Platycercus eximius*	-	-	18, 19, 43, 44, 45, 46, 48, T12, T23, T26	C	X
Red-rumped Parrot	*Psephotus haematonotus*	-	-	T34, Opp	C	X
Eastern Ground Parrot	*Pezoporus wallicus*	V	-	33, T25	U	X,H
Australian King-Parrot	*Alisterus scapularis*	-	-	45, T15	C	X
CUCULIDAE						
Pallid Cuckoo	*Cuculus pallidus*	-	-	2, 9, 18, 43, 47, 48, 51	C	X
Fan-tailed Cuckoo	*Cuculus flabelliformis*	-	-	2, 7, 8, 11, 18, 28, 28, 32, 33, 37, 40, 49, 51, T3	C	X
Common Koel	*Eudynamys scolopacea*	-	-	18, 19, 52, T32, T33	C	X
Horsfield's Bronze-Cuckoo	*Chalcites basalis*	-	-	29, 31, 43, 47, T25	C	X
Shining Bronze-Cuckoo	*Chalcites lucidus*	-	-	19, 36, 38, 48	C	X
Channel-billed Cuckoo	*Scythrops novaehollandiae*	-	-	22, T12, Opp	C	X
STRIGIDAE						
Powerful Owl	*Ninox strenua*	V	-	18, 47	I	X,H
PODARGIDAE						
Tawny Frogmouth	*Podargus strigoides*	-	-	8, 16, 22, 52, T10, Opp.	C	X
APODIDAE						
White-throated Needletail	*Hirundapus caudacutus*	-	-	12	U	X
Fork-tailed Swift	*Apus pacificus*	-	-	12	U	X
CORACIIDAE						
Dollarbird	*Eurystomus orientalis*	-	-	18, 19, 45, 47, T11, T26	C	X
ALCEDINIDAE						
Laughing Kookaburra	*Dacelo novaeguineae*	-	-	2, 8, 9, 11, 12, 15, 17,18, 20, 23, 24, 30, 44, 45, 48, 51, T1, T10, T15, T16, T34	C	X,H

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Birds (Continued)						
Sacred Kingfisher	*Todiramphus sanctus*	-	-	18, 47, 48, T14	C	X
Azure Kingfisher	*Alcedo azurea*	-	-	T20, Opp	C	X
MENURIDAE						
Superb Lyrebird	*Menura novaehollandiae*	-	-	9, 19, 26, 34, 36, 53, T49	C	X,H
CLIMACTERIDAE						
White-throated Treecreeper	*Cormobates leucophaea*	-	-	2, 5, 11, 12, 13, 14, 16, 18, 19, 26, 29, 31, 34, 36, 38, 43, 51, 53, T15, T16, T21, T34	C	X
MALURIDAE						
Variegated Fairy-wren	*Malurus lamberti*	-	-	18, 27, 33, 34, 37, 39, 44, 46, 48, 49	C	X
Splendid Fairy-wren	*Malurus splendens*	-	-	18, 22, 33, 34, 44, 46, 48, 49, 52, 54,T3, T20, T35, Opp	C	X
Southern Emu-wren	*Stipiturus malachurus*	-	-	24, 27, 33	C	X
PARADALOTIDAE						
Spotted Pardalote	*Pardalotus punctatus*	-	-	1, 2, 6, 9, 11, 12, 13, 14, 16, 18, 19, 22, 23, 26, 27, 28, 29, 30, 31, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 52, T6, T15, T20, T21, Opp.	C	X,H
Striated Pardalote	*Pardalotus striatus*	-	-	21, 50	C	X
ACANTHIZIDAE						
Rockwarbler	*Origma solitaria*	-	-	19, 29, 34, 36, 47, 53, T11, T21, Opp	C	X
Chestnut-rumped Heathwren	*Calamathus pyrrhopygius*	-	-	18	U	X
White-browed Scrubwren	*Sericornis frontalis*	-	-	12, 14, 16, 18, 22, 23, 26, 31, 37, 39, 41, 43, 52, 54, T15, T18, T20	C	X
Weebill	*Smicrornis brevirostris*	-	-	46	U	X
Brown Gerygone	*Gerygone mouki*	-	-	T3, Opp	C	X
White-throated Gerygone	*Gerygone olivacea*	-	-	T26	C	X,H
Brown Thornbill	*Acanthizia pusilla*	-	-	2, 5, 6, 9, 18, 19, 24, 26, 27, 29, 30, 33, 36, 37, 39, 40, 43, 44, 50, 53, 54, T3, T15, T16, T29, T35	C	X
Buff-rumped Thornbill	*Acanthizia reguloides*	-	-	19, 46	C	X
Yellow-rumped Thornbill	*Acanthizia chrysorrhoa*	-	-	46, Opp	C	X
Yellow Thornbill	*Acanthizia nana*	-	-	16, 18, 21, 34, 49, 50, T15, T26	C	X
Striated Thornbill	*Acanthizia lineata*	-	-	27, 30, Opp	C	X

