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Dendrobium Area 3
Species Impact Statement

October 2007

Biosis Research

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Report for BHP Billiton Illawarra Coal

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DECCLARATION

I, Gary Brassington, of BHP Billiton Illawarra Coal, PO Box 514, Unanderra NSW 2526, being the applicant for the development consent (DA 60-03-2001, Dendrobium Coal Mine, Area 3, Staged Development Area C, Cordeaux and Avon Metropolitan Catchment Special Areas, Wollongong Shire) have read and understood this Species Impact Statement. I understand the implications of the recommendations made in the statement and accept that they may be placed as conditions of consent or concurrence for the Proposal.

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Manager Environment, BHP Billiton Illawarra Coal

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Mathew Richardson, Manager – Wollongong Resource Group, Biosis Research

ACKNOWLEDGEMENTS

Biosis Research acknowledges the contribution of the following people in preparing this report:

- Garry Brassington (BHP Billiton Illawarra Coal)
- Bruce Blunden (BHP Billiton Illawarra Coal)
- Kirk Newport (Sydney Catchment Aurthority)
- Chris McEvoy (Cardno Forbes Rigby)
- James Bartbarto (mine Subsidence Engineering Consultants)
- Darryl Kay (Mine Subsidence Engineering Consultants)
- Dr Steve Short (Ecoengineers)
- Rob Suansri (Biosis Research)
- Theresa Pizzuto (Biosis Research)
- Melissa Starling (Biosis Research)
- Anne Rutlidge (Biosis Research)
- Ian Baird BLandMgt, MAppSc (Giant Dragonfly expert/PhD candidate University of Western Sydney)

ABBREVIATIONS

BHPBIC	BHP Billiton Illawarra Coal
CAMBA	China-Australia Migratory Bird Agreement
CAVS	Census of Australian Vertebrates
DEC	Department of Environment and Conservation (now DECC)
DECC	Department of Environment and Climate Change (formerly DEC)
DEH	Department of the Environment and Heritage (now DEW)
DEW	Department of Environment and Water Resources (formerly DEH)
DGR	Director-General’s Requirements
DIPNR	Department of Infrastructure Planning and Natural Resources
DNR	Department of Natural Resources (formerly part of DIPNR)
DoP	Department of Planning (formerly part of DIPNR)
DPI	Department of Primary Industries
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act* 1979
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
FM Act	*Fisheries Management Act* 1994
GIS	Geographic Information System
GL	Gigalitre (one billion litres)
GPS	Global Positioning System
IUCN	International Union for the Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
LGA	Local Government Authority
MNES	Matters of National Environmental Significance
NPWS	National Parks and Wildlife Service (now DECC)
PER	Public Environment Report
RFI Act	*Rivers and Foreshores Improvement Act* 1948
ROTAP	Rare or Threatened Australian Plant
SCA	Sydney Catchment Authority
SIS	Species Impact Statement
sp.	Species (singular)
spp.	Species (plural)
subsp.	subspecies
TSC Act	*Threatened Species Conservation Act* 1995
var.	variety
WM Act	*Water Management Act* 2000

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SUMMARY

Biosis Research was commissioned by BHP Billiton Illawarra Coal (BHPBIC) to prepare a Species Impact Statement (SIS) to support an application to modify the Dendrobium Mine Consent (DA- 60-03-2001) to incorporate a revised Area 3 footprint and longwall layout pursuant to section 75W of the *Environmental Planning and Assessment Act* 1979 (EP&A Act).

This SIS has been prepared in accordance with condition 1.1 (b) (iii) of the existing development consent for Dendrobium Colliery.

The SIS examines the impacts of the Proposal on threatened flora and fauna as listed in the Director-General's Requirements (dated 17 April 2007) and in accordance with the requirements of the *Conditions of Consent for the Dendrobium Underground Coal Mine*, DA60-03-2001 (Minister for Urban Affairs and Planning 2001).

Assessment Methodology

Background information was collated and analysed from a variety of sources including previous relevant studies conducted by Biosis Research, scientific literature, species databases, aerial photography, maps and plans. Advice was sought from experts where necessary.

Field surveys for the current study were carried out in autumn and winter 2007. Previous survey effort has been applied to portions of the Study Area during all seasons over the last 5 years. Survey design and effort followed the *Threatened Species Assessment Guidelines* (DEC 2005) and the Director-General's Requirements.

Plants were surveyed using vegetation condition assessments, plot-based surveys, random meander transects and abundance counts. Animals were surveyed using a variety of trapping techniques, bird surveys, frog and reptile surveys, spotlighting, call-playback, koala transects, echolocation for bats, habitat assessment and incidental observations.

Threatened Plants

The Director General's requirements listed nine threatened plant species to be considered in this SIS. An additional 14 threatened plant species listed on the *Threatened Species Conservation Act* 1995 (TSC Act) and/or *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) that have been recorded or have potential habitat within 10 km of the Study Area were also considered. Of these, two threatened plant species, *Acacia bynoeana* and *Pultenaea aristata*, were recorded within the Study Area. Potential habitat for a

further nine threatened species occurs within the Study Area:

- *Acacia baueri* ssp. *aspera,*
- *Cryptostylis hunteriana,*
- *Epacris purpurascens* var. *purpurascens,*
- *Grevillea parviflora* ssp. *parviflora,*
- *Leucopogon exolasius,*
- *Melaleuca deanei,*
- *Persoonia acerosa,*
- *Persoonia hirsuta* and
- *Persoonia bargoensis.*

Seven Part Tests concluded that the Proposal was unlikely to have a significant impact on any threatened flora with known or potential habitat in the Study Area.

Threatened Animals

The Director General's requirements lists 16 threatened animal species to be considered in this SIS. A further 47 threatened animal species listed on the TSC Act and/or EPBC Act that have been recorded or have potential habitat within 10 km of the Study Area were also considered. Of these, 55 animal species were determined to have potential habitat within the Study Area. Sixteen threatened animal species were recorded in the Study Area, either during this study or during previous studies conducted by Biosis Research:

- Littlejohn's Tree Frog,
- Giant Burrowing Frog,
- Red-crowned Toadlet,
- Gang-gang Cockatoo,
- Glossy Black Cockatoo,
- Olive Whistler,
- Barking Owl,
- Powerful Owl,
- Eastern Pygmy-possum,
- Eastern Freetail Bat,
- Koala,
- Grey-headed Flying-fox,
- Eastern Bentwing-bat,
- Large-eared Pied Bat,
- Southern Myotis and
- Rosenberg's Goanna.

Biosis Research has also recorded the following threatened microbats within the Study Area with 'probable' certainty: Little Bentwing-bat, Eastern False Pipistrelle, Yellow-bellied Sheathtail Bat and Greater Broad-nosed Bat;

and ‘possible’ certainty: Golden-tipped Bat and Eastern Cave Bat. One other threatened species previously recorded within the Study Area is the Southern Brown Bandicoot (DEC Atlas of NSW Wildlife).

Seven Part Tests concluded that the Proposal was likely to have a significant impact on local populations of Littlejohn’s Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Stuttering Frog and the Giant Dragonfly. The possible mechanisms of subsidence and physical effects of subsidence may have a direct impact on known and potential habitat for threatened animal species, such as waterways, Upland Swamps, riparian vegetation, ridge lines and rock overhangs and crevices. However, it is unlikely that impacts from subsidence would impact on other habitats or habitat components outside waterways, swamps, ridge lines and rocky outcrops/cliffs. For example, subsidence is unlikely to impact on woodland and forest habitats outside swamps or riparian vegetation or on specific habitat components such as tree hollows. Therefore, impacts from the Proposal are restricted to animal species that are reliant on habitat provided in waterways, Upland Swamps, ridge lines or rocky outcrops/cliffs.

The proposed longwall layout and set backs around two major creek lines,Wongawilli and Sandy Creek, means that impacts will be reduced in these areas. However other creeks and tributaries of Wongawilli and Sandy Creeks, ridgelines and Upland Swamps may be directly mined beneath and subjected to the full range of predicted subsidence-related movements.

Endangered Populations and Endangered Ecological Communities

No Endangered Populations as listed under the TSC Act occur within the Study Area.

One Endangered Ecological Community (EEC), Shale Sandstone Transition Forest (mapped as Transitional Shale Stringybark Forest), as listed on both the TSC and EPBC Acts, was recorded within the Study Area during the field surveys. Drainage lines and other areas which may be subject to potential subsidence impacts are not significant landscape features within this occurrence of Shale Sandstone Transition Forest. On this basis, this community is considered unlikely to be significantly impacted by the Proposal.

Comparison of Impact Assessment with Previous Studies

The project has been previously assessed in the *Dendrobium Coal Project Likely Impacts of Subsidence on Terrestrial Ecology* (Biosis Research 2001a). This previous assessment addressed the likely impact of subsidence on ecological features (with the exception of fish and fish habitat) above Areas 1, 2 and 3 of the proposed Dendrobium Coal mine. The current study assesses potential impacts of the proposed Dendrobium Area 3 longwall mining area only.

Changes in the assessment methodology since the 2001 report have resulted in a shift in focus from a regional and species-wide level of assessment (Eight Part Test), to the current Seven Part Test, where the focus is on the impact to a local population. Table 1 below illustrates the implications of these changes with respect to the current study.

The Stuttering Frog and Red-crowned Toadlet have been assessed in the current SIS as *significantly impacted*, where, previously they were not. However, a reduction in a *local* population of the Red-crowned Toadlet was predicted in 2001. Furthermore, the Giant Dragonfly has been assessed in the current SIS as *significantly impacted*, where, previously it was not assessed.

Table 1: Comparison of significance assessment from Biosis Research (2001a) and this study

Fauna species assessed to be impacted significantly by the Proposal		
Species	**2001 Impact Assessment Outcome**	**2007 Impact Assessment Outcome**
Giant Burrowing Frog	NOT DETECTED – Significant impact on species likely	DETECTED – Significant impact at local population level
Littlejohn's Tree Frog	NOT DETECTED – Significant impact on species likely	DETECTED – Significant impact at local population level
Stuttering Frog	NOT DETECTED – Significant impact on species unknown	NOT DETECTED – Significant impact at local population level
Red-crowned Toadlet	DETECTED – No significant impact on species (impact on a local population predicted)	DETECTED – Significant impact at local population level
Giant Dragonfly	This species was not assessed in 2001.	NOT DETECTED – Significant impact at local population level. Record for the species in the Locality recently confirmed.

Ameliorative measures

The following measures are recommended to minimise the impact of the Proposal on threatened species that occur within and adjacent to the Study Area:

- Where subsidence-related fracturing or dilation occurs, remediation works should be employed using various methods, including grouting. Grouting has been demonstrated to be an effective tool in redirecting sub-surface flows back to the surface following dilation of near surface stream bed rock resulting from subsidence. Where remediation works are to take place in or near waterways, appropriate measures must be taken to minimise the environmental impacts of the mitigation measures. This includes avoiding the infection or spread of Chytrid Fungus, following NPWS's guidelines (NPWS 2001b);

- Where surface water is lost due to subsidence induced fracturing these areas should be mitigated as soon as feasible following subsidence movements completing in order to minimise any impact on frog recruitment;

- Where surface cracks occur within general woodland and/or forest areas they should be mitigated as soon as feasible following subsidence movements completing in order to minimise impacts of fauna entrapment. Where significant cracking occurs across known preferred fauna corridors mitigation measures such as temporary fencing of cracks and/or placement of fauna egress points should be implemented where practical until remediation can take place. Fauna egress points (designed to provide fauna with a means of escape from a crack) would vary depending on the size, location and nature of the crack. Various implements could be used such as branches, piping or man-made ramps; and

- Prior to any remediation works, advice should be sought from an ecologist regarding the potential impacts of such remediation works on plant and animal populations within the area and further assessment should be conducted as required.

Compensatory strategies

Terrestrial flora and fauna compensatory measures for the mining areas are addressed in Sections 1.1 Adherence to terms of DA, EIS, etc., and 3.3.5 Subsidence impacts on threatened fish, aquatic habitat and terrestrial habitat of the Consent.

Ongoing monitoring

It is recommended that ongoing monitoring of impacts of the Proposal on plant and animal populations within the Study Area are undertaken as part of Subsidence Environmental Management Plans (SMPs) for Dendrobium Area 3. It is recommended that methodologies for ongoing monitoring are finalised as part of the development of SMPs for each of the mining areas. The monitoring program methodology is expected to be similar to the current monitoring program within Dendrobium Areas 1 and 2.

Targeted surveys and monitoring (as required) of known populations are recommended specifically for three animal species (Littlejohn's Tree Frog, Red-crowned Toadlet and Giant Dragonfly). Access restrictions to the Study Area during appropriate survey conditions limits the effectiveness of targeted surveys for the other two animal species (Giant Burrowing Frog and Stuttering Frog) which are considered likely to be significantly impacted at a local level by the Proposal. Should the SCA allow increased access to the Study Area during appropriate survey conditions, i.e. during and immediately following significant rainfall events, targeted surveys and monitoring would also be recommended for these two species.

1.0 COMPLIANCE WITH THE REQUIREMENTS OF THE DIRECTOR GENERAL OF THE DECC

1.1 Definitions

Definitions provided in the Director General's Requirement's are as follows:

- ***development*** has the same meaning as in the *Environmental Planning and Assessment Act* 1979.
- ***activity*** has the same meaning as in the EP&A Act.
- ***Proposal*** is the development, activity or action proposed.
- ***Subject Site*** means the area directly affected by the Proposal.
- ***Study Area*** is the Subject Site and any additional areas that are likely to be affected by the Proposal, either directly or indirectly.
- ***Locality*** is the area within a 5 km radius of the Subject Site.
- ***subject species*** means those threatened species that are known or considered likely to occur in the Study Area.

All other definitions are the same as those contained in the *Threatened Species Conservation Act* 1995 (TSC Act). The following definitions are also utilised in this SIS:

- ***abundance*** means a quantification of the population of the species or community.
- ***affected subject species*** means subject species likely to be affected by the Proposal.
- ***Director-General*** means the Director-General of the NSW Department of Environment and Climate Change.
- ***regional*** means the area defined with the applicable Bioregion, i.e. The Sydney Basin Bioregion.
- ***population*** (in reference to plants) means occurrences of plants are considered to be distinct populations if they are separated by discontinuities of at least 1 km (Keith 2000).
- ***local population*** is the population that occurs in the Study Area (DEC 2005).
- ***Trap night*** this refers to one trap being set for a period of one night. Thus ten traps set for one night would equal ten trap nights.

1.2 Matters which have been limited or modified

The following Section 110 matters do not need to be addressed by the SIS:

- Section 110(2) (e). This section is a replication of Section 110(2)(a);
- Section 110(2) (g) and 110(3) (d). The matters raised in these sections of the TSC Act have been clarified by the requirements below.

Section 110 matters in relation to any threat abatement plans or recovery plans need only be addressed where relevant. In relation to Key Threatening Processes, the following are relevant to this Proposal:

- Alteration of habitat following subsidence due to longwall mining;
- Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands; and,
- Human-caused Climate Change.

At the time of printing of the DGRs, the areas of declared critical habitat are not relevant to this Proposal.

Recovery plans may be approved, critical habitat may be declared and Key Threatening Processes may be listed between the issue of these requirements and the granting of consent. If this occurs, these additional matters will need to be addressed in the SIS and considered by the consent, determining or concurrence authority.

1.3 Matters to be addressed

The TSC Act provides that the SIS must meet all the matters specified in Sections 109 and 110 of the TSC Act with the exception of those matters limited above.

2.0 FORM OF THE SPECIES IMPACT STATEMENT

This Species Impact Statement (SIS) is in writing, in accordance with Section 109 (1) of the TSC Act and has been signed by the principle author and by the applicant (see "Declaration"), in accordance with Section 109 (2) of the TSC Act and as specified in the Requirements of the Director General of the Department of Environment and Climate Change (DECC).

Section 110 (1) of the TSC Act states that the applicant for development consent or the proponent of the activity must comply with the DGRs concerning the form and content of the SIS. Accordingly, the SIS is formatted to follow the sections and subsections provided in the DGRs.

3.0 CONTEXTUAL INFORMATION

3.1 Description of the Proposal, Subject Site and Study Area

3.1.1 Background

The Dendrobium Mine extracts coal from an area to the west of Wollongong and within the Metropolitan Special Areas Water Catchment (Figure 1).

BHP Billiton Illawarra Coal (BHPBIC) is currently mining Area 2 of the Dendrobium Colliery, one of three operating underground mines managed by BHPBIC south of Sydney. BHPBIC propose to continue its underground coal mining operations at Dendrobium, by extracting coal from the Wongawilli Seam in Area 3 using longwall mining techniques. The current mining schedule forecasts that longwall mining will commence in Dendrobium Area 3 in mid 2009. Dendrobium Areas 1 and 2 and the proposed Dendrobium Area 3 mining areas are shown in Figure 2. The description of the current Proposal is derived from the *Preliminary Environmental Assessment for Modification to Dendrobium Area 3* Cardno Forbes Rigby (2007c).

BHPBIC intends to apply to ***modify the Dendrobium Mine development consent (DA- 60-03-2001) to incorporate a revised*** Area 3 footprint and longwall layout pursuant to section 75W of the *Environmental Planning and Assessment Act* 1979 (EP&A Act).

The current SIS has been prepared in accordance with condition 1.1 (b) (iii) of the existing development consent (hereafter referred to as the Consent).

In February 2007 BHBPIC formerly requested that the Director General of the DECC provide requirements (DGR's) to undertake an SIS. The Director General issued the requirements for an SIS in April 2007. This document has been prepared based on the assessment of the Dendrobium Area 3 Study Area.

3.1.2 Description of the Proposal

BHPBIC seeks to modify the approved footprint for Dendrobium Area 3 in order to maximise potential coal extraction using longwall mining techniques. Figure 4 shows the Area 3 mining footprint approved in 2001 (18.9 sq. kilometres), and the proposed maximum footprint now being sought (33.5 sq. kilometres).

Although the proposed footprint indicates a mining area increase of 14.6 km^2, geological investigations indicate that in practice, much of the periphery of the footprint may be sterilised by geological constraints such as igneous intrusions and other geological features such as faults and dykes. The presence of Avon and Cordeaux Reservoirs and other sensitive surface features may also reduce the area of mining within the footprint.

Dendrobium Area 3 has been further divided into three mining units or groups of longwalls. These are defined in Figure 2 as Dendrobium Area 3A, 3B and 3C. These areas will be abbreviated as follows in the remainder of this report:

- Dendrobium Area 3A – DA3A
- Dendrobium Area 3B – DA3B
- Dendrobium Area 3C – DA3C

The proposed longwall layout for DA3A has been precisely defined and is subject to a detailed impact assessment by Mine Subsidence Engineering Consultants (MSEC 2007). The longwall layout for DA3A has been defined by applying criteria that are considered to be the thresholds for major impact to the major topographical features of the Study Area (e.g. Sandy and Wongawilli Creeks). These criteria have been defined as:

- A maximum predicted valley closure of 200 mm
- A maximum predicted tensile strain of 0.5 mm/m
- A maximum predicted systematic compressive strain of 2 mm/m

Section 1.2 of the MSEC report defines how these threshold criteria have been shown to minimise physical impacts to major creeks. That is, when mine geometry and similar geological conditions to those proposed and/or observed in DA3A have been observed in other mines, physical impacts on the important topographical features overlying the longwall area have incurred only minor impacts.

The layout of longwalls in DA3B and DA3C will be subject to further definition and additional consultation and investigations to identify a preferred layout which achieves an economically viable mine plan with acceptable subsidence impacts. BHPBIC will use the assessment process implemented for DA3A and as described above to deliver a mine plan for Areas DA3B and DA3C such that major impacts do not occur to Wongawilli Creek, Lake Cordeaux and Lake Avon. To that end, it is appropriate to extrapolate the impacts predicted for DA3A to the greater footprint of Dendrobium Area 3 excluding the setbacks applied to Wongawilli Creek. The specific maximum subsidence movement predictions of DA3A have been applied uniformly to DA3B and DA3C.

The intention of BHPBIC is to seek a number of approvals with respect to

Dendrobium Area 3. They are defined by Cardno Forbes Rigby (2007c) as:

- ***Modification to the Development Consent for Dendrobium Area 3*** pursuant to section 75W of the EP&A Act;

- ***Further approval*** pursuant to Condition **1.1 (b) (iii)** of the Dendrobium consent which required further assessment of a sub area (Area C[1]), of the originally approved Area 3;

- ***Subsidence Management Plan (SMP) approval for DA3A***. The specific requirements for SMPs are described in the *Guideline for Applications for Subsidence Management Approvals* (DPIM 2003).

  The current SIS supports all of these approvals and provides the basis against which SMP Development Applications for DA3B and DA3C should be assessed. The current SIS also provides the basis for developing ecological monitoring programs for Dendrobium Area 3 as required in accordance with Condition 3.3.5 (b).

3.1.3 Subsidence and Mining Geometry Terminology

Subsidence of the surface is an unavoidable consequence of coal extraction using longwall mining methods. As well as vertical subsidence, reduced subsidence or upsubsidence is likely to occur in the base of valleys (creek lines). This is due to valley bulging associated with subsidence movements. Upsidence as a result of fracturing or dilation in the beds of watercourses has the potential to result in redirection of water into the strata below and consequential draining of pools. Differential subsidence movements could result in additional pools being formed or existing pools being made deeper. Upsidence and subsidence impacts have been considered collectively as "subsidence impacts" throughout the remainder of this report.

Before it is possible to define the Subject Site and Study Area for this SIS (Section 3.1.4) it is important to define several important terms that are coincident with other expert reports associated with the current Proposal.

The Mine Subsidence Engineering Consultants report (MSEC 2007) uses the proposed layout within DA3A to assess subsidence impacts within Dendrobium Area 3. The report also specifically identifies the DA3A area known as the "SMP Area". The SMP or Subsidence Management Plan area discussed in the MSEC (2007) report is specific to Longwalls 6-10 in DA3A and it includes the following:

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[1] The Consent refers to Dendrobium Area 3 as defined in this SIS as "Area C". This report and reports associated with the further approvals currently being sought refer to Dendrobium Area 3 being divided into three sub-sections i.e. DA3A, DA3B and DA3C.

- The 35 degree angle of draw line: this is a defined line on the lands surface that is projected up from the goaf[2] at an angle of 35 degrees from vertical;

- The predicted limit of vertical subsidence: is taken as the 20 mm subsidence contour which is the point on the lands surface at which vertical subsidence movements up to 20 mm are predicted; and

- Features sensitive to far field movements: surface features, either natural (e.g. creek valleys) or man made (e.g. dams or other infrastructure) may be influenced by subsidence movements beyond either the 35 degree angle of draw or the 20 mm subsidence contour. In the current assessment MSEC have identified two features that may be sensitive to far field movements and which may provide habitat for threatened terrestrial biota. These include Lake Cordeaux and Upper Cordeaux No. 2 Dam. The MSEC report details that far field effects are unlikely to alter these features such that the availability or quality of potential habitats for threatened terrestrial biota would be reduced. To that end, far field movements have not been considered further in this SIS insofar as they may occur outside the identified Subject Site.

Taken together these three definitions have been considered and are included within the definition of the Subject Site below.

3.1.4 Description of Subject Site and Study Area

The **Subject Site** is the area associated with the Proposal that may be directly impacted by subsidence related to the extraction of coal from Area 3 (DA3A, DA3B and DA3C inclusive). Figure 2 shows this area, including the three sub-areas.

The Subject Site is located to the west of Lake Cordeaux and East of Lake Avon and falls within the southern portion of the Sydney Basin Bioregion as defined by Thackway and Cresswell (Thackway and Cresswell 1995). The Subject Site occupies 33.5 sq. kilometres and is approximately 5 km north to south and 6 km east to west. It includes the headwaters of Donald's Castle Creek, Wongawilli Creek and Sandy Creek, their tributaries and other unnamed creeks. The Subject Site also includes a section of the western foreshore of Lake Cordeaux (Figure 2). Topography is variable between 270 m and 420 m elevation, including undulating rises, ridgetops, steep sandstone cliffs and flat areas.

The surface overlying Dendrobium Area 3 is part of the Sydney Catchment Authority's Special Areas as defined in the *Sydney Water Catchment Management*

[2] The goaf is the area from which coal is extracted below the lands surface.

Act 1998. The surface is catchment for Cordeaux Dam and Avon Dam and consists largely of undisturbed native vegetation. With the exceptions of fire trails, a power line easement, the abandoned Maldon Dombarton Railway, seismic lines and boreholes, the Study Area is undeveloped.

In accordance with the DGR's, the Subject Site includes all areas that will be directly impacted by the Proposal. The **Study Area** includes the Subject Site and an area of indirect impacts. It has been assessed that these indirect impacts are limited to potential down stream water quality issues and these are discussed in Section 3.2.1. For the purpose of this report, indirect impacts downstream from the Subject Site have been considered for a distance of 900 m along the streams.

As the Proposal to mine Area 3 does not at this stage require the development of any further surface infrastructure there will be no vegetation clearing. To that end, classical edge effects which include changes to microclimatic or physical parameters such as air temperature, soil moisture, humidity, noise, vibration and the deposition of air borne sediments will not occur as a result of mining in Area 3.

Dendrobium Mine pit top is located approximately 10 kilometres west of Wollongong on the Illawarra escarpment near Mt Kembla Village. This site is not required to be included in either the Subject Site or the Study Area.

3.2 Predicted Impacts of Mine Subsidence

Terrestrial ecological values that may be affected by subsidence are those that are located within the limit of subsidence. The relationship of subsidence to these values is aligned with the expression of subsidence movements in landscape change or alteration that occurs with longwall mining, e.g. rock falls in a creek valley which may affect water quality and therefore ecological function.

Five longwalls have been proposed for DA3A, Longwalls 6-10. The width of the longwalls is 250 m, and they range in length from 2,375 m to 2,700 m. The longwalls have a depth of cover ranging from 255 m at the eastern end to a maximum depth of 400 m at the tailgate of Longwall 6.

This section of the report details how extraction of coal from Longwalls 6-10 has been predicted to affect the landscape features within the limit of subsidence in that area. The predicted effects, in the form of potential habitat change, will form the basis for the impact assessment of this SIS. The following information is based on impacts described by MSEC (2007) unless otherwise stated. Further information regarding the predicted impacts to natural features within DA3 is provided by Cardno Forbes Rigby (2007a).

The layout of the future longwalls in DA3B and DA3C will be developed as further resource assessments are undertaken following the completion of exploration activities. The layout could not be finalised at the time of this report. However, the future longwalls will be located within the maximum footprint areas to the north of DA3A. The preliminary predictions and impact assessments provided in the following sections are based on mining of longwalls in DA3B and DA3C with similar void widths, chain pillar widths and seam extraction height to Longwalls 6 to 10 in DA3A. Variations in mining geometry will affect the predicted subsidence parameters and, hence, the impact assessments will be refined during preparation of SMPs for these areas.

The assessment of impacts on threatened species has taken into account the proposed amelioration and rehabilitation measures identified in Section 3.4 and Section 8.0

The major natural features and items of surface infrastructure in DA3B and DA3C are shown in Drawings Nos. MSEC311-20 to MSEC311-22 (MSEC 2007). These figures have been reproduced in this report as Figure 4, Figure 5 and Figure 6. The following sections provide a brief description of each feature and the impact assessments based on the maximum predicted systematic subsidence parameters from DA3A. The impact assessments for each feature will be refined during the development of the SMP for these areas once the final layouts of the future longwalls in DA3B and DA3C are finalised.

The depths of cover contours across DA3B and DA3C average 360 and 350 m respectively. The minimum depths of cover in DA3B and DA3C of 225 m and 215 m, respectively, occur at the bases of Wongawilli Creek and Lake Cordeaux, respectively. The maximum depths of cover in DA3B and DA3C of 425 m occurs along a ridgeline west of Wongawilli Creek.

The depths of cover above Longwalls 6 to 10 in DA3A vary between 255 m and 400 m, with an average depth of cover of approximately 320 m.

3.2.1 Creeks and Watercourses

There are numerous watercourses within Dendrobium Area 3. These include Wongawilli Creek, Sandy Creek, Donalds Castle Creek, Cordeaux River, Lake Cordeaux and Lake Avon. General descriptions of rivers and creeks within Area 3 are provided by the Ecology Lab (2007). The MSEC (2007) report describes the following effects of subsidence on creeks within Area 3.

Wongawilli Creek and Sandy Creek are permanent streams within DA3A. Wongawilli Creek is the largest watercourse in DA3A and is located 110 m west of the proposed longwalls at its closest point. The creek generally flows in a northerly direction and drains into the Cordeaux River over 4 km to the north of the proposed longwalls.

It is proposed that the future longwalls within Areas DA3B or DA3C will be set back from Wongawilli Creek such that it is assessed that no major impacts on the creek would occur, which includes significant fracturing and surface water diversions. However it would still be possible that some minor fracturing could occur along the creek, since this has been previously observed outside extracted longwall goaf edges in the Southern Coalfields.

The future longwalls in DA3B or DA3C will be set back from Wongawilli Creek using the same methodology adopted for the proposed longwalls in DA3A, which was outlined in Section 3.2.1. Monitoring during the extraction of Longwalls 6 to 10 in DA3A would be used to further refine the methodology for determining suitable set backs from the creek.

It would be expected, therefore, that any impacts that occurred along Wongawilli Creek, resulting from the extraction of the future longwalls in DA3B or DA3C would be of a minor nature, similar to that described for Longwalls 6 to 10 in DA3A. The management strategies and methods of remediation would also be similar to that proposed for Longwalls 6 to 10 in DA3A.

Sandy Creek crosses the eastern part of the SMP Area in DA3A and is located 85 m from the edge of the longwalls at its closest point. The creek generally flows in a northerly direction and terminates at Lake Cordeaux, joining the impoundment at a waterfall that occurs approximately 250 m east of Longwall 7.

Donalds Castle Creek lies within the western section of DA3C and northern section of DA3B. Approximately 2.25 km of the upper reach of the Creek occurs within the proposed footprint. Although not as large as Wongawilli or Sandy Creeks, the main channel of Donalds Castle Creek is characterised series of permanent pools connected by semi permanent surface flows (The Ecology Lab 2007). It is expected that connectivity between pools would not persist through extended dry periods (The Ecology Lab 2007). Where Donalds Castle Creek is located directly above the future longwalls it is expected to be subject to the full range of subsidence movements as predicted by MSEC (2007). Several smaller permanent, semi-permanent and ephemeral creeks and tributaries of Wongawilli and Sandy Creeks occur within DA3A. Many of these smaller creeks originate from Upland Swamps in the headwaters of the valleys.

There are a number of smaller creeks and drainage lines which are located across the extents of Areas DA3B and DA3C. Where these features are located directly above the future longwalls it is expected that they will be subjected to the full range of predicted subsidence movements.

It is likely that where these movements oppose natural drainage gradients that this would result in increased levels of ponding and flooding within these streams. Where the subsidence movements in the drainage lines add additional gradient to the streams it is likely that there would be increased levels of scouring of the banks and alluvial beds. It is also likely that the predicted subsidence movements would result in cracking in alluvial beds and the fracturing and dilation of bedrock directly above, and immediately adjacent to the future longwalls.

The nature and extent of impacts on the drainage lines in DA3B and DA3C are predicted to be similar to that of the drainage lines within DA3A. It is likely that some remediation works would be required, after the extraction of the future longwalls, using similar methods to that recommended for the Longwalls 6 to 10 in DA3A.

Potential for Ponding, Flooding and Scouring

Wongawilli and Sandy Creeks

Section 5.2 of the MSEC Report (MSEC 2007) details the predicted likelihood for ponding, flooding and desiccation in Wongawilli and Sandy Creeks within DA3A. These predictions are summarised below.

Wongawilli and Sandy Creeks are permanent streams with small flows, except for increased flows for short periods of time during and following significant rain events. The larger pools in the streams are permanent and naturally develop at creek rockbars and where sediment and debris accumulations are present.

An increased level of ponding and some minor flooding of the adjacent riparian areas can occur in the locations where the maximum predicted tilts, due to the net vertical movements, oppose and are greater than the natural creek gradients that exist before mining. An increased likelihood of scouring of the creek banks can occur in the locations where the predicted tilts, due to net vertical movements, considerably increase the natural creek gradients that exist before mining.

The maximum predicted increasing tilts along the Wongawilli and Sandy Creeks, due to net vertical movements, are both 1 mm/m (i.e.: 0.1 %), or a change in grade of 1 in 1000. The maximum predicted decreasing tilts along Wongawilli and Sandy Creeks, due to net vertical movements, are 1.5 mm/m (i.e. 0.2 %) and 2.5 mm/m (i.e.: 0.3 %), respectively, or changes in grade of 1 in 665 and 1 in 400, respectively.

The natural gradient of Wongawilli Creek within the SMP Area varies between a minimum of less than 1 mm/m and a maximum of 25 mm/m, with an average natural gradient of approximately 4 mm/m. The natural gradient of Sandy Creek within the SMP Area, upstream of the waterfall, varies between a minimum of less than 1 mm/m and a maximum of 30 mm/m, with an average natural gradient of approximately 10 mm/m.

Although the creeks have relatively shallow natural gradients, it is unlikely that there would be any significant increases in the levels of ponding, flooding, or scouring of the creek banks, as the maximum predicted changes in grade along the creeks are very small, being less than or equal to 0.3 %, or 1 in 400. However, it is possible, that there could be some very localised increased level of ponding or flooding where the maximum predicted tilts coincide with existing pools, steps or cascades along the creeks.

Other Drainage Lines

Two larger drainage lines have been identified by MSEC (2007) as occurring within DA3A. These drainage lines are shown in Figure 7 and have been identified by MSEC as Drainage Line 1 (WC17) and Drainage Line 2 (Banksia Creek). Other drainage lines, including the semi permanant upper reaches of Donalds Castle Creek, have been investigated within DA3 by Biosis Research for the purposes of this SIS. The predicted impacts described below for the larger Drainage Lines 1 and 2 have been applied to all similar drainage lines in DA3.

The predicted systematic tilts along Drainage Line 1 (WC17) are small when compared to the existing natural grades and are unlikely, therefore, to result in a significant increase in the levels of ponding, flooding and/or scouring along the drainage line. The predicted systematic tilts along Drainage Line 2 (Banksia Creek) are of a similar order of magnitude to the existing natural grades and could, therefore, result in increased levels of ponding and flooding adjacent to the longwall tailgates, and increased levels of scouring adjacent to the longwall maingates.

Where the drainage lines have alluvial beds it is predicted that the controlling sediments of the pool water levels would erode during subsequent rain events, especially during high flow. It would be expected over time, after a sufficient volume of water has flowed, that the gradients along the drainage lines would approach those which existed before mining. In summary, the above specific predictions for Drainage Lines 1 and 2 within DA3A may result in minor increases in pond size (ponding/flooding) in some areas and increased scouring in other areas. In the event that these situations arise in DA3A, it is likely that any impacts will be short lived (see MSEC, 2007 Section 5.3.2).

Potential for Fracturing and Surface Flow Diversions in Creeks

Wongawilli and, Sandy Creeks

Section 5.2.3.2 of MSEC (2007) describes the potential for fracturing and surface flow diversion within the two major creeks of DA3A in the following manner.

Wongawilli and Sandy Creeks are not directly mined beneath by Longwalls 6 to 10 in DA3A and are located at minimum distances of 110 m and 85 m from the proposed longwalls respectively. As the maximum predicted total closure movements along these creeks are less than 200 mm, it has been assessed that it is unlikely that significant fracturing or surface water flow diversions would occur along these creeks as a result of the extraction of the proposed longwalls.

However, it is possible that there could be minor fracturing in the beds of Wongawilli and Sandy Creeks as a result of the extraction of the proposed longwalls. This assessment is based on previously observed fractures in the beds of rivers and creeks adjacent to longwall mining in the Southern Coalfields up to 400 m from longwall mining. Any fracturing that does occur in the beds of these creeks would be expected to be isolated and of a minor nature and not result in any significant surface water flow diversions.

Other Drainage Lines

Section 5.3.2 of MSEC (2007) describes the potential for fracturing and surface flow diversion within two drainage lines in DA3A (Drainage Line 1/WC17 and Drainage Line 2/Banksia Creek). This information is described below. Other drainage lines have been investigated within DA3 by Biosis Research for the purposes of this SIS. The predicted impacts described below for Drainage Lines 1 and 2 have been applied uniformly to all similar drainage lines in DA3A.

The maximum predicted systematic tensile and compressive strains along these drainage lines are 4.5 mm/m and 9.4 mm/m, respectively. The associated minimum radii of curvatures associated with the maximum predicted systematic tensile and compressive strains are 3.3 km and 1.6 km, respectively. The maximum predicted valley related upsidence and closure movements along the drainage lines are also likely to result in elevated compressive strains in the base of the drainage lines of greater than 10 mm/m.

Tensile strains greater than 0.5 mm/m may be of sufficient magnitude to result in cracking in the beds of the drainage lines. Compressive strains greater than 2 mm/m may be of sufficient magnitude to result in the underlying strata to buckle and fracture, which can induce surface cracking in the beds of the drainage lines.

Where the upper reaches of the drainage lines have alluvial beds any surface cracking is likely to be filled with alluvial material during subsequent flow events. Where the drainage lines have exposed bedrock along the lower reaches, there may be some diversion of surface water flows into the dilated strata beneath them and the draining of any pools which exist within those drainage lines. It is unlikely that there would be any net loss of water from the catchment as the depth of dilation in rivers and creeks has generally been observed to be less than 15 m in the past and, therefore, any diverted surface water is likely to re-emerge further downstream at the limit of the fracturing.