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Birds (Continued)						
MELIPHAGIDAE						
Yellow-faced Honeyeater	*Lichenostomus chrysops*	-	-	12, 13, 14, 18, 21, 23, 26, 28, 30, 31, 34, 35, 36, 37, 38, 39, 40, 43, 44, 45, T15, T20, T21, T34	C	X
White-eared Honeyeater	*Lichenostomus leucotis*	-	-	12, 13, 22, 28, 32, 33, 34, 36, 40	C	X
Yellow-tufted Honeyeater	*Lichenostomus melanops*	-	-	11, 44	C	X
White-plumed Honeyeater	*Lichenostomus penicillatus*	-	-	16, 21, Opp	C	X
Lewin's Honeyeater	*Meliphaga lewinii*	-	-	18, 45, 47, 48, T3, T29	C	X
Bell Miner	*Manorina melanophrys*	-	-	45, 46, 47, 48, T15	C	X,H
Noisy Minor	*Manorina melanocephala*	-	-	18, 21, 22, 23, 24, 44, 46, 48, 52, T1, T10	C	X
Black-chinned Honeyeater	*Melithreptus gularis*	V	-	43	U	X
Brown-headed Honeyeater	*Melithreptus brevirostris*	-	-	T16	U	X
White-naped Honeyeater	*Melithreptus lunatus*	-	-	T15	U	X
Noisy Friarbird	*Philemon corniculatus*	-	-	19, 22, 30, 34, T21, Opp	C	X,H
Little Wattlebird	*Anthochaera chrysoptera*	-	-	1, 3, 4, 8, 9, 13, 15, 16, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 32, 33, 34, 40, 42, 44,51, 52, 53, 54, T4, T7, T8, T18, T20, T21, T25, T29, Opp.	C	X,H
Red Wattlebird	*Anthochaera carunculata*	-	-	1, 4, 6, 7, 13, 17, 18, 21, 23, 24, 32, T4, T7, T8, T11, T34, T35.	C	X,H
New Holland Honeyeater	*Phylidonyris novaehollandiae*	-	-	1, 3, 5, 6, 8, 9, 11, 18, 19, 20, 21, 22, 23, 27, 29, 31, 37, 41, 42, 51, 52, 54, T6, T15, T18, T20, T25	C	X,H
White-cheeked Honeyeater	*Phylidonyris niger*	-	-	19, 44, 45, 51	C	X
Tawny-crowned Honeyeater	*Glyciphila melanops*	-	-	24, 27, T25	C	X
Eastern Spinebill	*Acanthorhynchus tenuirostris*	-	-	1, 5, 6, 7, 8, 10, 11, 13, 15, 19, 20, 21, 22, 23, 26, 27, 28, 29, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 49, 51, 52, 53, T5, T6, T20, T21	C	X
Scarlet Honeyeater	*Myzomela sanguinolenta*	-	-	37, 43, 44, 45, 47, 48, 49, T29	C	X