Many drainage lines within the Study Area are permanently flowing or have permanent pools (including Drainage Line 2/Banksia Creek). In times of heavy rainfall, the majority of the runoff would flow over the beds and would not be diverted into the dilated strata below. However, in times of low flow a larger proportion of the total water flow may be diverted into the dilated strata below the beds and this could affect the quality and quantity of the water flowing into the creeks.

Where Longwalls 1 to 10 at Elouera Colliery were mined beneath Wongawilli and Native Dog Creeks, buckling of the strata in the base of the valley resulted in upsidence and dilation of the strata and the creation of voids beneath the beds of the creeks. Fracturing of the surface rocks allowed surface water in the creeks to be redirected into the dilated strata during low flow events. Pools in some sections of these creeks were drained due to the occurrence of the surface fractures at these locations.

Where subsidence-related fracturing or dilation occurs, remediation works could be employed using various methods, including grouting. Grouting has been demonstrated to be an effective tool in redirecting sub-surface flows back to the surface following dilation of near surface stream bed rock resulting from subsidence.

In summary, fracturing of bedrock and therefore re-direction of surface flows is possible in the creeks that are directly mined beneath. This fracturing may lead to draining of some pools over the longwalls.

Catchment Area Change

The potential for mine subsidence to alter catchment boundaries (and therefore catchment areas) has been investigated by Cardno Forbes Rigby (2007a). Based on the report by Cardno Forbes Rigby (2007a) increases in catchment size may generate higher flows, which potentially may cause increased erosion when combined with other factors such as grade changes, poor vegetation cover or existing erosion or nick points. Decreases in catchment size may reduce flows and therefore the water available to swamp and creek ecosystems. Altering the hydrological balance may potentially lead to changes in species composition of swamp vegetation and fauna.

Assessment of the potential for altered catchment boundaries resulting from subsidence has previously been described by Palamara (2006) and relies on analysis of predicted subsidence profiles overlayed in GIS with catchment boundaries identified on a high resolution digital terrain model. Based on an assessment of potential catchment area changes in DA3A (Cardno Forbes Rigby 2007a), it has been assessed that it is unlikely the majority of swamps in DA3 will be impacted by mining induced catchment change. Further detailed catchment analyses will be conducted in DA3B & DA3C when mine layouts are confirmed (pending geological investigations) and submitted with the relevant subsidence management plan submissions (Cardno Forbes Rigby 2007a).

Potential Impacts to Water Quality and Groundwater

A water quality impact assessment for Dendrobium Area 3 has been undertaken by Ecoengineers (2006, 2007). They conclude that subsidence has the potential to impact water quality in three main ways, through erosion, physico chemical effects and from the induction of upland ferruginous springs. A brief discussion of each of these phenomena and their potential to impact on water quality is described below. Unless otherwise stated, the information described below has been derived from Ecoengineers (2006, 2007).

Erosion associated with rock falls or soil slumping

Mine subsidence may lead to erosion and loss of soil materials into gullies and other watercourses through rock falls or slumping arising from induced cliff instability. It is known that minor rock falls occurred as the result of mining in Area 1.

Within Dendrobium Area 3A, some steep slopes and cliff lines occur along the western edge on either side of the main channel of Wongawilli Creek and in several short un-named tributaries particularly that designated WC13 on the eastern side of Wongawilli Creek and those designated WC12 and WC15 on the western side of the Creek. These creeks are short, have high average gradients and the steep slopes in their small catchments are relatively close to the Creek. These catchments are founded on Hawkesbury Sandstone and soils are of the Warragamba type. Sediments comprised of coarse to fine sands and some kaolinite are predicted to be exported into the Creek, especially during and following intense storm events.

There are a small number of catchments with steep slopes draining the western side of Area 3B to the Native Dog Creek Arm of Lake Avon and the eastern side of Area 3C to Lake Cordeaux. These steep slopes are comprised of the extremely erodible Hawkesbury (COha), moderate to highly erodible Penrose (Erpea) and high to extremely erodible Gymea (ERgy) soil landscapes and it is expected that some minor erosion may occur due to mine subsidence-induced slope stability effects in these areas. This would be particularly so if bushfires had reduced vegetation cover in these areas of steep slope. It is predicted that such erosive events would be relatively isolated, would have only minor, localised impacts on lower sections of creeks or at the shorelines of lakes Avon and Cordeaux and would be generally indistinguishable from the suite of similar localise effects that occur following bushfires in any event.

Given that:

- Dendrobium Area 3 longwalls will not mine directly under the main channels of Sandy or Wongawilli Creeks; and
- the cliff lines and slopes of the general SMP Area are no more extreme than those extensively mined beneath further upstream by Elouera Longwalls 1 through 6 over an eight year period between February 1993 and September 2001 with those slopes also mantled by Hawkesbury soil landscapes,

Ecoengineers (2007) conclude that it is highly unlikely that the mining of Area 3 would lead to any deleterious effects on the aquatic ecology induced by cliff instabilities or erosion resulting from mine subsidence.

Physico-chemical effects

Subsidence beneath creeks and riverbeds can produce a complex suite of physico-chemical effects. Hydrological measurements, visual observations and water quality monitoring over recent years in the Southern Coalfield indicate these effects are:

1. Compressive and buckling failure of the Hawkesbury Sandstone bedrock leading to increased permeability and storage, reduced surface flows over the mined-under of the watercourse, especially at the low end of the flow rate regime and more rapid draining of defined pools in no and low flow situations.

2. Diversion of stream flows through the fractured bedrock leading to loss of surface flows and potential loss of catchment yield to deep aquifer storage.

3. Dispersion of small quantities of kaolinite from freshly fractured unweathered sandstone in the bedrock and its re-emergence from the bedrock immediately downstream of upsidence-affected areas. This effect has only been detected visually, occurs very early in the fracturing sequence, does not significantly affect downstream turbidities at anywhere near the levels that natural rainfall/runoff events cause and decays very rapidly.

4. Oxidative dissolution of accessory marcasite (a form of pyrite, FeS_2) within freshly cracked groundwater pathways, leading to release of sulfuric acid (H_2SO_4), dissolved iron (Fe), manganese (Mn), nickel (Ni) and zinc (Zn) and re-emergence of more acidic water of lower pH, lower redox potential (Eh) and dissolved oxygen (DO) concentrations and higher concentrations

of the above metals from the bedrock immediately downstream of upsidence affected areas.

5. Increased concentrations of dissolved aluminium (Al) in water emerging from the bedrock immediately downstream of fracturing affected areas due to the leaching of Al from kaolinite in the walls of flow paths conducting acidic water through the fractured sandstone bedrock.

It has been observed that withdrawing longwalls by some distance from direct mining beneath major watercourses significantly reduces the above-described ‘upsidence-related’ sub-bed flow diversions and their hydrologic and ecologic effects. Recent examples of this include Longwalls 301 and 302 of Appin Area 3 adjacent to Cataract River and West Cliff Area 5 Longwalls 31 to 33 adjacent to Georges River.

Dendrobium Area 3A longwalls 6 to 10 do not mine under Wongawilli Creek and stop short of the Creek by a distance in the range from 130 – 370 m. The rationale for this decision is described in detail in the companion report by Mine Subsidence Engineering Consultants (MSEC).

It is likely that minor fracturing will occur at rockbars, rock shelves and knick points along tributary creek beds for DA3A particularly in and around Main Gate 10 and Tailgate 9 on the Banksia Creek Tributary of Sandy Creek, in the longer more incised tributaries of Wongawilli Creek in DA3B e.g. creeks designated WC15 and 21 and in DA3C in the incised headwaters of Donalds Castle Creek and the tributaries designated lC6 and LC7 which drain into Lake Cordeaux.

<u>Ecoengineers (2007) therefore conclude that it is very unlikely that the mining of Area 3 will lead to significant creek bed fracturing and subsequent hydrologic and/or geochemical effects.</u>

Upland ferruginous springs

Ferruginous springs have been identified as a consequence of subsidence of upland areas over the last three years in the Southern Coalfield in subcatchments of the Nepean, Cataract and Georges River.

It is known that mining-related subsidence can have the effect of delaminating erosion surfaces and bedding planes within and between strata. These effects are predicted to occur preferentially along the interfaces between materials with different elastic properties. Where broad scale upland subsidence occurs as a consequence of longwall mining, delamination, dilation and hence interfacial permeability enhancement is likely along the sub-horizontal interface between a sub-cropping Hawkesbury Sandstone and an outcropping Wianamatta Shale sequence.

This in turn apparently facilitates increased detention and storage of infiltrating meteoric waters within the Shale and close to the Shale/Sandstone interface in effect creating a subsidence-induced perched aquifer. The water stored at the shale/sandstone interface subsequently drains downgradient in the direction of local topographical lows such as a creek or river. In some cases it may then travel down natural or valley closure-induced cracks and widened bedding planes in the Sandstone and subsequently appear as well-defined springs in valley walls.

The significance of this effect to Dendrobium Area 3 derives from the fact that a significant fraction of the uplands of Area 3B is mantled by Wianamatta Shale-based soils (Lucas Heights RElh soil landscape type) and that such soils occupy significant portions of several catchments at the 1 – 2 km^2 scale which drain via steep (10 – 20%) slopes with sandstone outcrops (Penrose Variant A ERpea soil landscape type) southwest to the Native Dog Creek Arm of Lake Avon. Drainage of the Wianamatta Shale-based soil uplands to the northwest to tributaries of Donald's Castle and Wongawilli Creeks occurs over longer distances of far gentler slopes.

It is therefore predicted that ferruginous springs may be induced in the slopes of the southwest-draining catchments over Area 3B.

It is predicted by Ecoengineers (2007) that such an effect, if it does occur is likely to be largely aesthetic rather than posing any significant impact on stream ecology due to the relatively short length and high gradients of the creeks potentially involved and the substantial dilution and dispersion that would occur at the Lake Avon shoreline.

Impacts on Stored Waters – Lake Avon and Lake Cordeaux

The MSEC (2007) report states that subsidence associated with extracting coal from Dendrobium Area 3 is not expected to impact the stored waters in either Lake Cordeaux or Lake Avon. Hence, no impacts are predicted for terrestrial flora and fauna which may utilise the habitats provided by Lake Cordeaux or Lake Avon.

Cliffs and Natural Rock Formations

MSEC (2007) identifies cliffs as continuous rock faces having a minimum height of 10 m and minimum slopes of 2 in 1. Within DA3A most of the identified cliffs occur within the Wongawilli Creek gorge, although a number of small cliffs have also been identified above Longwall 10 within the valley that contains Lake Cordeaux. A 25 m waterfall occurs at the termination of Sandy Creek at the point where it meets the Lake Cordeaux Impoundment. MSEC (2007) have identified 11 cliffs within DA3A, which are identified in Table 2 and Figure 6.

Table 2. Cliffs within DA3A.

Cliff ID	Overall Length (m)	Maximum Height (m)
DA3-CF2	15	15
DA3-CF3	20	15
DA3-CF6	85	25
DA3-CF7	25	15
DA3-CF8	25	10
DA3-CF13	100	10
DA3-CF14	300	15
DA3-CF15	100	15
DA3-C16	70	10
DA3-C17	280	10
DA3-CF18	180	15

MSEC (2007) state that within DA3A the maximum predicted systematic subsidence parameters at the cliffs occur at Cliffs DA3-CF7 and DA3-CF8, which are directly above Longwall 10. However, it is unlikely that the maximum predicted tilt in this case would be of sufficient magnitude to directly result in topping type failures along these cliffs.

It is possible that if the systematic strains were of sufficient magnitude, existing sections of rock could fracture along existing bedding planes or joints and become unstable, resulting in sliding or toppling type failures along the cliffs. Examples of previous sliding or toppling type failures along the cliffs is provided by Cardno Forbes Rigby (2007a).

Fracturing of sandstone has been observed in the Southern Coalfields where tensile strains have been greater than 0.5 mm/m and compressive strains have been greater than 2 mm/m. Therefore, it is possible that the maximum predicted systematic strains at Cliffs DA3-CF7 and DA3-CF8 (Figure 6) are of sufficient magnitude to result in the fracturing of sandstone and, hence, cause rock falls.

Monitoring of Dendrobium Longwalls 1 and 2 indicated that between 7 and 10% of the total plan length of a cliffline, where the longwalls mined directly beneath the cliffs, were subject to some level of failure or impact. The percentage of cliffline disturbed along Cliffs DA3-CF7 andDA3-CF8, resulting from the extraction of the proposed longwalls, is expected to be similar to that observed in Area 1. The remaining cliffs within the SMP Area are located outside of goaf areas of the proposed longwalls and are unlikely to be impacted.

The maximum predicted systematic tilt at the cliffs located outside the longwall goaf areas is 3.5 mm/m (ie: 0.4%), or a change in grade of 1 in 285, which occurs at Cliff DA3-CF17. As discussed previously, it is unlikely that a tilt of this magnitude would have a significant impact on the cliffs (e.g. cause rock falls).

In summary, there is predicted to be some impact to between 7 and 10% of those cliff lines that will be directly mined beneath by Longwalls 6-10. Cliff lines that will not be directly mined beneath are unlikely to exhibit any significant impacts.

The extent of disturbance at the rock outcrops is expected to be similar to that observed in Dendrobium Area 1, where Longwalls 1 and 2 mined directly beneath a ridgeline. Rock falls were observed in eight locations, all of which were located directly above Longwall 1 (MSEC 2007). The length of ridgeline disturbed as a result of the extraction of Dendrobium Area 1 Longwalls 1 and 2 was estimated to be between 7 and 10% of the total plan length of ridgeline directly above the longwalls.

Previous experience in the Southern Coalfields indicates that the percentage of rock outcrops that are likely to be impacted by mining is small. Rock falls are more likely to occur where rock outcrops are continuous, massive, overhanging and marginally stable. Therefore, it is expected that the extent of disturbance to the rock outcrops above DA3A Longwalls 6 to 10 would be less than that observed along the cliff line in Dendrobium Area 1.

There are cliffs within DA3B and DA3C that are located along the alignment of Wongawilli Creek. The cliffs are similar to those identified in DA3A, having heights varying between 10 m and 25 m and having overhangs up to 6 m. There are also numerous rock outcrops located across the extents of DA3B and DA3C that are discontinuous and typically less than 5 m in height.

As described previously, it is proposed that future longwalls in DA3B and DA3C will be offset from Wongawilli Creek such that no significant impacts would occur to the creek. Therefore, any cliffs located directly adjacent to Wongawilli Creek are unlikely to be mined under by future longwalls in DA3B and DA3C.

Any cliffs that were mined directly beneath by the future longwalls could experience instabilities, with the likelihood and extent of rock falls being similar to that observed in Dendrobium Area 1, and similar to that assessed for the cliffs located above Longwalls 6 to 10 in DA3A. Therefore it is expected that the percentage of cliff disturbance in DA3B and DA3C would be between 7 to 10% of the total length of cliff line mined directly beneath.

The rock outcrops in DA3B and DA3C are expected to experience the full range of predicted systematic subsidence movements resulting from the extraction of the future longwalls. The likelihood and extent of impacts on the rock outcrops is expected to be similar to that assessed for the rock outcrops in DA3A, being much less than 7 to 10 % of the total length of rock outcrops mined directly beneath, as the smaller rock outcrops are less susceptible to impact than the larger cliffs.

3.2.2 Steep Slopes

A number of steep slopes occur within DA3A. MSEC (2007) define steep slopes as areas in which existing ground slopes are marginally stable and have a natural gradient of between 1 in 3 and 2 in 1. Steep slopes in DA3A have been identified in the Wongawilli Creek gorge. The majority of the steep slopes are stabilised, to some extent, by natural vegetation. The steep slopes located directly above the proposed longwalls typically have natural grades of up to 1 in 2, or angles to the horizontal of up to 27 degrees.

Section 5.7.2 of the MSEC (2007) report identifies that the predicted maximum systematic tensile strain at the steep slopes is likely to be of sufficient magnitude to result in surface cracking. The predicted maximum compressive strain at the steep slopes is likely to be of sufficient magnitude to result in the buckling of underlying strata, which could in turn result in surface cracking, where the depths of the overlying soils are shallow. It is also likely that the predicted maximum systematic strains would result in the slippage of soils down the steep slopes, resulting in tension cracks at the tops of the slopes and compressive ridges at the bottoms of the slopes.

These movements are consistent with observations of upsidence and closure in creek valleys where compression is developed at the bottoms of the valleys and tension is developed at the tops of the valleys. The terrain in DA3A is generally flatter and the depth of cover is generally greater than in Areas 1 and 2 at the mine. It is likely, therefore, that the maximum size and extent of surface cracking at the steep slopes above Longwalls 6 to 10 will be less than that observed during the extraction of Longwalls 1 and 2 in Area 1 and during the extraction of Longwall 3 in Area 2 at the mine.

It is unlikely that mine subsidence would result in any large-scale slope failure, since such failures have not been observed as the result of longwall mining in the Southern Coalfields. This includes the extraction of Longwalls 1, 2 and 3 at the mine where the grades of the steep slopes are generally greater than those in DA3A.

It is recommended that any significant cracking that is likely to result in soil erosion channels should be remediated as soon as subsidence movements have ceased. With these mitigation measures in place, it is unlikely that there would be any significant impact on the environment.

There are steep slopes located across the extents of DA3B and DA3C having natural grades similar to the steep slopes in DA3A. The future longwalls are expected to result in cracking in the surface soils and possible downhill movements, similar to or less than that observed in Dendrobium Areas 1 and 2, and similar to that assessed for the Longwalls 6 to 10 in DA3A. The greatest surface cracking and downhill movements are expected to occur along the steep slopes which are directly mined beneath and are located adjacent to ridgelines. It is recommended that remediation measures be implemented in areas of potential erosion, at the completion of subsidence movements, using similar techniques to those adopted for Areas 1 and 2, and proposed for DA3A. With these mitigation measures in place, it is unlikely that there would be any significant impact on threatened biota resulting from surface cracking and rock falls on steep slopes.

3.2.3 Upland Swamps

Five Upland Swamps are present within DA3A and these are identified in Figure 8. Swamps 12 and 15b are located directly above Longwalls 7 and 8, and Swamp 15a is partially located above Longwalls 9 and 10. Swamp 10 is located south of the proposed longwalls and Swamp 16 is located to the north of the proposed longwalls.

Section 5.8.2 of MSEC (2007) states that Swamps 12, 15a, 15b and 16 are located within or partially within the valleys of drainage lines and could, therefore, be subjected to upsidence and closure movements as a result of the extraction of the proposed longwalls. Swamp 34 is located on the side of a valley and is unlikely, therefore, to be subjected to any significant upsidence or compressive strains due to closure movements.