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Birds (Continued)						
PETROICIDAE						
Eastern Yellow Robin	*Eopsaltria australis*	-	-	2, 5, 9, 11, 13, 14, 15, 16, 18, 20, 21, 22, 34, 35, 44, 51, 52, 53, T15, T16, T18, T29, T36.	C	X
Jacky Winter	*Microeca fascinans*	-	-	T26	C	X
Rose Robin	*Petroica rosea*	-	-	9	U	X
Pacific Robin	*Petroica multicolor*	-	-	T15	U	X
EUPETIDAE						
Eastern Whipbird	*Psophodes olivaceus*	-	-	11, 12, 19, 20, 45, 48, T3, T20, T29	C	X,H
Spotted Quail-thrush	*Cinclosoma punctatum*	-	-	38, 39, Opp	C	X
NEOSITTIDAE						
Varied Sitella	*Daphoenositta chrysoptera*	-	-	21, 52	C	X
PACHYCEPHALIDAE						
Golden Whistler	*Pachycephala pectoralis*	-	-	9, 18, 29, 30, 34, 35, 43, 54, T20, Opp	C	X,H
Rufous Whistler	*Pachycephala rufiventris*	-	-	9, 11, 12, 16, 22, 30, 34, 35, 37, 39, 41, 43, 44, 45, 46, 48, 49, 53, T15, T21, T26, T36	C	X,H
Little Shrike-thrush	*Colluricincla megarhyncha*	-	-	5, 9, 11, 12, 18, 21, 22, 23, 26, 27, 29, 30, 34, 36, 37, 38, 39, 41, 54, T3, T12, T20, T25	C	X
Grey Shrike-thrush	*Colluricincla harmonica*	-	-	T39, T48	U	X
Crested Shrike-tit	*Falcunculus frontatus*	-	-	18, 44	C	X
DICRURIDAE						
Rufous Fantail	*Rhipidura rufifrons*	-	-	21, 47, 52, 54, Opp.	C	X
New Zealand Fantail	*Rhipidura fuliginosa*	-	-	5, 9, 12, 16, 18, 21, 24, 27, 29, 30, 31, 34, 35, 36, 38, 39, 40, 43, 44, 45, 48, 49, 50, 51, 54,T3, T16, T20, T26, T29, T35	C	X
Willie Wagtail	*Rhipidura leucophrys*	-	-	2, 4, 8, 9, 13, 16, 21, 23, 28, 45, 48, 50, T2, T8, T12, T14, T20, T34, Opp.	C	X,H
Magpie-lark	*Grallina cyanoleuca*	-	-	6, 10, 17, 18, 44, T1, T9, T12, T16, T26, T35.	C	X,H
Leaden Flycatcher	*Myiagra rubecula*	-	-	46	C	X
Restless Flycatcher	*Myiagra inquieta*	-	-	45	U	X

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Birds (Continued)						
ARTAMIDAE						
Grey Butcherbird	*Cracticus torquatus*	-	-	4, 9, 13, 18, 19, 21, 22, 23, 30, 44, 46, 50, T15, T34	C	X
Australian Magpie	*Gymnorhina tibicen*	-	-	9, 12, 18, 19, 22, 23, 46, 47, 48, 49, T1,T12	C	X,H
Pied Currawong	*Strepera graculina*	-	-	1, 2, 5, 8, 10, 13, 14, 17, 19, 20, 21, 24, 30, 38, 43, 51, T1, T5, T9, T10, T34	C	X,H
Grey Currawong	*Strepera versicolor*	-	-	T44	1	X
Dusky Woodswallow	*Artamus cyanopterus*	-	-	11, 24, T15, T26	C	X
CAMPEPHAGIDAE						
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	-	-	16, 18, 19, 20, 21, 23, 38, 39, 45, 46, 50, T34, T35, Opp	C	X,H
ORIOLIDAE						
Olive-backed Oriole	*Oriolus sagittatus*	-	-	18, 48, T26	C	X
CORVIDAE						
Australian Raven	*Corvus coronoides*	-	-	10, 16, 18, 22, 26, 30, 32, 43, 44, 46, 47, 48, 49, T1, T9, T15, T16, T35, Opp.	C	X,H
CORCORACIDAE						
White-winged Chough	*Corcorax melanoramphos*	-	-	19, 21, 43, 44	C	X,H
PTILONORHYNCHIDAE						
Satin Bowerbird	*Ptilorhynchus violaceus*	-	-	47, T3, Opp	C	X,H
STURNIDAE						
Common Starling*	*Sturnus vulgaris*	-	-	18, 19, 24, 45, 47, T15, T26	C	X
Common Myna*	*Acridotheres tristis*	-	-	19, 24, 45, 50, Opp	C	X
HIRUNDINIDAE						
Welcome Swallow	*Hirundo neoxena*	-	-	1, 3, 11, 14, 17, 23, 25, 31, 45, 51, T5, T9, T11, T12, T13, T14, T15, T35, Opp	C	X
Fairy Martin	*Petrochelidon ariel*	-	-	18, T13	C	X
Tree Martin	*Petrochelidon nigricans*	-	-	51, T18, Opp	C	X
PYCNONOTIDAE						
Red-whiskered Bulbul*	*Pycnonotus jocusus*	-	-	18, 19, 23, 47, 49, T29	C	X
ZOSTEROPIDAE						
Silvereye	*Zosterops lateralis*	-	-	19, 24, 29, T29	C	X
SYLVIIDAE						
Clamorous Reed-Warbler	*Acrocephalus stentoreus*	-	-	T16, T20, Opp	C	X,H
Rufous Songlark	*Cincloramphus mathewsi*	-	-	49	U	X