The predicted differential total subsidence and total tilt within Swamps 12, 15a and 15b may result in increased water levels above the centrelines of the longwalls, and decreased water levels above the chain pillars and longwall goaf edges. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. Generally, however, the surfaces of the swamps are free draining, and it is not anticipated that significant changes in ponding would occur as a result of differential subsidence or tilt. Significant changes to vegetation within swamps are not likely as these impacts have not been observed within monitored swamps that have been mined beneath (Biosis Research 2007e, d, c). Although there are a small number of swamps that have been mined under that have displayed changes in vegetation it is not conclusive that these effects are a direct result of mining impacts. In addition, there are numerous swamps that have been mined under that have not displayed changes in vegetation.

There are a number of large Upland Swamps located within DA3B and DA3C. The swamps located directly above the future longwalls are expected to be subjected to the full range of predicted systematic subsidence and valley related movements.

It is possible that the extraction of the future longwalls could result in changes in the distribution of water (see Section 3.2.1) and, hence, the distribution of vegetation in these swamps. It is likely that the extraction of the future longwalls would also result in cracking in the swamp beds and potentially result in the fracturing and dilation of the underlying strata. Any surface or groundwater with a flow path gradient to this fracturing would flow into the fractures. However, the volume of water flowing into these fractures is likely to be relatively small as there is unlikely to be any connection through to the mine or other deep storage.

Scouring events have been identified in a small number of Upland Swamps that have been mined beneath. There is speculation that mining is a potential contributor to these impacts. With regards to this matter Ecoengineers (2007) provides the following assessment as to the potential for the current Proposal to result in any such impact. Unless otherwise stated the discussion below has been derived from Ecoengineers 2007.

MSEC (2007) predicts that subsidence induced strains across the swamps are not expected and hence it is considered unlikely that significant fracturing or draining via bedrock could occur. In addition, it is not expected that the swamps would be susceptible to scour under high rates of runoff unless significant prior fire damage had occurred (Earthtech 2003).

The factors described below have been found to be more generally relevant to assessment of the likelihood or otherwise of potential impact of mine subsidence on Upland Swamps.

There is substantial evidence that scour effects on swamps have been an integral part of their evolutionary cycle throughout their history. Active and stabilised scour pools have been identified within approximately one half of 35 swamps studied by Earthtech (2003). These features are present in swamps that have been mined beneath and have not been mined beneath. The most recent examples of swamp erosion has demonstrated the importance of bushfire in this process. More recently two swamps have been monitored as they were mined under by the Elouera Colliery. Adverse hydrologic effects such as discrete or broad zones of desiccation Upland Swamp have not been detected or verifiably demonstrated in these swamps despite the period 2001 – 2006 having been generally characterised by prolonged drought conditions.

Extensive water quality monitoring within swamps and immediately downstream of them in the region over almost 5 years of study has also failed to detect any geochemical effects from mining subsidence beneath swamps. The only chemical effects detected have been due to variable rates of evaporative concentration and dilution of trace salts between drought and high rainfall periods and variation in the rates of leaching of relatively strong low molecular weight organic acids (e.g. oxalic, acetic acids) relating to periods of dessication and increased fermentation (aerobic decomposition) following period of enhanced recharge. This process is part of the natural evaporative water loss and rainfall recharge events within upland swamp systems.

3.2.4 Surface Bedrock Fracturing and Soil Cracking

Surface bedrock and soil cracking may occur due to systematic subsidence movements where tensile strains are greater than 0.5mm/m. Cracking may occur where jointed bedrock is exposed at the surface and coincident with higher tensile strains. Surface cracking tends to increase as the depth of cover decreases and only minor fracturing would be expected where the depths of cover are greater than 300 m and the terrain is relatively flat. In the case of DA3A, MSEC (2007) predict that fractures at the surface due to systematic subsidence could be as wide as 50 mm in relatively flat areas. It is also likely that surface cracking will occur above the proposed longwalls as a result of downhill movements adjacent to the ridgelines and along the steep slopes, similar to that observed in Dendrobium Area 1 (up to 400mm wide). The terrain in DA3A is flatter than that in Area 1, however, and it is therefore expected that the maximum crack widths above the proposed longwalls would be less than that observed in Area 1 (MSEC 2007).

The impacts on these features in DA3B and DA3C are anticipated to be similar to that described for DA3A.

3.2.5 Likelihood of Gas Emissions at the Surface

Gas emissions may result from the liberation of gases that are trapped below the ground when fracturing or dilation of strata occurs due to subsidence. Gas emissions, in particular circumstances, may result in vegetation dieback. This phenomenon has previously been observed only once in the Southern Coalfields within the Cataract River where small patches of vegetation were impacted. Any such impacts are short lived and, in the case of the vegetation within the Cataract River, natural regeneration occurred rapidly.

Monitoring of riparian vegetation affected by gas emissions within Cataract River was undertaken by Suzanne Fyfe, between 1997 and 2000. Four small areas of riparian vegetation, ranging from 160 m^2 to 525 m^2 were initially affected by gas emissions. These emissions resulted in the loss of approximately 90 trees, most of which were saplings or young trees. An inspection of the area by Biosis Research (February 2006) showed that large, hollow bearing trees were unaffected by the emissions, although some small shrub and groundcover species were affected.

Regular monitoring of gas affected vegetation showed regeneration of shrubs, trees and grasses occurring almost immediately following the initial die back. Episodic gas emissions hindered regeneration on occasion after the initial event at one of the sites and tubestock planting was undertaken to improve regeneration at two of the sites.

At the cessation of monitoring in 2000, substantial regeneration of the riparian vegetation had occurred at all affected sites, although at one site not all the original vegetation layers had yet regenerated. The report (Fyfe 2000) concluded that longwall mining had resulted in only very minor impacts on vegetation of the Cataract and Nepean Rivers, with a total of 0.12 ha of riparian vegetation impacted. The report also concluded that the minor revegetation works and weed control undertaken at the sites assisted with regeneration of gas affected areas.

An inspection of previously affected areas within Cataract River in February 2006 showed that these areas have regenerated further since the last inspection in 2000, with a good covering of all vegetation layers in a condition at least equivalent to other sections of the Cataract River where dieback was not observed. Areas within the Nepean River and Elladale Creek, where gas emissions were recorded during extraction of coal from Tower Colliery Longwalls 14-20, were briefly inspected during the February 2006 site inspection. There were no identifiable impacts on riparian vegetation in these areas.

MSEC (2007) states that there has been no reported cases of significant gas emission from mining in the Wongawilli Seam that have resulted in the death of vegetation. Mining has been undertaken in the general vicinity of DA3A (Dendrobium Areas 1 and 2 and Elouera Colliery longwall workings) for many years with no impacts observed. The impacts from gas emissions in DA3B and DA3C are anticipated to be similar to that described for DA3A.

It is considered unlikely that there will be significant gas emissions or associated impacts for Dendrobium Area 3.

3.3 Approach to the Impact Assessment

This SIS has been prepared in support of the application to alter the Development Consent for Dendrobium Area 3 and the further approval to develop the area. It also supports the SMP application for DA3A. To assess the impacts of mining in Dendrobium Area 3 the predicted maximum subsidence parameters from DA3A have been extrapolated to the entire Dendrobium Area 3 footprint. This methodology is appropriate because:

- The physical, topographical and natural features of DA3A are fundamentally similar to DA3B and DA3C; and
- BHPBIC have committed to certain subsidence impact outcomes in the areas not supported by final mine plan layouts.

The extrapolation of these predicted maximum subsidence parameters forms the basis to prepare an SIS for the entire Area 3 Subject Site. Should future mine planning in DA3B and DA3C determine that the likely mine subsidence impacts are greater than that discussed in Section 3.2, the outcomes of this SIS will need to be revised.

It should be noted that in some cases habitat for a threatened species may have been recorded within the Study Area, but the nature of subsidence related impacts may be such that there is no known or reasonable mechanism for subsidence to impact that particular habitat feature (e.g. tree hollows). In the absence of direct or indirect impact mechanism for the habitat for a threatened species, formal seven part tests are not considered necessary.

3.4 Amelioration, Rehabilitation and Compensatory Measures

Mitigation, rehabilitation and monitoring proposed by BHPBIC are an integral part of the proposed mining activity, and are summarised below. All information in this Section is derived from Cardno Forbes Rigby, (2007b), *Dendrobium Colliery Area 3A - Longwalls 6 to 10, Part B - Subsidence Management Plan*.

Preventative Options

The mine layout for DA3 has been designed to be set back from Wongawilli Creek and Sandy Creek and the Lakes Avon and Cordeaux, which will reduce the subsidence impacts to these areas.

Rehabilitation

- Natural Remediation – while sealing of surface fractures will occur naturally in some instances and over time, it is recognised that this may not provide sufficient mitigation in some situations and that active sealing of the streams may be required in some locations.
- Grouting and Repair - Fracturing of creek beds and diversion of water flows in ephemeral water courses will be remediated through grouting and repair of

significant surface water controlling features such as significant rock bars. A number of methods may be used, including hand mortaring, injection grouting, pattern grouting, deep angled hole grouting, permeation grouting, impermeable blankets or linings and joint sealing.

- Surface treatment - where cracking to the lands surface develops in significant areas (apart from drainage lines) and natural sealing is not progressing, the cracks may require forking over and compacting to prevent subsequent erosion. Larger cracks may require more work to repair them, such as mulch or other protection, to prevent the development of erosion channels. Surface protection will remain in place until revegetation covers the disturbed area. In some cases, if the cracks are wider they may require gravel or sand filling up to surface level and revegetation using local native plants. Considerable care and relevant approvals will be obtained to ensure the protection of the environment as such works are implemented.

- Land stability - specific actions to address subsidence impacts on cliffs and steep slopes will be developed and implemented where adverse subsidence impacts occur. Remediation requirements for any mine related rock falls and slippage would be in accordance with DoP Guidelines and to the satisfaction of DoP and SCA. Measures may include:

  - Surface water management measures to minimise sediment mobilisation

  - Erosion and sedimentation control measures to minimise downstream effects

  - Revegetation of disturbed areas

  - Preventive measures such as removal or stabilisation of loose boulders and scaling of loose rocks from cliff faces

  - Filling and mulching over large cracks to prevent the development of erosion channels

- Gas Release - A typical driver of gas release at the surface is fracturing of the rock mass and associated release with groundwater flows to the surface. Grouting techniques discussed above typically reduce these associated gas flows. In all identified circumstances in the Southern Coalfields the gas releases have diminished over time. Typically this time is a number of months but it can be a number of years. Long running gas releases significantly reduce in quantity over time. Where vegetation is impacted by gas releases the areas affected will be revegetated once monitoring determines the gas releases have ceased or reduced to an extent that vegetation is no longer affected. It is considered unlikely that there will be significant gas emissions or associated impacts for Dendrobium Area 3.

Environmental compensation

Should impacts remain following rehabilitation, compensation to ecological value, rehabilitation of aquatic habitats or water flow and quality in nearby (or distant) streams will be implemented as compensation. These measures may include:

- Assisting DPI Fisheries to conduct surveys to determine the status of the various populations of Macquarie Perch in eastern drainages
- Assisting DPI Fisheries to conduct research to determine the genetic status and relationships of the various lake bound and riverine populations of Macquarie Perch
- Fair and reasonable contribution towards the funding of the construction of fishways to rehabilitate fish habitats and ameliorate impacts on Macquarie Perch populations
- Assisting SCA to maintain or improve values within the Special Areas relating to water quality and quantity

Contingency plan and emergency response

It may be impractical to carry out final remedial measures (if required) until all longwalls in an area have been mined. In such cases it may be necessary to temporarily support ecological systems until rehabilitation can be completed. To minimise the impacts associated with subsidence and rehabilitation works a number of measures can be implemented. These include:

- Relocation of fauna and fish.
- Rehabilitation of aquatic habitats and temporary maintenance of individual species such as watering aquatic plants (introduction of flows to a waterway).
- Provision of compensatory habitat.
- Timing of works.
- Staged work programs.
- Altering mining methods or modifying the mining area.

Contingency and emergency measures would be monitored to confirm maintenance of the ecological values of the area and to confirm that measures in place to manage secondary impacts are effective.

For further discussion on amelioration and rehabilitation refer to Section 8.0.

3.5 Provision of Relevant Maps and Plans

The location of the Study Area within a regional context is provided in Figure 1. An aerial photograph of the Locality, showing the boundary of the Study Area and Subject Site, is provided in Figure 2.

A topographic map of the Study Area (at a scale of 1:250,000) is provided in Figure 3, showing current land use (mining, agricultural and rural). Maps of the Locality showing zoning, land tenure, parks and reserves and townships, are provided in Figure 9.

A map of the plant communities within the Locality and Study Area is provided in Figure 10. Maps showing survey locations are provided in Figure 11 and Figure 12. Maps showing the location of database search results for threatened plant and animal species from the DECC Atlas of NSW Wildlife are provided in Figure 14 and Figure 15 respectively. Maps showing the location of threatened plant and animal species (including habitats) recorded by Biosis Research during surveys are provided in Figure 16 and Figure 17 respectively.

3.6 Land Tenure Information

The Study Area is located on the Woronora Plateau in the Wollongong Local Government Area (LGA) and the Sydney Basin Bioregion. The proposed mining operations are located to the west of Lake Cordeaux within the Sydney Metropolitan Catchment Area (Figure 3). The Study Area is zoned 7a Special Environmental Protection (Water Catchment).

Numerous Fire Roads occur throughout the Study Area, including sections of Fire Roads 6A, 6C and 6F. The disused Maldon - Dombarton Railway line also occurs in the west of the Study Area. Two high voltage power easements run approximately north – south in the east of the Study Area.

Exploration works, including seismic lines boreholes and associated tracks have been undertaken within the Study Area.

4.0 INITIAL ASSESSMENT AND IDENTIFICATION OF SUBJECT SPECIES

4.1 Assessment of Available Information

4.1.1 Previous Studies by Biosis Research

Extensive survey effort has previously been undertaken by Biosis Research in the Dendrobium Area 3 Study Area and surrounds. Long term monitoring (4 years) of vegetation (using quadrats and transects) and fauna (bird, frog and reptile surveys) has been undertaken as part of the Dendrobium Area 1 and 2 monitoring requirements. Other previous studies conducted by Biosis Research within the Locality have involved habitat assessments, incidental observations (birds, frogs, reptiles, mammals), Anabat recording and harp trapping (bats), call-playback (owls, frogs and arboreal mammals), spotlighting (owls, frogs and mammals), cage, Elliot and hairtube ground trapping (medium and small mammals) and pitfall trapping (invertebrates).

Previous studies undertaken by Biosis Research within the Study Area and Locality include:

Dendrobium Coal Project Species Impact Statement (Biosis Research 2001d);

Dendrobium Coal Project: Terrestrial and Aquatic Habitat Assessment (Biosis Research 2001e);

Dendrobium Coal Project Likely Impacts of Subsidence on Terrestrial Ecology (Biosis Research 2001b);

Habitat Assessment of Swamp 18 (Biosis Research 2001f);

Swamp 17 – Post Fire Flora and Fauna Habitat Assessment (Biosis Research 2003b);

Upland Swamp Ground Water Monitoring Bore - Terrestrial Flora and Fauna Habitat Assessment. (Biosis Research 2003c);

Elouera Colliery LW 9 and 10 Terrestrial Flora and Fauna Habitat Assessment (Biosis Research 2003a);

Elouera Colliery Longwall 14 Impacts of Subsidence on Terrestrial Flora and Fauna (Biosis Research 2005b);

Terrestrial Flora and Fauna Habitat Assessment: Dendrobium Colliery Area 3

Seismic and Borehole Survey Investigations (Biosis Research 2005d);

Dendrobium Area 3 Surface Exploration Works - Additional Boreholes Flora and Fauna Assessment (Biosis Research 2005a);

Delta Colliery Longwall 17 Impacts of Subsidence on Terrestrial Flora and Fauna (Biosis Research 2006b);

Dendrobium Coal Mine and Elouera Colliery Flora and Fauna Environmental Management Program, Annual Monitoring Report - Spring 2003 to Winter 2006 (Biosis Research 2007b);

Delta Colliery Longwall 11A, 11B, 12, 15, 16, 18 and 19 Impacts of Subsidence on Terrestrial Flora and Fauna (Biosis Research 2006a);

Terrestrial Flora and Fauna Assessment Longwall 14 End of Panel Report. (Biosis Research 2007e);

Flora and Fauna Assessment Longwalls 9 and 10 End of Panel Report (Biosis Research 2007d);

Flora and Fauna Assessment Delta Colliery - Longwall 17 End of Panel Report (Biosis Research 2007c); and,

Dendrobium Area 2 Longwalls 3-5a Impacts of Subsidence on Terrestrial Flora and Fauna (Biosis Research 2007a).

4.1.2 Relevant Literature

A list of relevant literature and references is provided with this document. Key documents that were consistently referred to for this SIS include:

- DECC 2007, *Director-General's Requirements for a Species Impact Statement for the Dendrobium Area 3 Stage Development Area C,* Wollongong, NSW;
- Minister for Urban Affairs and Planning 2001, *Environmental Planning and Assessment Act, 1979. Integrated State Significant Development. Determination of Development Application Pursuant to Sections 76(A)9 & 80. Proponent: BHP Billiton. Conditions of Consent for the Dendrobium Underground Coal Mine,* Planning NSW, Sydney;
- NPWS' Primary Submission to the Commission of Inquiry into the Dendrobium Coal Project, (NPWS 2001c);
- NPWS' Submission - In - Reply to the Commission of Inquiry into the Dendrobium Coal Project (NPWS 2001d); and,

- Threatened species Recovery Plans as published by DECC (formerly DEC and NPWS).

4.1.3 Databases

Key databases used in the preparation of this SIS include:

- DECC Atlas of NSW Wildlife (last accessed June 2007);
- DEW's EPBC Act Protected Matters Search Tool (last accessed June 2007);
- Herbarium of NSW, PlantNet;
- Bionet (last accessed September 2007);
- Viridans (2003), NSW Flora Information System (accessed May 2007, used internally by Biosis Research);
- DECC Threatened species profiles (last accessed September 2007); and,
- Birds Australia's Atlas of Australian Birds (last accessed June 2007).

4.1.4 Photographs, maps and plans

Key photographs, maps and plans used in the preparation of this SIS include:

- Aerial photographs of the Locality (supplied by BHP Billiton);
- Topographic maps (Wollongong, Avon, Bargo and Bulli 1:25 000 Map Sheets); and,
- NPWS vegetation mapping (NPWS 2003).

4.1.5 Consultation

Ian Baird BLandMgt, MAppSc (Giant Dragonfly expert/PhD candidate University of Western Sydney) was consulted during the preparation of this SIS.

Throughout the course of ecological monitoring and impact assessment for Areas 1 and 2, consultation has been undertaken with the Independent Expert Review Panel (Dr Kevin Mills, expert ecologist).

4.2 Nomenclature

Plants were identified using relevant volumes of the *Flora of NSW* (Harden 1992, 1993, Harden 2000, 2002). Species names were verified with the *Australian Plant Name Index* (ANBG 2007) where necessary. Other key references consulted for this report included Fairley and Moore (2000), Robinson (2003). Advice was sort from the National Herbarium of NSW for unconfirmed specimens.