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Birds (Continued)						
Golden-headed Cisticola	*Cisticola exilis*	-	-	T3, T31, Opp	C	X
DICAEIDAE						
Mistletoebird	*Dicaeum hirundinaceum*	-	-	49, T15, T26	C	X
PASSERIDAE						
House Sparrow*	*Passer domesticus*	-	-	T3, T15, Opp	C	X
Eurasian Tree Sparrow*	*Passer montanus*	-	-	12, 18, 20, 22, 24, T1,T13	C	X
MOTACILLIDAE						
Australian Pipit	*Anthus australis*	-	-	18, 19, T13, T31, Opp	C	X
ESTRILDIDAE						
Red-browed Finch	*Neochmia temporalis*	-	-	11,12,18, 22, 44, 45, 49, T15	C	X
Double-barred Finch	*Taeniopygia bichenovii*	-	-	T3, Opp	C	X
Mammals						
ORNITHORHYNCHIDAE						
Platypus	*Ornithorhyncus anatinus*	-	-	20	1	X
TACHYGLOSSIADE						
Short-beaked Echidna	*Tachyglossus aculeatus*	-	-	10, 20, 30, 46, 48, 50, 53	C	X
DASYURIDAE						
Spotted-tailed Quoll	*Dasyurus maculatus*	V	E	Opp	1	X
Yellow-footed Antechinus	*Antechinus flavipes*	-	-	17, 31	C	X
Brown Antechinus	*Antechinus stuartii*	-	-	3, 5, 9, 10, 11, 14, 15, 20, 25, 26, 27, 29, 30, 31, 36, 37, 38, 39, 43, 51, 52, 53, 54	C	X
Common Dunnart	*Sminthopsis murina*	-	-	2	1	X
PERAMELIDAE						
Southern Brown Bandicoot (eastern)	*Isoodon obesulus obesulus*	E	E	37, T39, T42, T45, T47, T53	U	X, T
Long-nosed bandicoot	*Perameles nasuta*	-	-	22, 28, 33, 37, 38, 43, 51, 54	C	X
PHASCOLARCTIDAE						
Koala	*Phascolarctos cinereus*	V	-	20, T9, T20, T50	U	T
VOMBATIDAE						
Common Wombat	*Vombatus ursinus*	-	-	9, 25, 30, 31, 34, 36, 37, 38, 40, 43, 45, 47, 50, 51, 53, 54, T45	C	X
BURRAMYIDAE						
Eastern Pygmy-possum	*Cercartetus nanus*	V	-	5, 28, 32, 33, 39, 40, 54	C	X
PETAURIDAE						
Sugar Glider	*Petaurus breviceps*	-	-	2, 13, 18, 26, 28, 29, 31, 32, 33, 36, 37, 39, T23	C	X