In the body of this report, plants are referred to by their scientific names only. Common names, where available, have been included in the Appendices.

Names of vertebrates (fauna) follow the Census of Australian Vertebrates (CAVs) maintained by DEW. In the body of this report Vertebrates are referred to by both their common and scientific names when first mentioned. Subsequent references to these species cite the common name only. Common and scientific names are included in Appendix 4.

4.3 Threatened Flora

Table 3 lists nineteen threatened plant species that have been previously recorded, or have the potential to occur within the Study Area. The list was compiled from a variety of data sources including the DECC Atlas of NSW Wildlife (accessed June 2007), the DEW EPBC Act Protected Matters Search Tool (accessed June 2007) and the Director Generals Requirements issued in April 2007 (DECC 2007c).

4.3.1 Subject Plant Species

The list of subject plant species has been derived from Table 3. Of these, only *Acacia bynoeana* and *Pultenaea aristata* were recorded within the Study Area during the field surveys. The subject plant species include *Acacia bynoeana*, *Pultenaea aristata*, *Acacia baueri* ssp. *aspera*, *Cryptostylis hunteriana*, *Epacris purpurascens* var. *purpurascens*, *Grevillea parviflora* ssp. *parviflora*, *Leucopogon exolasius*, *Melaleuca deanei*, *Persoonia acerosa*, *Persoonia hirsuta* and *Persoonia bargoensis*.

These 11 subject plant species are considered further in Section 6.1.1 Affected Flora.

Table 3: Threatened flora considered in the SIS.

Key: Endangered (E), Vulnerable (V) or Endangered Population on the TSC Act (EP)

Scientific Name	EPBC Act	TSC Act	Habitat	Potential Habitat
Acacia baueri ssp. *aspera*	-	V	Restricted to the Sydney region, occurring on the Kings Tableland in the central Blue Mountains and with sporadic occurrences on the Woronora Plateau in the Royal National Park, Mt. Keira district and at Wedderburn. Occurs in low, damp heathlands, often on exposed rocky outcrops. Appears to prefer open conditions; rarely observed where there is any shrub or tree canopy development; and many of the observations of this species have been made following fire, suggesting the species prefers early successional habitats. Peak flowering occurs December to March (DEC 2005a).	**Yes**

Scientific Name	EPBC Act	TSC Act	Habitat	Potential Habitat
Acacia bynoeana	V	E	Bynoe's wattle is found in central eastern NSW, from the Hunter District (Morisset) south to the Southern Highlands and west to the Blue Mountains. It has recently been found in the Colymea and Parma Creek areas west of Nowra. Occurs in heath or dry sclerophyll forest on sandy soils. Seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches (DEC 2005b).	**Yes Recorded in Study Area**
Caladenia tessellata	V	E	Low open forest with heath or sometimes grass understorey this species only grows in very dense shrubbery in coastal areas (Bishop 1996). Currently known from two disjunct areas: Braidwood on southern tablelands and three populations in Wyong area on the Central Coast (DEC 2005g).	No
Chorizema parviflorum	-	EP	Heath and sclerophyll woodland and forest on heavy soils (Harden 2002). All known sites (excluding the site at Austinmer) occupy woodland or forest dominated by *Eucalyptus tereticornis* and *E. longifolia* (DEC 2005h).	No
Cryptostylis hunteriana	V	V	This species typically grows in swamp-heath on sandy soils chiefly in coastal districts (Harden 1993) but has also been recorded on steep bare hillsides (Bishop 1996). This species does not appear to have well defined habitat preferences and is known from a range of communities, including swamp-heath and woodland. Appears to prefer open areas in the understorey of and is often found in association with the *C. subulata* (DEC 2005i).	**Yes**
Cynanchum elegans	E	E	Rainforest gullies scrub and scree slopes in Gloucester and Wollongong districts (Harden 1992). Occurs mainly at the ecotone between dry subtropical rainforest and sclerophyll forest/woodland communities (NPWS 2002a). Has been recorded in dry subtropical rainforest, littoral rainforest, *Leptospermum laevigatum-Banksia integrifolia* Coastal scrub, *Eucalyptus tereticornis* forest and woodland, *Corymbia maculata* forest and woodland and *Melaleuca armillaris* scrub to open scrub (NPWS 2002a).	No
Daphnandra sp. *'Illawarra'*	E	E	Occupies the rocky hillsides and gullies of the Illawarra lowlands, occasionally extending onto the upper escarpment slopes. Associated vegetation includes rainforest and moist eucalypt forest (DEC 2005j).	No
Epacris purpurascens var. *purpurascens*	-	V	Sclerophyll forest, scrub and swamps from Gosford and Sydney districts (Harden 1992) specifically this species is thought to require wet heath vegetation (T. James pers. comm.). Characteristically found in a range of habitat types, most of which have a strong shale soil influence. These include ridgetop drainage depressions supporting wet heath within or adjoining shale cap communities (including Shale Sandstone Transition Forest). Also occurs in riparian zones draining into Sydney Sandstone Gully Forest, shale lenses within sandstone habitats and colluvial areas overlying or adjoining sandstone or tertiary alluvium. Has been recorded from Gosford, Narrabeen, Silverdale and Avon Dam vicinity (DEC 2005q)	**Yes**
Grevillea parviflora ssp. *parviflora*	V	V	Sporadically distributed throughout the Sydney Basin with the main occurrence centred around Picton, Appin and Bargo. Separate populations are also known further north from Putty to Wyong and Lake Macquarie on the Central Coast and Cessnock and Kurri Kurri in the Lower Hunter. Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Often occurs in open, slightly disturbed sites such as along tracks. Flowering has been recorded between July to December as well as April-May (DEC 2005v).	**Yes**
Lepidium hyssopifolium	E	E	Associated with introduced weedy species that tend to populated areas that receive little maintenance and are generally allowed to lie as derelict pasture. Original habitat is eucalypt woodland with grassy groundcover, low open *Casuarina* woodland with a grassy ground cover and tussock grassland (Cropper 1993b).	No
Leucopogon exolasius	V	V	Woodland on sandstone, restricted to the Woronora and Grose Rivers (Harden 1991). The plant occurs in woodland on sandstone and prefers rocky hillsides along creek banks (NPWS 1997). Flowering occurs in August and September.	**Yes**
Melaleuca deanei	V	V	The species grows in heath on sandstone (DEC 2005k). Occurs in two distinct areas of Sydney (Ku-Ring-Gai/Berowra and Holsworthy/Wedderburn) and has isolated occurrences in the Blue Mountains, Nowra and Central Coast areas (DEC 2005|). Flowers appear in summer but seed production appears to be small and consequently the species exhibits a limited capacity to regenerate.	**Yes**

Scientific Name	EPBC Act	TSC Act	Habitat	Potential Habitat
Persoonia acerosa	V	V	The Needle Geebung has been recorded only on the central coast and in the Blue Mountains, from Mt Tomah in the north to as far south as Hill Top where it is now believed to be extinct. Mainly in the Katoomba, Wentworth Falls, Springwood area. The Needle Geebung occurs in dry sclerophyll forest, scrubby low-woodland and heath on low fertility soils (DEC 2005~).	**Yes**
Persoonia bargoensis	V	E	Restricted to a small area south-west of Sydney on the western edge of the Woronora Plateau. Its entire range falls between Picton, Douglas Park, Yanderra, Cataract River and Thirlmere. Occurs in woodland or dry sclerophyll forest on sandstone and on heavier, well drained, loamy, gravely soils typical of Shale Sandstone Transtion Forest. Like most Geebungs this species seems to benefit from the reduced competition and increased light available on disturbance margins including roadsides (DEC 2005).	**Yes**
Persoonia hirsuta	E	E	Occurs from Gosford to Royal NP and in the Putty district from Hill Top to Glen Davis where it grows in woodland to dry sclerophyll forest on sandstone (Harden 2002) or rarely on shale (NSW Scientific Committee 1998). Two subspecies are recognised, *P. hirsuta* ssp. *hirsuta* (Gosford to Berowra and Manly to Royal NP) and *P. hirsuta* ssp. *evoluta* (Blue Mountains, Woronora Plateau and Southern Highlands). Found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone and shale-sandstone transition areas (DEC 2005€).	**Yes**
Pimelea spicata	E	E	In western Sydney, *P. spicata* is restricted to areas supporting, or that previously supported, Cumberland Plain Woodland. Pimelea spicata has been recorded from both shale hills and shale plains woodland. Pimelea spicata has also been recorded from highly degraded areas that no longer support native vegetation, but that would have supported CPW previously (DEC 2004b). In the coastal Illawarra it occurs commonly in Coast Banksia open woodland with a more well developed shrub and grass understorey.	No
Pomaderris brunnea	V	V	Open forest confined to the Colo River & upper Nepean River (Harden 1990), on clay & alluvial soils (Fairley and Moore 1995) of flood plains and creek lines. In the Hawkesbury/Nepean region, the species is known to be associated with Dry sclerophyll forests, Coastal Floodplain Wetlands and Coastal Valley Grassy Woodlands (DEC 2005).	No
Pultenaea aristata	V	V	Restricted to the Woronora Plateau, a small area between Helensburgh, south of Sydney, and Mt Kiera above Wollongong. The species occurs in either dry sclerophyll woodland or wet heath on sandstone. Flowering has been recorded in winter and spring (DEC 2005,). Single unconfirmed record outside the study area from 1957 (Figure 14).	**Yes** **Recorded in Study Area**
Solanum celatum	-	E	Restricted to an area from Wollongong to just south of Nowra, and west to Bungonia. Majority of records are prior to 1960 and the majority of populations are likely to have been lost to clearing. Grows in rainforest clearings, or in wet sclerophyll forests. Flowers August to October and produces fruit December to January (DEC 2005‡).	No

4.4 Threatened Fauna

Table 4 lists the 63 threatened animal species considered in the SIS. The list was compiled from a variety of data sources including the DECC Atlas of NSW Wildlife (last accessed August 2007), the DEW EPBC Act Protected Matters Search Tool (last accessed June 2007), the Director Generals Requirements issued in April 2007 (DECC 2007c), Birds Australia Atlas (last accessed June 2007), previous reports relating to the Study Area or Locality (see 4.1.1), and the results of Anabat surveys conducted within the Study Area.

4.4.1 Subject Animal Species

The list of subject animal species has been derived from Table 4. Eleven threatened animal species were recorded within the Study Area during the current surveys. A further six threatened species (microbats) were detected within the Study Area during the current surveys with ‘probable’ and or ‘possible’certainty. Microbats detected with ‘probable’ certainty are likely to be the species named, although there is a low probability of confusion with other species that use similar calls. Microbats detected with ‘possible’ certainty have a higher probability of being confused with species that emit similar calls and therefore, may not be the species named.

Five additional threatened animal species have been recorded within the Study Area by Biosis Research during Dendrobium fauna monitoring surveys or as incidental observations. One other threatened animal species has been previously recorded within the Study Area (DECC Atlas of NSW Wildlife). Therefore, a total of 23 threatened animals have previously been recorded within the Study Area.

Potential habitat occurs within the Study Area for a further 32 threatened animals (Table 4). In total, the Study Area is considered to have potential habitat for 55 threatened species. These 55 species are hereafter referred to as subject species and are further considered in Section 6.1.2.

Table 4: Threatened animal species and/or their habitat listed on the TSC and/or EPBC Acts that have previously been recorded within 10 km of the Study Area and/or are required for consideration in the Director-General's Requirements.

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Amphibians						
Litoria aurea	Green and Golden Bell Frog	V	E1	Found in marshes, dams and stream sides, particularly those containing bullrushes or spikerushes (NPWS 1999f). Preferred habitat contains water bodies that are unshaded, are free of predatory fish, have a grassy area nearby and have diurnal sheltering sites nearby such as vegetation or rocks (White and Pyke 1996, NPWS 1999f).	No	The species has not been previously recorded within a 10 km radius of the Study Area. The closest records lie between 10.5 and 14.5 km east of the Study Area (Bionet).
Litoria littlejohni	Littlejohn's Tree Frog	V	V	Littlejohn's Tree Frog appears to be restricted to sandstone woodland and heath communities from 100 to 950 m above sea level (White and Ehmann 1997) on the eastern slopes of the Great Dividing Range (Barker *et al.* 1995). Prefers rock flowing streams, but individuals have also been collected from semi-permanent dams with some emergent vegetation (Barker *et al.* 1995). Forages both in the tree canopy and on the ground, and has been observed sheltering under rocks on high exposed ridges during summer. It is not known from coastal habitats.	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Heleioporus australiacus	Giant Burrowing Frog	V	V	Prefers hanging swamps on sandstone shelves adjacent to perennial non-flooding (Daly 1996b). Can also occur within shale outcrops within sandstone formations. In the southern part of its range can occur in wet and dry forests, montane sclerophyll woodland and montane riparian woodland (Daly 1996b). Individuals can be found around sandy creek banks or foraging along ridge-tops during or directly after heavy rain. Males often call from burrows located in sandy banks next to water (Barker *et al.* 1995).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Mixophyes balbus	Stuttering Frog	V	E1	This species is usually associated with mountain streams, wet mountain forests and rainforests (Barker *et al.* 1995). It rarely wanders very far from the banks of permanent forest streams, although it will forage on nearby forest floors. Eggs are deposited in leaf litter on the banks of streams and are washed into the water during heavy rains (Barker *et al.* 1995).	Yes	The species has not been previously recorded within a 10 km radius of the Study Area. The closest records lie approximately 18 km south-west of the Study Area and were recorded in 2000 (Bionet).

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Mixophyes iteratus	Giant Barred Frog	E	E1	Usually found in coastal riverine rainforest and upland areas such as the Border Ranges (Barker *et al.* 1995).	Yes, but Study Area is beyond species current known limit of distribution	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 120 km north-east of the Study Area and was recorded in 1996 (Bionet).
Pseudophryne australis	Red-crowned Toadlet	-	V	Occurs on wetter ridge tops and upper slopes of sandstone formations on which the predominant vegetation is dry open forests and heaths. This species typically breeds within small ephemeral creeks that feed into larger semi-perennial streams. These creeks are characterised after rain by a series of shallow pools lined by dense grasses, ferns and low shrubs (Thumm and Mahony 1996, Thumm and Mahoney 1997).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife and Biosis Research).
Birds						
Botaurus poiciloptilus	Australasian Bittern	-	V	Inhabits terrestrial and estuarine wetlands, generally where there is permanent water. Prefers wetlands with dense vegetation including rushes and reeds (NPWS 1999a).	No	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 11.5 km east of the Study Area and was recorded in 1991 (Bionet).
Ixobrychus flavicollis	Black Bittern	-	V	Usually found on coastal plains below 200 m. Often found along timbered watercourses, in wetlands with fringing trees and shrub vegetation. The sites where they occur are characterized by dense waterside vegetation (NPWS 1999b).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.
Burhinus grallarius	Bush Stone-curlew	-	E1	Lightly timbered open forest and woodland, or partly cleared farmland with remnants of woodland, with a ground cover of short sparse grass and few or no shrubs where fallen branches and leaf litter are present (DEC 2005f).	Yes	The species has not been previously recorded within a 10 km radius of the Study Area. The closest records lie approximately 17.5 km north and north-west of the Study Area and were recorded in 1981 and 1991 (Bionet).
Callocephalon fimbriatum	Gang-gang Cockatoo	-	V	In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests (Higgins 1999). Also occur in sub-alpine Snow Gum woodland and occasionally in temperate or regenerating forest (Forshaw and Cooper 1981). In winter, 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). It requires tree hollows in which to breed (Gibbons and Lindenmayer 1997).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife and Biosis Research).

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Calyptorhynchus lathami	Glossy Black-cockatoo	-	V	Inhabits forest with low nutrients, characteristically with key Allocasuarina species. Tends to prefer drier forest types (NPWS 1999e) with a middle stratum of Allocasuarina below Eucalyptus or Angophora. Often confined to remnant patches in hills and gullies (Higgins 1999). Breed in hollows stumps or limbs, either living or dead (Higgins 1999).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife and Biosis Research).
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	-	V	Live in eucalypt woodlands, especially areas of relatively flat open woodland typically lacking a dense shrub layer, with short grass or bare ground and with fallen logs or dead trees present (Traill and Duncan 2000).	Yes	The species has not been previously recorded within a 10 km radius of the Study Area. The closest records occur within the Blue Mountains National Park more than 40 km north-west of the Study Area (Bionet).
Coracina lineata	Barred Cuckoo-shrike	-	V	Found in rainforests, vine thickets and their margins. Also found in eucalypt forests and clearing in secondary growth forests (Pizzey and Knight 1997).	Yes	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record occurs approximately 12.5 km east of the Study Area (Bionet).
Ptilinopus magnificus	Wompoo Fruit-Dove	-	V	Mainly occurs in large undisturbed patches of tall tropical or subtropical rainforest. Occasionally occurs in patches of monsoon forest, closed gallery forest, wet sclerophyll forest, tall open forest, open woodland or vine thickets near rainforest (Higgins and Davies 1996).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.
Ptilinopus regina	Rose-crowned Fruit-Dove	-	V	Occurs in tall tropical and subtropical, evergreen or semi-deciduous rainforest, especially with dense growth of vines. Prefers large patches of rainforest, but sometimes occurs in remnant patches surrounded by suboptimal habitat including farmlands (Higgins and Davies 1996).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.
Ptilinopus superbus	Superb Fruit-Dove	-	V	Mostly closed forests, including monsoon rainforests and mesophyll vine forests (Higgins and Davies 1996).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.
Grantiella picta	Painted Honeyeater	-	V	Found mainly in dry open woodlands and forests, where it is strongly associated with mistletoe (Higgins *et al.* 2001). Often found on plains with scattered eucalypts and remnant trees on farmlands.	Yes	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 77 km north of the Study Area and was recorded in 1989 (Bionet).
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	-	V	Found mostly in open forests and woodlands dominated by box and ironbark eucalypts (Higgins *et al.* 2001). It is rarely recorded east of the Great Dividing Range (Higgins *et al.* 2001).	Yes, but suboptimal	The species has been previously recorded within a 10 km radius of the Study Area (Biosis Research), but not within it.