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Mammals (Continued)						
PSEUDOCHEIRIDAE						
Greater Glider	*Petauroides volans*	-	-	11	1	X
Common Ringtail Possum	*Pseudecheirus peregrinus*	-	-	26, 29, 30, 31, 36, 37, 38, 41, 52, 53, T15	C	X
PHALANGERIDAE						
Common Brushtail Possum	*Trichosurus vulpecula*	-	-	10, 17, 20, 32, 35, 38, 44, 45, 46, 48, 52, T11, T15	C	X
MACROPODIDAE						
Eastern Grey Kangaroo	*Macropus giganteus*	-	-	9, 29, 32, 33, 42, 45, 49, 50, 52, Opp	C	X
Euro	*Macropus robustus robustus*	-	-	18, 19, 43, 44, 47, 50, T31, T32, T34	C	X
Swamp Wallaby	*Wallabia bicolor*	-	-	5, 13, 17, 18, 19, 20, 21, 27, 28, 29, 30, 33, 36, 37, 38, 40, 43, 44, 47, 48, 51, 52, 53, 54, T23, T40, T41, T47, T49, T50, T52	C	X
PTEROPODIDAE						
Grey-headed Flying-fox	*Pteropus poliocephalus*	V	V	3, 7, 8, 20, 25, 33, 38, 43, 45, 49, 52, 53	C	X
RHINOLOPHIDAE						
Eastern Horseshoe Bat	*Rhinocephalus megaphyllus*	-	-	52	U	H
VESPERTILIONIDAE						
Eastern Bentwing-bat	*Minopterus schreiberseii*	V	-	9	U	H
Gould's Wattled Bat	*Chalinolobus gouldii*	-	-	4, 7, 8, 13, 20, 27, 31, 43, 45, 54.	C	H
Chocolate Wattled Bat	*Chalinolobus morio*	-	-	2, 4, 7, 9, 18, 23, 25, 26, 28, 29, 30, 34, 36, 37, 39, 43, 44, 45, 52, 53, T11	C	H
Large-footed Myotis	*Myotis macropus*	V	-	T28, T30	U	H
Little Forest Bat	*Vespedelus vulturnus*	-	-	8, 10, 18, 22, 26, 29, 30, 33, 35, 36, 38, 39, 41, 43, 51, 52, T11, T15, T23	C	H
MURIDAE						
New Holland Mouse	*Pseudomys novaehollandiae*	-	-	18, 19	U	X
House Mouse*	*Mus musculus*	-	-	3, 5, 8, 9, 10, 12, 14, 15, 16, 18, 19, 20, 21, 23, 24, 29, 31, 32, 33, 35, 44, 45, 46, 52, T3	C	X

Table C1 (Continued)
Fauna Species Recorded During the Surveys

Common Name	Scientific Name	Conservation Status		Survey Sites[3]	Relative Abundance[4]	Method of Detection[5]
		TSC Act[1]	EPBC Act[2]			
Mammals (Continued)						
Eastern Bush Rat	*Rattus fuscipes*	-	-	2, 3, 10, 11, 20, 25, 26, 27, 29, 30, 31, 33, 34, 36, 37, 38, 39, 40, 41, 42, 43, 48, 51, 52, 53, 54,. T38, T39, T40, T42, T43, T44, T46	C	X
Swamp Rat	*Rattus lutreolus*	-	-	3, 28, 51, 54	U	X
Black Rat*	*Rattus rattus*	-	-	3, 16, 45, 47	C	X
CANIDAE						
Domestic Dog*	*Canis lupus familiaris*	-	-	30, 35, 38, 43, 46	C	X
Red Fox*	*Vulpes vulpes*	-	-	29, 32, 34, 35, 47, T3, T31, T39, Opp	C	X
FELIDAE						
Cat*	*Felis catus*	-	-	29, 32, 35, 39, T34, T42	C	X
LEPORIDAE						
Brown Hare*	*Lepus capensis*	-	-	34, 37, 44	C	X
Rabbit*	*Oryctolagus cuniculus*	-	-	35, 37, 39, 44, 45, 46, 47, 48, 49, 50	C	X
BOVIDAE						
Goat*	*Capra hircus*	-	-	47	U	X

1 Threatened species status under the NSW *Threatened Species Conservatoin Act, 1995* (current as at 11 May 2009).
E – Endangered V – Vulnerable

2 Threatened species status under the Commonwealth *Environment Protection and Biodivesity Conservation Act, 1999* (current as at 11 May 2009).
E – Endangered V – Vulnerable

3 A prefix of 'T' denotes a targeted survey site without trapping. 'Opp' denotes an opportunistic sighting.

4 I One sighting of the species, or at least one trace found.
U Uncommon, 2-5 observations of the species, as well as an assessment of how widespread and persistent the species was.
C Common, 6-30 observations of the species, as well as an assessment of how widespread and persistent the species was.

5 X Visual Id
H Heard, identified by call
T Trace, identified by tracks, droppings, diggings etc.

* Introduced species.

^ Species recording obtained via identification of snake skin only.