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Xanthomyza phrygia	Regent Honeyeater	E	E1	A semi-nomadic species occurring in temperate Eucalypt woodlands and open forests. Most records are from box-ironbark eucalypt forest associations and wet lowland coastal forests (Pizzey 1983, NPWS 1999g).	Yes, but suboptimal	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 14 km north of the Study Area and was recorded in 1954 (Bionet).
Lophoictinia isura	Square-tailed Kite	-	V	Typically inhabits coastal forested and wooded lands of tropical and temperate Australia (Marchant and Higgins 1993). In NSW it is often associated with ridge and gully forests dominated by Woollybutt *Eucalyptus longifloria*, Spotted Gum *E. maculata* or Peppermint Gum *E. elata*, *E. smithii* (NPWS 1999i).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.
Pachycephala olivacea	Olive Whistler	-	V	Found in a range of habitats including alpine thickets, wetter rainforest/woodlands, riparian vegetation and heaths (Pizzey and Knight 1997).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Pyrrholaemus sagittata	Speckled Warbler	-	V	This species occurs in eucalypt and cypress woodlands on the hills and tablelands of the Great Dividing Range. They prefer woodlands with a grassy understorey, often on ridges or gullies (NSW Scientific Committee 2001). The species is sedentary, living in pairs or trios and nests on the ground in grass tussocks, dense litter and fallen branches. They forage on the ground and in the understorey for arthropods and seeds (NSW Scientific Committee 2001). Home ranges vary from 6-12 hectares (NSW Scientific Committee 2001).	Yes	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 12 km north-west of the Study Area and was recorded in 2004 (DECC Atlas of NSW Wildlife).
Stagonopleura guttata	Diamond Firetail	-	V	Found in a range of habitat types including open Eucalypt forest, mallee and acacia scrubs (Pizzey and Knight 1997).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.
Lathamus discolor	Swift Parrot	EM	E1	The Swift Parrot occurs in woodlands and forests of NSW from May to August, where it feeds on eucalypt nectar, pollen and associated insects (Forshaw and Cooper 1981). The Swift Parrot is dependent on flowering resources across a wide range of habitats in its wintering grounds in NSW (Shields and Crome 1992). This species is migratory, breeding in Tasmania and also nomadic, moving about in response to changing food availability (Pizzey 1983).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Neophema chrysogaster	Orange-bellied Parrot	E	E1	Mostly found within 3km of the coast, mostly in sheltered coastal areas such as lagoon and estuaries (Higgins 1999). The species can be found foraging in weedy areas associated with these coastal habitats or even in totally modified landscapes such as pastures, seed crops and golf courses (DEC 2005}).	No	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 52 km south of the Study Area and was recorded in 1986 (Bionet).
Neophema pulchella	Turquoise Parrot	-	V	Occurs in open woodlands and eucalypt forests with a ground cover of grasses and understorey of low shrubs (Morris 1980). Generally found in the foothills of the Great Divide, including steep rocky ridges and gullies (Higgins 1999). Nest in hollow-bearing trees, either dead or alive; also in hollows in tree stumps. Prefer to breed in open grassy forests and woodlands, and gullies which are moist (Higgins 1999).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.
Pezoporus wallicus wallicus	Eastern Ground Parrot	-	V	Mainly found in heathland, sedgeland or buttongrass plains providing medium to dense cover (Higgins 1999).	Yes	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 24 km south of the Study Area and was recorded in 1989 (Bionet).
Dasyornis brachypterus	Eastern Bristlebird	E	E1	Found in coastal woodlands, dense scrub and heathlands, particularly where it borders taller woodlands (Pizzey and Knight 1997).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	-	V	This species lives in a wide range of temperate woodland habitats, and a range of woodlands and shrublands in semi-arid areas (Traill and Duncan 2000).	Yes	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 53.5 km west of the Study Area and was recorded in 2003 (Bionet).
Petroica rodinogaster	Pink Robin	-	V	Found in dense, dank forest/treefern gullies and disperses in autumn-winter to open forests, woodlands and scrublands (Pizzey and Knight 1997).	Yes	The species has not been previously recorded within a 10 km radius of the Study Area. The closest records lie approximately 16 km south-east of the Study Area and were recorded in 1987 and 1996 (Bionet).
Rostratula australis	Australian Painted Snipe	V	E1	Usually found in shallow inland wetlands including farm dams, lakes, rice crops, swamps and waterlogged grassland. They prefer freshwater wetlands, ephemeral or permanent, although they have been recorded in brackish waters (Marchant & Higgins 1993).	No	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 82.5 km north of the Study Area and was recorded in 1982 (Bionet).

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Sterna albifrons	Little Tern	M	E1	Found in sheltered coastal environments including lagoons, estuaries, river mouths and deltas, lakes, bays, harbours and inlets (Higgins and Davies 1996).	No	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 17 km north of the Study Area (Birds Australia).
Oxyura australis	Blue-billed Duck	M	V	Almost wholly aquatic, preferring deep water in large, permanent wetlands with an abundant aquatic flora (Marchant and Higgins 1990).	No	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 11.5 km east of the Study Area and was recorded in 1996 (DECC Atlas of NSW Wildlife).
Stictonetta naevosa	Freckled Duck	M	V	The Freckled Duck breeds in permanent fresh swamps that are heavily vegetated. Found in fresh or salty permanent open lakes, especially during drought. Often seen in groups on fallen trees and sand spits (Simpson and Day 1996).	No	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.
Ninox connivens	Barking Owl	-	V	Generally found in open forests, woodlands, swamp woodlands and dense scrub. Can also be found in the foothills and timber along watercourses in otherwise open country (Pizzey 1983).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Ninox strenua	Powerful Owl	-	V	Occupies wet and dry eucalypt forests and rainforests. Can occupy both un-logged and lightly logged forests as well as undisturbed forests where it usually roosts on the limbs of dense trees in gully areas. It is most commonly recorded within Red Turpentine in tall open forests and Black She-oak within open forests (Debus and Chafer 1994). Large mature trees with hollows at least 0.5 m deep are required for nesting (Garnett 1992). Tree hollows are particularly important for the Powerful Owl because a large proportion of the diet is made up of hollow-dependent arboreal marsupials (Gibbons and Lindenmayer 1997). Nest trees for this species are usually emergent with a diameter at breast height of at least 100 cm (Gibbons and Lindenmayer 1997).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife and Biosis Research).
Tyto capensis	Grass Owl	-	V	Occurs mainly in open tussock grassland, usually in treeless areas. Can also occur in marshy areas with tall dense tussocks of grass. Occasionally occurs in densely vegetated agricultural lands such as sugarcane fields (Higgins 1999).	Yes, but suboptimal	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 126 km north of the Study Area and was recorded in 1991 (Bionet).

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Tyto novaehollandiae	Masked Owl	-	V	Inhabits a diverse range of wooded habitat that provide tall or dense mature trees with hollows suitable for nesting and roosting (Higgins 1999). Mostly recorded in open forest and woodlands adjacent to cleared lands. Nest in hollows, in trunks and in near vertical spouts or large trees, usually living but sometime dead (Higgins 1999). Nest hollows are usually located within dense forests or woodlands (Gibbons and Lindenmayer 1997). Masked owls do prey upon hollow-dependent arboreal marsupials, but terrestrial mammals make up the largest proportion of the diet (Gibbons and Lindenmayer 1997, Higgins 1999).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife), but not within it.
Tyto tenebricosa	Sooty Owl	-	V	Often found in tall old-growth forests, including temperate and subtropical rainforests. In NSW mostly found on escarpments with a mean altitude <500 m. Nests and roosts in hollows of tall emergent trees, mainly eucalypts (Higgins 1999) often located in gullies (Gibbons and Lindenmayer 1997). Nests have been located in trees 125 to 161 cm in diameter (Gibbons and Lindenmayer 1997).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife and Biosis Research), but not within it.
Mammals						
Cercartetus nanus	Eastern Pygmy-possum	-	V	Inhabits rainforest through to sclerophyll forest and tree heath. Banksias and myrtaceous shrubs and trees are a favoured food source. Will often nest in tree hollows, but can also construct its own nest (Turner and Ward 1995). Because of its small size it is able to utilise a range of hollow sizes including very small hollows (Gibbons and Lindenmayer 1997). Individuals will use a number of different hollows and an individual has been recorded using up to 9 nest sites within a 0.5ha area over a 5 month period (Ward 1990).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Dasyurus maculatus	Spotted-tailed Quoll	E	V	Uses a range of habitats including sclerophyll forests and woodlands, coastal heathlands and rainforests (Dickman and Read 1992). Habitat requirements include suitable den sites, including hollow logs, rock crevices and caves, an abundance of food and an area of intact vegetation in which to forage (Edgar and Belcher 1995).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW), but not within it.

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Petrogale penicillata	Brush-tailed Rock-Wallaby	V	E1	Found in rocky areas in a wide variety of habitats including rainforest gullies, wet and dry sclerophyll forest, open woodland and rocky outcrops in semi-arid country. Commonly sites have a northerly aspect with numerous ledges, caves and crevices (Eldridge and Close 1995).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW), but not within it.
Macropus parma	Parma Wallaby	-	V	Occurs in wet and dry sclerophyll forest with a thick, shrubby understorey associated with grassy patches. They may also occur in rainforest but prefer the wet sclerophyll forest (Strahan 1995). This species feed on grasses and herbs (Strahan 1995).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (within the Cataract catchment in 1969) (DEC 2005Ž), but not within it.
Mormopterus norfolkensis	Eastern Freetail Bat	-	V	Most records are from dry eucalypt forests and woodlands to the east of the Great Dividing Range. Appears to roost in trees, but little is known of this species habits (Allison and Hoye 1995, Churchill 1998).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E	E1	Prefers sandy soils with scrubby vegetation and/or areas with low ground cover that are burnt from time to time (Braithwaite 1995). A mosaic of post fire vegetation is important for this species (Maxwell *et al.* 1996). The species nests in shallow depressions covered by leaf litter and plant material underneath shrubs such as Xanthorrhoea species but may also utilise rabbit burrows, rock ledges or crevices for breeding (DEC 2005‰).	Yes	The species has been recorded within the Study Area including the Subject Site, as well as within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Petaurus australis	Yellow-bellied Glider	-	V	Restricted to tall native forests in regions of high rainfall. Preferred habitats are productive, tall open sclerophyll forests where mature trees provide shelter and nesting hollows. Critical elements of habitat include sap-site trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of different forest types(NPWS 1999j).	Yes, but limited	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW), but not within it.

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Petaurus norfolcensis	Squirrel Glider	-	V	Generally occurs in dry sclerophyll forests and woodlands but is absent from dense coastal ranges in the southern part of its range (Suckling 1995). Requires abundant hollow bearing trees and a mix of eucalypts, banksias and acacias (Quin 1995). There is only limited information available on den tree use by Squirrel Gliders, but it has been observed using both living and dead trees as well as hollow stumps (Gibbons and Lindenmayer 1997). Within a suitable plant community at least one species should flower heavily in winter and one species of eucalypt should be smooth barked (Menkhorst *et al.* 1988).	Yes	The species has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW), but not within it.
Phascolarctos cinereus	Koala	-	V	Inhabits eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall (Reed and Lunney 1990, Reed *et al.* 1990).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Potorous tridactylus	Long-nosed Potoroo	V	V	Inhabits coastal heath and wet and dry sclerophyll forests. Generally found in areas with rainfall greater than 760 mm. Requires relatively thick ground cover where the soil is light and sandy (Johnston 1995).	Yes	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 20 km south-west of the Study Area and was recorded in 1970 (Bionet).
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, Melaleuca swamps and Banksia woodlands. Bats commute daily to foraging areas, usually within 15 km of the day roost (Tidemann 1995) although some individuals may travel up to 70 km (Augee and Ford 1999).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Miniopterus australis	Little Bentwing-bat	-	V	Shows a preference for well timbered areas including rainforest, wet and dry sclerophyll forests, Melaleuca swamps and coastal forests. Roost in caves, congregating into maternity colonies in summer months (Churchill 1998).	Yes	The species has 'probably' been recorded within the Study Area including the Subject Site (Biosis Research[i]). The closest confirmed record lies approximately 70 km north-east of the Study Area and was recorded in 1992 (Bionet).
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	-	V	This species uses a broad range of habitat including rainforest, wet and dry sclerophyll forest, paper bark forest and open woodland and grassland (Churchill 1998). The species is cave dweller (although some individuals occasionally roost in human constructed tunnels and buildings) (Strahan 1995, Churchill 1998).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife and Biosis Research).

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Located in a variety of drier habitats, including the dry sclerophyll forests and woodlands to the east and west of the Great Dividing Range (Hoye and Dwyer 1995). Can also be found on the edges of rainforests and in wet sclerophyll forests (Churchill 1998). This species roosts in caves and mines in groups of between 3 and 37 individuals (Churchill 1998).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Falsistrellus tasmaniensis	Eastern False Pipistrelle	-	V	Inhabit sclerophyll forests, preferring wet habitats where trees are more than 20 m high (Churchill 1998). Two observations have been made of roosts in stem holes of living eucalypts (Phillips 1995). The species may also roost and breed in caves (DEC 2005n). There is debate about whether or not this species moves to lower altitudes during winter, or whether they remain sedentary but enter torpor (Menkhorst and Lumsden 1995). This species also appears to be highly mobile and records showing movements of up to 12 km between roosting and foraging sites (Menkhorst and Lumsden 1995).	Yes	The species has 'probably' been recorded within the Study Area including the Subject Site (Biosis Research[i]). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Kerivoula papuensis	Golden-tipped Bat	-	V	Occurs in rainforest and along rainforest gullies in wet sclerophyll forest. Have been found roosting in the abandoned nests of gerygones and scrubwrens (Churchill 1998). The species may breed in tree hollows, under bark, in rock fissures or caves (DEC 2005t).	Yes	The species has 'possibly' been recorded within the Study Area including the Subject Site (Biosis Research[ii]). The closest confirmed record lies approximately 138.5 km north-east of the Study Area and was recorded in 2001 (Bionet).
Myotis macropus (Myotis adversus)	Southern Myotis (Large-footed Myotis)	-	V	Occurs in most habitat types as long as they are near permanent water bodies, including streams, lakes and reservoirs. Commonly roost in caves, but can also roost in tree hollows, under bridges and in mines (Richards 1995, Churchill 1998).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	-	V	Reported from a wide range of habitats throughout eastern and northern Australia, including wet and dry sclerophyll forest, open woodland, Acacia shrubland, mallee, grasslands and desert (Churchill 1998). They roost in tree hollows and have also been observed roosting in animal burrows, abandoned Sugar Glider nests, cracks in dry clay, hanging from buildings and under slabs of rock (Churchill 1998). The species flies high and fast and forages above the canopy (Churchill 1998).	Yes	The species has 'probably' been recorded within the Study Area including the Subject Site (Biosis Research[i]). The closest confirmed record lies approximately 17.5 km east of the Study Area and was recorded in 1964 (Bionet).

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Scoteanax rueppellii	Greater Broad-nosed Bat	-	V	Prefer moist gullies in mature coastal forests and rainforests, between the Great Dividing Range and the coast. They are only found at low altitudes below 500 m (Churchill 1998). In dense environments they utilise natural and human-made opening in the forest for flight paths. Creeks and small rivers are favoured foraging habitat (Hoye and Richards 1995). This species roosts in hollow tree trunks and branches (Churchill 1998).	Yes	The species has 'probably' been recorded within the Study Area including the Subject Site (Biosis Research[i]). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Vespadelus troughtoni	Eastern Cave Bat	-	V	A cave-roosting species that is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings. It is occasionally found along cliff-lines in wet eucalypt forest and rainforest. The Eastern Cave Bat is found in a broad band on both sides of the Great Dividing Range from Cape York to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT (NPWS 2005).	Yes	The species has 'possibly' been recorded within the Study Area including the Subject Site (Biosis Research[ii]). The closest confirmed record lies approximately 124.5 km south of the Study Area and was recorded in 2001 (Bionet). This single record lies more than 300 km south of the southern limit of the species' normal distribution.
Reptiles						
Hoplocephalus bungaroides	Broad-headed Snake	V	E1	Mainly occurs in association with communities occurring on Triassic sandstone within the Sydney Basin. Typically found among exposed sandstone outcrops with vegetation types ranging from woodland to heath. Within these habitats they generally use rock crevices and exfoliating rock during the cooler months and tree hollows during summer (Webb 1996).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife and Biosis Research).
Varanus rosenbergi	Rosenberg's Goanna	-	V	This species is a Hawkesbury/Narrabeen sandstone outcrop specialist (Wellington and Wells 1985). Occurs in coastal heaths, humid woodlands and both wet and dry sclerophyll forests (Cogger 1992).	Yes	The species has been recorded within the Study Area including the Subject Site (Biosis Research). The species has also been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife).
Invertebrates						
Meridolum corneovirens	Cumberland Plain Land Snail	-	E1	Most likely restricted to Cumberland Plain, Castlereagh Woodlands and boundaries between River-flat Forest and Cumberland Plain Woodland. It is normally found beneath logs, debris and amongst accumulated leaf and bark particularly at the base of trees. May also use soil cracks for refuge (NPWS 2000).	No	The species has not been previously recorded within a 10 km radius of the Study Area. The closest record lies approximately 20 km north of the Study Area and was recorded in 1991 (Bionet).

Scientific Name	Common Name	EPBC Act[a]	TSC Act[b]	Habitat	Potential Habitat / Subject Species	Comments
Petalura gigantea	Giant Dragonfly	-	E1	Live in permanent swamps and bogs with some free water and open vegetation. Adults spend most of their time settled on low vegetation on or adjacent to the swamp (DEC 2005s).	Yes	The species has recently been recorded in the Locality (specific location not known). The next closest records occur approximately 18.5 km south-west of the Study Area (no date given) and approximately 27 km south-west of the Study Area (recorded in the 1990's (Bionet)).

Key: a: V = Vulnerable, E = Endangered, M = Migratory.

b: V = Vulnerable, E1 = Endangered.

i: 'Probable' Anabat recording = the call is most likely the species named however there is a low probability of confusion with other species that use similar calls.

ii: 'Possible' Anabat recording = the call may belong to the species named however there is a moderate to high probability of confusion with other species using similar calls.

4.5 Endangered Populations

Endangered Populations are listed on Schedule 1 (Part 2) of the TSC Act. An Endangered Population is one in which the population has been reduced to such a critical level, or its habitat has been so drastically reduced, that it is in immediate danger of extinction. It will be geographically isolated and near the limit of the species' natural range, or will be genetically distinct, or will have some other conservational significance (DECC 2006).

There are currently no Endangered Populations listed within the Locality.

4.6 Endangered Ecological Communities

Descriptions of all plant communities within the Study Area are included in Section 6.2.1.

Map Unit 23 of NPWS (2003), Transitional Shale Stringybark Forest, has been mapped at flora survey sites Q5 and Q6 Figure 11. Transitional Shale Stringybark Forest forms a component of the Endangered Ecological Community (EEC), Shale Sandstone Transition Forest. Shale Sandstone Transition Forest is listed as an EEC on both the TSC and EPBC Acts.

Map Unit 18 of NPWS (2003), Highlands Shale Tall Open Forest, has been mapped at flora survey sites Q12 and Q13 Figure 11. Highlands Shale Tall Open Forest forms a component of the Southern Highlands Shale Woodlands EEC (listed on the TSC Act only). Ground-truthing during the field surveys revealed that the Southern Highlands Shale Woodlands EEC was not present within the Study Area at these survey locations. This and other vegetation mapping discrepancies, have been described in further detail in Section 6.2.1.

Therefore, Shale Sandstone Transition Forest is the only EEC under consideration in this SIS (Section 7.0).

4.7 Key Threatening Processes

Three Key Threatening Processes (KTPs) as listed under Schedule 3 of the TSC Act are considered relevant to the Proposal:

- Alteration of habitat following subsidence due to longwall mining (NSW Scientific Committee 2005a);
- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands (NSW Scientific Committee 2002a); and,
- Human-caused Climate Change (NSW Scientific Committee 2000b).

4.7.1 Alteration of habitat following subsidence due to longwall mining

On 15 July 2005, *Alteration of habitat following subsidence due to longwall mining* (NSW Scientific Committee 2005a) was listed as a KTP under Schedule 3 of the TSC Act.

Following meetings between DECC and DPIM (Department of Primary Industries – Minerals) to discuss the implications of this listing, it was decided that a threat abatement plan did not need to be prepared for the longwall mining industry because existing approvals processes (primarily Subsidence Management Plans or SMPs) satisfactorily address subsidence impacts on the natural environment and threatened biodiversity.

The final determination for this KTP (NSW Scientific Committee 2005a) lists threatened biota that are known or have the potential to occur in areas affected by subsidence due to longwall mining. Of these, the threatened plant species *Acacia baueri* subsp. *aspera*, *Boronia deanei*, *Epacris purpurascens* var. *purpurascens*, *Leucopogon exolasius*, *Melaleuca deanei*, *Persoonia acerosa*, *Pterostylis pulchella*, *Pultenaea aristata* and *Tetratheca juncea* and all the threatened fauna listed in the KTP have been considered in this SIS. The endangered ecological community Shale Sandstone Transition Forest is listed under the KTP and has been considered in this SIS.

The listing also refers to species that are not currently listed as threatened but may become so as a result of habitat alteration following subsidence due to longwall mining. Of these, *Darwinia grandiflora* and *Lomandra fluviatilis* were recorded in the Study Area during the field surveys, but as these species are not currently listed on the TSC Act they have not been considered in this SIS.

This KTP is necessarily broad ranging in its approach and includes issues associated with all coalfields in New South Wales. For the most part, it accurately describes the mechanism and reports on the current knowledge regarding subsidence impacts on the lands surface. The listing acknowledges that subsidence issues will vary between the various coalfields, operations and even individual longwall panels.

While it is appropriate for the NSW Scientific Committee to identify the concerns raised by longwall mining in association with natural heritage values, there are several features of the KTP that might be misinterpreted. These include:

- The dissolution of some limited concerns across all coalfields and all operations.
- Lack of current information: The KTP cites a number of well known and often spectacular case studies to do with both impact and remediation of subsidence that lack the benefit of current knowledge.
- Confusion of issues: The KTP identifies some impacts associated with some surface operations which are not linked to subsidence, such as vegetation clearing and mine water discharge.
- Horizontal displacements up to 1 km from the mine workings: The KTP cites various reports that identify that horizontal movements may occur up to 1 km from mine workings. However, the KTP does not quantify what these movements translate into in terms of surface impacts.

4.7.2 Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands

On the 31 May 2002, *Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands* (NSW Scientific Committee 2002a) was listed as a KTP under Schedule 3 of the TSC Act.

The Final Determination for this KTP states that alteration to natural flow regimes can occur through reducing or increasing flows, altering seasonality of flows, changing the frequency, duration, magnitude, timing, predictability and variability of flow events, altering surface and sub-surface water levels and changing the rate of rise or fall of water levels (NSW Scientific Committee 2002a). Habitat loss through altered hydrology patterns in rivers and wetlands has been identified as a threat for the endangered Spotted Tree Frog (*Litoria* *spenceri*) and the vulnerable birds, Blue-billed Duck and the Freckled Duck. None of these threatened species have been recorded or has potential habitat in the Study Area. The impacts of this KTP overlap with those described for Alteration of Habitat Following Subsidence due to Longwall Mining as described above.

4.7.3 Human-caused Climate Change

On the 3 November 2000, *Human-caused Climate Change* (NSW Scientific Committee 2000b) was listed as a KTP under Schedule 3 of the TSC Act.

The NSW Scientific Committee (2000b) state there is evidence that modification of the environment by humans may result in future climate change. Human induced activities as a result of energy use, industrial processes, solvent and other product use, agriculture, land use change and forestry, and waste cause greenhouse gas emissions. Human-caused climate change may occur at a faster rate than has previously occurred naturally and may involve both changes in average temperature conditions and changes to the frequency of occurrence of extreme events (e.g. fire).

The distribution of most species, populations and communities is determined by climate and many species would be adversely affected unless populations were able to move across the landscape. Species at risk include those with long generations, poor mobility, narrow ranges, specific host relationships, isolated and specialised species and those with large home ranges (NSW Scientific Committee 2000b). Examples of threatened species listed as being at risk in NSW include the Mountain Pygmy-possum, Sooty Owl, Striped Legless Lizard and Southern Corroboree Frog (*Pseudophryne corroboree*) (NSW Scientific Committee 2000b). Of these threatened species, the Sooty Owl has potential habitat within the Study Area and has been previously recorded within the Locality.

This KTP is likely to result as a flow-on effect of the Proposal. Greenhouse gas emissions including methane and carbon dioxide would be produced and released into the atmosphere during the extraction of the coal and as it is used in downstream steel making and power generation.

4.8 Critical Habitat

Under the TSC Act, the Director-General of the DECC maintains a Register of Critical Habitat. As of September 2007, Critical Habitat had been either declared or was awaiting finalisation for the following threatened biota:

- Bomaderry *Zieria* within the Bomaderry bushland;
- Eastern Suburbs Banksia Scrub Endangered Ecological Community;
- Gould's Petrel;
- Little penguin population in Sydney's North Harbour;
- Mitchell's Rainforest Snail in Stotts Island Nature Reserve; and,
- *Wollemia nobilis* (the Wollemi Pine).

None of these threatened biota occur within the Study Area and therefore the Proposal will not have an adverse effect on Critical Habitat for these threatened biota. Also, no Critical Habitat has, to date been declared for any threatened biota within the Study Area.

5.0 SURVEY

5.1 Requirement to Survey

Flora and fauna surveys were conducted in accordance with the Director-General's Requirements (DECC 2007c). The threatened species and ecological communities targeted are those identified as Subject Species in Section 4.0.

5.2 Documentation of Survey Technique

5.2.1 Flora Survey Technique

The locations of the flora survey sites are shown in Figure 11.

The aim of the flora survey was to:

1. Ground-truth the vegetation mapping of the area.
2. Conduct targeted surveys for subject plant species.
3. Assess the extent and condition of potential habitat for subject plant species.
4. Determine the likely impacts on affected plant species.

The techniques used during the flora surveys are described below.

Vegetation Mapping and Condition Assessment

Targeted Species: All vegetation units within the Study Area with a particular focus on Endangered Ecological Communities and potential habitat for threatened flora.

The native vegetation of the locality has previously been mapped (NPWS 2003). To confirm the extent and condition of each plant community within the Study Area, vegetation assessments were undertaken. Data from the vegetation assessment was compared to the vegetation mapping of NPWS (2003). The vegetation mapping of the Study Area was then updated (Figure 10). Plant communities identified within the Study Area were classified and named according to the descriptions in NPWS (2003).

The data collected during the vegetation assessments included:

- Geographic coordinates in MGA;
- Location description;
- Landscape features such as slope, aspect, outcropping, surface rock and soil

type;

- Vegetation structure and composition;
- Vegetation Condition was assessed according to the degree to which it resembled relatively natural, undisturbed vegetation and on a collective assessment of structure, composition and resilience (see below for a description of the categories). Resilience is the capacity of a site for natural regeneration; and,
- Other information impacting on native vegetation in the Study Area such as fire history, vegetation condition, tree age and regeneration, understorey characteristics, presence of introduced species, adjacent land uses and disturbances.

The following categories were used to assess vegetation condition:

- **Good**; containing a high number of indigenous species; no weeds present or weed invasion restricted to edges and track margins; vegetation community contains original layers of vegetation; vegetation layers (ground, shrub, canopy etc.) are intact, or if modified, natural soil profile remains intact;

- **Moderate**; containing a moderate number of indigenous species; moderate level of weed invasion; weeds occurring in isolated patches or scattered throughout; one or more of original layers of vegetation are modified; vegetation layers (ground, shrub, canopy etc.) are largely intact, or if modified, natural soil profile remains intact; able to be regenerated to Good condition with minimal level of management;

- **Poor**; containing a low number of indigenous species; high level of weed invasion; weeds occurring in dense patches or scattered throughout; one or more of the original layers of vegetation are highly modified; one or more original vegetation layers (ground, shrub, canopy etc.) are modified or missing, but natural soil profile intact; able to be regenerated to Moderate or Good condition with substantial management; and,

- **Unnatural landscape**; highly modified landscape containing few or no indigenous species; exotic species dominant; original native vegetation layers removed; natural soil profile disturbed; unable to be regenerated to natural condition; requires a high input of resources to achieve restoration goals.

Plot Based Surveys (Quadrats and Transects)

Targeted Species: All plant communities and Subject Plant Species.

Quadrats and transects were used to enhance the vegetation assessments. Flora data from 20 m x 20 m quadrats and 0.5 m x 15 m transects was recorded from vegetation that was considered to accurately represent each plant community within the Study Area. Data collected assisted in ground-truthing the vegetation mapping and describing the plant communities of the Study Area.

Species not identifiable in the field were pressed and later identified. Data from a total of 35 quadrats and 15 transects was recorded (Figure 11). A vegetation assessment (see above) was also undertaken at each quadrat location.

The determination of the number of quadrats and transects was based on:

- an analysis of the recommendations for threatened biodiversity surveys contained in DEC (2004c);
- the area of each vegetation unit; and
- a prioritisation of vegetation units with likely conservation significance or for which pre-existing data was limited.

In this way, all vegetation units were accurately ground truthed during the field survey. Sampling sites were located within undisturbed native vegetation with representative species diversity and low weed abundance.

Quadrats

Within the quadrats, the cover abundance of identifiable plant species was recorded using a modified 7 point Braun-Blanquet scale (Braun-Blanquet 1928). Table 5 illustrates the modified cover abundance scores used in the quadrats. Quadrats were used in woodland and forest areas.

Table 5. Modified Braun-Blanquet (1928) Cover Abundance Scores Used in the Quadrats

Score	Species Cover in Quadrat	Other Attributes
1	< 5 %	3 or less individuals of a species
2	<5%	More than 3 individuals of a species
3	<5%	Species common throughout plot
4	5% - 25%	-
5	25% - 50%	-
6	50% - 75%	-
7	75% - 100%	-

Transects

Half-metre sampling-quadrats were surveyed along the centre line of a 15 metre transect (i.e. 30 sampling-quadrats). A single score was assigned to a species if it was present within a quadrat, regardless of its abundance. The number of scores recorded for a species was then extrapolated and provided the means to calculate the frequency of the species along that transect. *Note: Frequency = total score for a* *species (the number of sampling-quadrats in which a species occurs)/30 (the total number of sampling-quadrats)*. Transects were used in Upland Swamps.

Targeted Surveys (Random Meander Transects)

Targeted Species: All Subject Plant Species (see Table 3).

Targeted searches were undertaken and involved survey of all preferred or potential habitat as identified in the general habitat assessment. Targeted searches included random meanders (Cropper 1993b) which were undertaken in pairs traversing the Study Area. This technique was used during targeted searches to provide a greater coverage of the Study Area (DEC 2004d). Global Positioning Systems (GPS) were used to delineate the Subject Site in combination with associated maps. This ensured a more complete coverage of the areas that may be impacted by the Proposal. A record of GPS tracking for these surveys is in included in Figure 6.

Estimation of Threatened Species Populations

Targeted Species: *Acacia bynoeana* and *Pultenaea aristata*

Where isolated occurrences of threatened plants were observed, the species, size, condition and a GPS location of the specimen was recorded.

Where relatively small numbers of individuals were observed, each specimen was individually counted and the size and geographic location of each population recorded using a GPS.

Where a threatened plant species was abundant (as was the case with *Pultenaea aristata*), the population density was estimated using sample plots (i.e. the number of specimens of a species in a 10 X 10 m quadrat) and extrapolated to an area of potential habitat such that the total population could be estimated.

Pultenaea aristata has a patchy distribution within the Study Area. The boundaries of large patches of *Pultenaea aristata* were first determined by undertaking parallel line searches (Cropper 1993a). Once the boundary and area of each patch had been determined, quadrats were randomly placed within the sampled patch. The location of each quadrat was recorded by GPS. A total of four quadrats were surveyed.

5.2.2 Fauna Survey Technique

The survey techniques described below were employed for the Dendrobium Area 3 surveys (2007). For other survey techniques, employed during the Dendrobium Coal Project Species Impact Statement (Biosis Research 2001d), Dendrobium

Area 2 Monitoring Program (2005 to date), and other Biosis Research assessments conducted within the Study Area, see 'Previous Studies by Biosis Research' in Section 4.1.1. The locations of previous and current fauna survey sites are shown in Figure 12 and Figure 13 respectively.

Bat Call Detection (Echolocation Analysis)

Targeted species: Eastern Freetail Bat, Eastern Bentwing-bat, Little Bentwing-bat, Large-eared Pied Bat, Eastern False Pipistrelle, Golden-tipped Bat, Large-footed Myotis/Southern Myotis, Yellow-bellied Sheathtail-bat, Greater Broad-nosed Bat and Eastern Cave Bat.

Six Anabat II detectors with digital ZCAIM recording devices (Titley Electronics) were used to record microchiropteran bat calls (echolocation) within the Study Area. Calls can provide information on frequency and call sequence, thus allowing species identification. Potential habitat within gully, Upland Swamp and rainforest vegetation was targeted. The surveys were conducted during autumn (see Table 12 for exact dates).

The detectors were set before dusk within or near a suspected bat flyway, and left to record over night. Detectors were set above watercourses and or along cleared tracks/gaps within vegetation. This positioning was designed to cover the foraging areas of the targeted bat species.

The Anabat detectors were placed at 27 sites (23 within gully, three within Upland Swamp and one within rainforest habitat), for two to three consecutive nights, resulting in 58, eight and two successful night's recording within gully, Upland Swamp and rainforest habitat respectively. Nights not counted towards the survey effort (due to equipment failure) include two nights in gully habitat and two nights in rainforest habitat.

Recorded calls were analysed by bat call analyst Narawan Williams (Ecotone Ecological Consultants).

Locations of the Anabat detectors are shown in Figure 13.

Harp Traps

Targeted species: Eastern Freetail Bat, Eastern Bentwing-bat, Little Bentwing-bat, Large-eared Pied Bat, Eastern False Pipistrelle, Golden-tipped Bat, Large-footed Myotis/Southern Myotis, Yellow-bellied Sheathtail-bat, Greater Broad-nosed Bat and Eastern Cave Bat.

Harp traps were used to trap foraging bat species within potential habitat in the Study Area. Potential habitat within gully vegetation was targeted. The surveys were conducted during autumn (see Table 12 for exact dates).

Four harp traps were used to trap bats at ten sites, for two to three consecutive nights. Twenty-four trap nights were conducted in total. Harp traps were set across suspected bat flyways, which included areas over creeks and cleared tracks, as well as across gaps within vegetation. The harp traps were set before dusk and checked the following morning. Any captured animals were identified to species and then released at the site of capture after dusk the following night.

Locations of the traps are shown in Figure 13.

Tree Mounted Elliott Traps

Targeted Species: Eastern Pygmy-possum and Squirrel Glider

Tree mounted size B Elliott traps (460 x 160 x 150 mm) and size E Elliott traps (230 x 90 x 80 mm) were used to survey for arboreal mammal species within potential habitat in the Study Area. Only potential habitat within Upland Swamps was targeted due to this habitat type being reliant on ground and surface water and the presense of dense stands of Banksia (a preferred food source for these species). The location of potential habitat, and hence survey sites, was based on prior knowledge of the Study Area, vegetation mapping, and where signs and or evidence of arboreal fauna occurred (e.g. glider notches on tree trunks and limbs).

Three transects, each containing six Elliott B's and six Elliott E's were set in three different Upland Swamps for four nights, totalling 72 trap nights per Elliott trap-size. Pairs of each trap-size were located approximately 20 - 40 m apart within each transect. Locations of the traps are shown in Figure 13.

Traps were set on tree trunks or on major branches at approximately 1.8 m in height using a wooden platform and an elasticised strap. The wooden platforms were attached using a hand-held magnetic drill and screws. The traps were baited with a mixture of rolled oats, peanut butter and honey and a diluted honey mixture was sprayed on trees around the traps. Traps were checked each morning and any captured animals were identified to species and released at the site of capture.

Tree Mounted Hair Tubes

Targeted species: Eastern Pygmy-possum and Squirrel Glider

Arboreal hair tubes (entrance diameter 140 x 90 mm) were used to survey for arboreal mammal species within potential habitat in the Study Area. Only potential habitat within Upland Swamps was targeted for the same reasons given for tree mounted Elliot traps. The location of potential habitat, and hence survey sites, was based on prior knowledge of the Study Area, vegetation mapping, and where signs and or evidence of arboreal fauna occurred (e.g. glider notches on tree trunks and limbs).

Three transects, two containing 21 hair tubes and one containing 18 hair tubes (60 employed in total) were set in three different Upland Swamps for a minimum of four nights and a maximum of seven nights, totalling 303 trap nights. For the most part, three hair tubes were erected at each tree containing a pair of arboreal Elliott traps. As more hair tubes were used than pairs of Elliott traps, two transects ended with three hair tubes and no Elliott traps. Locations of the hair tubes are shown in Figure 13.

Hair tubes that were placed with arboreal Elliott traps were placed on or near each tree that contained the traps. At each tree, hair tubes were placed between one and two metres high and were attached using fabric tape. The hair tubes were baited with a mixture of rolled oats, peanut butter and honey and a diluted honey mixture was sprayed on trees around the hair tubes.

Cage Traps (ground)

Targeted species: Spotted-tailed Quoll, Southern Brown Bandicoot, Long-nosed Potoroo and Rosenberg's Goanna

Ground-dwelling mammals and reptiles were surveyed using single platform metal/wire cage traps (610 x 300 x 300 mm) in potential habitat within the Study Area. Potential habitat within gully vegetation was targeted. The location of potential habitat, and hence survey sites, was based on prior knowledge of the Study Area, vegetation mapping, and where signs and or evidence of ground-dwelling fauna occurred (e.g. scats and diggings).

Six transects of six cage traps were set in gully habitat for ten nights, totalling 360 trap nights. Cage traps were placed on the ground at intervals of approximately 20 m within each transect. The traps were baited with chicken wings. Traps were checked each morning and any captured animal was identified to species and released at the site of capture.

Locations of the traps are shown in Figure 13.

Diurnal Bird Surveys

Targeted species: Gang-gang Cockatoo, Glossy Black-cockatoo, Black Bittern, Bush Stone-curlew, Brown Treecreeper (eastern subspecies), Barred Cuckoo-

shrike, Painted Honeyeater, Black-chinned Honeyeater (eastern subspecies), Regent Honeyeater, Olive Whistler, Speckled Warbler, Diamond Firetail, Swift Parrot, Turquoise Parrot, Square-tailed Kite, Eastern Ground Parrot, Eastern Bristlebird, Hooded Robin (south-eastern form), Superb Fruit-Dove, Rose-crowned Fruit-dove, Wompoo Fruit-dove and Pink Robin.

Diurnal bird species were surveyed by a zoologist either by direct observation using 10 x 42 field binoculars or by their calls. Surveys were generally carried out at either dusk or dawn over the entire Study Area. Potential habitat within ridge, gully, Upland Swamp and rainforest vegetation was targeted. Surveys were conducted during autumn. Bird species lists compiled during other surveys conducted by Biosis Research in or adjacent to the Study Area have been included in Appendix 5.

Bird surveys were conducted as either a point census for 20 minutes, or as an area search (2 ha) for 20 – 30 minutes. Six hours and thirty-six minutes of diurnal bird surveys were carried out in ridge habitat at 19 survey sites; 5.12 person hours were conducted in gully habitat at 15 survey sites; 0.67 person hours were performed in Upland Swamp habitat at two survey sites; and, 1.49 person hours were performed in rainforest habitat at four survey sites.

Survey locations are shown in Figure 13.

Diurnal Herpetological Surveys

Targeted species: Broad-headed Snake, Rosenberg's Goanna, Red-crowned Toadlet, Littlejohn's Tree Frog, Stuttering Frog, Giant Barred Frog and Giant Burrowing Frog

One to two zoologists conducted diurnal herpetological searches within potential habitat within the Study Area. Potential habitat within ridge, gully, Upland Swamp and rainforest vegetation was targeted. Surveys were conducted in autumn (see Table 12 for exact dates). Incidental species lists complied during other surveys conducted by Biosis Research in or adjacent to the Study Area have been included in Appendix 5.

Searches consisted of an area search (at least 40 m x 40 m) and were concentrated at water courses and rocky outcrops. Searches involved examining ground litter, turning over logs and rocks, examining rock cavities and crevices (with a head torch) and examining tree trunks and limbs. Each survey site was searched twice, on two separate days. Any captured animals were identified to species and then released at the site of capture.

Diurnal herpetological surveys were conducted for 22.33 person hours within ridge habitat at 23 survey sites; 15 person hours within gully habitat at 15 survey sites; two person hours in Upland Swamp habitat at two survey sites; and, one person hour in rainforest habitat at two survey sites.

Survey locations are shown in Figure 13.

Diurnal Call-playback

Targeted species: Red-crowned Toadlet, Littlejohn's Tree Frog and Green and Golden Bell Frog

Species that are particularly cryptic, such as frogs, may be detected using call-playback. This technique relies on behavioural responses associated with territory and threat, whereby emitted calls may induce a defending response (either call or display) from individuals of the same species.

Potential habitat within gully and Upland Swamp vegetation was targeted. Surveys were conducted in autumn. A JNC MP3 player connected to a TOA megaphone was used to emit the calls. Each session began with a 5 minute listening period to detect any species already present in the area. Each call was emitted for three minutes, followed by three minutes of listening. The call of each targeted species' was not emitted at every site. Any animals encountered were identified by direct observation or by their calls.

Diurnal frog call-playback was conducted at ten sites, five in gully, one in ridge and four in Upland Swamp vegetation, over two different days.

Survey locations are shown in Figure 13.

Diurnal Frog Habitat Search

Targeted species: Red-crowned Toadlet, Littlejohn's Tree Frog, Stuttering Frog, Giant Barred Frog, Giant Burrowing Frog and Green and Golden Bell Frog

One to two zoologists conducted diurnal frog habitat searches within potential habitat within the Study Area. Potential habitat within gully, Upland Swamp and rainforest vegetation was targeted. Surveys were conducted in autumn (see Table 12 for exact dates).

Surveys consisted of an area search (at least 40 m x 40 m) and were concentrated at water courses, damp areas and rocky outcrops. Searches involved examining ground litter, turning over logs and rocks, dip-netting, looking through low shrubs and examining rock cavities and crevices (with a head torch). Any captured animals were identified to species and then released at the site of capture.

Diurnal frog habitat searches were conducted for one person hour within each vegetation type at two gully, two Upland Swamp and one rainforest sites.

Survey locations are shown in Figure 13.

Nocturnal Frog Habitat Search

Targeted species: Red-crowned Toadlet, Littlejohn's Tree Frog, Stuttering Frog, Giant Barred Frog, Giant Burrowing Frog and Green and Golden Bell Frog

Two different survey techniques were used to spotlight for frogs within the Study Area: nocturnal habitat searches and nocturnal watercourse searches. One to two zoologists conducted nocturnal frog habitat searches within potential habitat within the Study Area. Potential habitat within gully and Upland Swamp vegetation was targeted. A nocturnal frog habitat search in rainforest vegetation was replaced with a nocturnal watercourse search due to limited rainforest habitat (see 'Nocturnal Watercourse Search' below). Surveys were conducted in autumn (see Table 12 for exact dates).

Nocturnal frog habitat searches consisted of an initial five minute listening period followed by active searching of either an area (at least 40 m x 40 m) or of a transect (up to 200 m long) and were concentrated at watery and damp sites that were not a creek line. Searches involved examining ground litter, turning over logs and rocks, dip-netting and examining low shrubs. Zoologists used a head torch and handheld 50-w spotlight to conduct the surveys. Any captured animals were identified to species and then released at the site of capture.

Nocturnal frog habitat searches were conducted for one and a half person hours at one gully site and for two person hours at two Upland Swamp sites (with each site surveyed twice over two different nights).

Survey locations are shown in Figure 13.

Nocturnal Watercourse Search (frogs)

Targeted species: Red-crowned Toadlet, Littlejohn's Tree Frog, Giant Burrowing Frog, Stuttering Frog, Giant Barred Frog and Green and Golden Bell Frog

Nocturnal watercourse searches were conducted within gully and rainforest vegetation. Surveys were conducted during autumn (see Table 12 for exact dates). Frog species lists compiled during other surveys conducted by

Biosis Research in or adjacent to the Study Area have been included in Appendix 5.

Nocturnal watercourse searches consisted of an initial five minute listening period followed by two person hours of active spotlight searching of 200 m of a watercourse. Zoologists used a head torch and handheld 50-w spotlight to conduct the surveys.

Twenty-five nocturnal watercourse transects were conducted in gully habitat and one in rainforest habitat. Any animals encountered were identified by direct observation or by their calls.

Survey locations are shown in Figure 13.

Spotlighting (reptiles only)

Targeted species: Broad-headed Snake

Spotlighting was carried out in potential habitat within the Study Area to detect nocturnal or sheltering reptiles. Potential habitat within ridge and gully vegetation was targeted. Surveys were conducted in autumn (see Table 12 for exact dates).

Surveys, conducted by one to two zoologists using handheld 50-w spotlights, consisted of an area search (at least 40 m x 40 m) and were concentrated in wooded areas with rocky outcrops.

Three person hours of reptile spotlighting was conducted over seven sites within ridge habitat. One person hour was performed over two sites within gully habitat. Additional reptile spotlighting took place concurrently with mammal spotlighting (see below). Any animals encountered were identified by direct observation.

Survey locations are shown in Figure 13.

Spotlighting (mammals, reptiles and birds)

Targeted species: Eastern Pygmy-possum, Grey-headed Flying-fox, Koala, Squirrel Glider, Yellow-bellied Glider, Spotted-tailed Quoll, Brush-tailed Rock-Wallaby, Parma Wallaby, Southern Brown Bandicoot, Long-nosed Potoroo, Barking Owl, Masked Owl, Powerful Owl, Sooty Owl, Grass Owl, Bush Stone-curlew and Broad-headed Snake

Spotlighting was carried out in potential habitat within the Study Area to detect arboreal mammals, owls, the Broad-headed Snake, ground-dwelling mammals and the Bush Stone-curlew. Potential habitat within ridge, gully, Upland Swamp and rainforest vegetation was targeted. Surveys were conducted in autumn (see Table 12 for exact dates). Incidental species lists complied during other surveys conducted by Biosis Research in or adjacent to the Study Area have been included in Appendix 5.

Spotlighting surveys took place both on foot and from a slow moving vehicle, by two zoologists using handheld 50-w spotlights. The speed of survey was 1 km per hour on foot or up to 5 km per hour from a vehicle.

Spotlighting on foot was conducted for 26.38 hours over 30 sites in ridge habitat; 17.36 hours over 17 sites in gully habitat; two hours over three sites in Upland Swamp habitat; and, three hours over three sites in rainforest habitat.

Spotlighting from a vehicle was conducted for 7.42 hours over nine sites in ridge habitat and 3.8 hours over five sites in gully habitat. Spotlighting from a vehicle could not be conducted in Upland Swamp or rainforest habitat due to no vehicular access to these areas.

Any animals encountered during spotlighting were identified by direct observation using 10 x 42 field binoculars or by their calls.

Survey locations are shown in Figure 13.

Stag-watching

Targeted species: Eastern Pygmy-possum, Squirrel Glider, Barking Owl, Masked Owl, Powerful Owl, Sooty Owl and Broad-headed Snake

Nocturnal species that utilise tree hollows were surveyed by stag-watching. Two ‘stags’ (one dead and one live hollow bearing tree) within two different Upland Swamps were surveyed by two to three zoologists during autumn (see Table 12 for exact dates). Upland SwampUpland SwampHollow-bearing trees themselves are unlikely to be impacted in a way that would be detrimental to fauna.

Each stag was surveyed for the 30 minutes just prior to sunset without the use of spotlights (unless an animal was observed). Spotlights were not required at this stage to detect movement as the stag was silhouetted against the horizon. Stag-watching then continued for 60 minutes following sunset using head torches and handheld 50-w spotlights. Any animals encountered during a stag-watch were identified by direct observation using 10 x 42 field binoculars or by their calls.

A total of three hours of stag-watching was conducted at two sites. Survey locations are shown in Figure 13.

Nocturnal call-playback (frogs)

Targeted species: Red-crowned Toadlet, Littlejohn's Tree Frog, Giant Burrowing Frog and Stuttering Frog

Species that are particularly cryptic, such as frogs, may be detected using call-playback. This technique relies on behavioural responses associated with territory and threat, whereby emitted calls may induce a defending response (either call or display) from individuals of the same species.

Potential habitat within gully, Upland Swamp and rainforest vegetation was targeted. Surveys were conducted in autumn (see Table 12 for exact dates). A JNC MP3 player connected to a TOA megaphone was used to emit the calls. Each session began with a three to ten minute listening period to detect any species already present in the area. The first species' call was played for three minutes, followed by three minutes of listening. Each subsequent species' call was played for three minutes followed by a three minute listening period until all species calls had been emitted. Any animals encountered were identified by direct observation or by their calls.

Nocturnal frog call-playback was conducted at nine gully sites, two Upland Swamp sites and two rainforest sites, with call-playback at each gully and Upland Swamp site repeated over two separate nights. Within rainforest habitat, the first survey site could not be repeated due to unsafe access and therefore a new site was selected for the second night of call-playback.

Survey locations are shown in Figure 13.

Nocturnal Opportunistic Call-playback (frogs)

Targeted species: Red-crowned Toadlet and Littlejohn's Tree Frog

In addition to the frog call-playback completed above, opportunistic call-playback for the Red-crowned Toadlet and Littlejohn's Tree Frog was carried out in areas of suitable habitat.

Call-playback for one or both of the target species was carried out at four gully sites and two Upland Swamp sites. Surveys were conducted in autumn (see Table 12 for exact dates). A JNC MP3 player connected to a TOA megaphone was used to emit the calls. Each session began with a five minute listening period to detect any species already present in the area. The first species' call was played for three minutes (or less if the target species responded), followed by three minutes of listening. The first species' call was repeated in some surveys. If both frog calls were to be emitted then the second species' call was played for three minutes followed by a three minute listening period. Any animals encountered were identified by direct observation or by their calls. Opportunistic call-playback for frogs was repeated at each site between one and four times, on different nights.

Survey locations are shown in Figure 13.

Nocturnal call-playback (mammals)

Targeted species: Koala, Squirrel Glider and Yellow-bellied Glider

Nocturnal species that are particularly cryptic (e.g. Koala and Squirrel Glider) are generally difficult to locate during nocturnal spotlighting, but may be detected using call-playback. This technique relies on behavioural responses associated with territory and threat, whereby emitted calls may induce a defending response (either call or display) from individuals of the same species.

Potential habitat within Upland Swamp vegetation was targeted. Surveys were conducted in autumn (see Table 12 for exact dates). A JNC MP3 player connected to a TOA megaphone was used to emit the calls. Each session began with a ten minute listening period to detect any species already present in the area. The first species' call was played for five minutes, followed by five minutes of listening. Each subsequent species' call was played for five minutes followed by a five minute listening period until all species calls had been emitted. A final ten minute spotlight of the area was conducted following the call-playback. Any animals encountered were identified by direct observation using 10 x 42 field binoculars or by their calls.

Mammal call-playback was conducted at two sites, separated by at least 1 km, over two nights.

Survey locations are shown in Figure 13.

Nocturnal call-playback (owls)

Targeted species: Barking Owl, Masked Owl, Powerful Owl, Sooty Owl, and Grass Owl

Nocturnal species with large home ranges (e.g. Barking Owl, Powerful Owl, Masked Owl and Sooty Owl) are generally difficult to locate during nocturnal spotlighting, but may be detected using call-playback. This technique relies on behavioural responses associated with territory and threat, whereby emitted calls may induce a defending response (either call or display) from individuals of the same species.

Potential habitat within gully and Upland Swamp vegetation was targeted. Surveys were conducted in autumn (see Table 12 for exact dates). A JNC MP3 player connected to a TOA megaphone was used to emit the calls. Each session began with a ten minute listening period to detect any species already present in the area. The first species' call was played for five minutes, followed by five minutes of listening. Each subsequent species' call was played for five minutes followed by a five minute listening period until all species calls had been emitted. A final 10 minute spotlight of the area was conducted following the call-playback. Any animals encountered were identified by direct observation using 10 x 42 field binoculars or by their calls.

Owl call-playback was conducted at four sites (two in gully and two in Upland Swamp habitat), separated by at least 1 km. Call-playback was repeated at each site on eight different nights for the Masked Owl and six different nights for the Sooty Owl and five different nights for the Powerful, Barking and Grass Owls.

Survey locations are shown in Figure 13.

Nocturnal call-playback (Bush Stone-curlew)

Targeted species: Bush Stone-curlew

The Bush Stone-curlew is a nocturnal and cryptic species that can be difficult to locate during nocturnal spotlighting. However, the bird may be detected using call-playback. This technique relies on behavioural responses associated with territory and threat, whereby emitted calls may induce a defending response (either call or display).

Potential habitat within ridge and gully vegetation was targeted. Surveys were conducted in autumn (see Table 12 for exact dates). A JNC MP3 player connected to a TOA megaphone was used to emit the calls. Each session began with a five minute listening period to detect any species already present in the area. The Bush Stone-curlew's call was then played for 30 seconds, followed by 4.5 minutes of listening. This was repeated, using the same 30 seconds of call, until it had been played three times. Any animals encountered were identified by direct observation using 10 x 42 field binoculars or by their calls.

Bush Stone-curlew call-playback was conducted at two sites (one in ridge and one in gully habitat).

Survey locations are shown in Figure 13.

Koala Transects

Targeted species: Koala

The aim of the targeted surveys for Koalas was to gather information on Koala presence and habitat usage within the Study Area. Two zoologists conducted active searching along transects within potential habitat for Koalas and or signs of Koalas (e.g. scats and scratches). Surveys were conducted in autumn (see Table 12 for exact dates).

Two surveys within ridge vegetation were carried out, totalling 1.83 person hours. Koalas were also surveyed in other areas of potential habitat by spotlighting, nocturnal call-playback and opportunistic scat, scratch and sighting searches.

Survey locations are shown in Figure 13.

Fauna Habitat Assessment

Three categories were used to evaluate fauna habitat of the Study Area - Good, Moderate or Poor - and are detailed below:

Good: ground flora containing a high number of indigenous species; vegetation community structure, ground, log and litter layer intact and undisturbed; a high level of breeding, nesting, feeding and roosting resources available; a high richness and diversity of native fauna species.

Moderate: ground flora containing a moderate number of indigenous species; vegetation community structure, ground log and litter layer moderately intact and undisturbed; a moderate level of breeding, nesting, feeding and roosting resources available; a moderate richness and diversity of native fauna species.

Poor: ground flora containing a low number of indigenous species, vegetation community structure, ground log and litter layer disturbed and modified; a low level of breeding, nesting, feeding and roosting resources available; a low richness and diversity of native fauna species.

Other habitat features, such as the value of the Study Area as a habitat corridor, was also used to assess habitat quality.

Twelve specific habitat assessments were made within the Study Area (two within ridge, nine within gully, and one within rainforest habitat) and general habitat notes and assessments were made continuously throughout the surveys described in this SIS.

Survey locations are shown in Figure 13.

Incidental Observations

Both indirect and direct evidence of fauna was recorded and used to identify species presence. Direct evidence of fauna species included actual sightings or identification of the species by calls (e.g. birds, frogs and some nocturnal mammals). Indirect evidence of fauna species included remains (e.g. bones, skin, fur), scats (droppings), diggings or burrows, tracks and hair or body remains identified from predator scats. Scats collected during the surveys were analysed by Barbara Triggs.

During the current surveys conducted by Biosis Research, the zoologists, botanists and archaeologists made incidental animal observations each day as part of their respective surveys. The habitat in which species were observed was recorded (e.g. ridge, gully, Upland Swamp or rainforest). A waypoint was marked at the location of any threatened species encountered.

5.3 Documentation of Survey Effort

This section documents the survey effort for each survey technique used in the flora and fauna surveys. Copies of completed field data sheets have been included in Appendix 2 (flora) and Appendix 3 (fauna). Previous survey effort within the Study Area (Section 4.1) has not been included, with the exception of the Dendrobium Area 2 monitoring surveys (Biosis Research 2007b). Where appropriate, the results of previous surveys have been included in this report.

5.3.1 Flora Survey Effort

Table 6 through to Table 10 summarise the flora survey effort for the SIS.

Table 6. Vegetation Assessment

Survey to ground-truth plant communities and potential habitat for threatened flora.	
Task	**Details**
Targeted subject species	Shale Sandstone Transition Forest, Southern Highlands Shale Woodlands, All potential habitats for threatened flora
Survey technique	Vegetation assessment, ground-truthing of aerial photography and vegetation mapping
Time invested (excludes vehicle movements and survey planning time)	Included as part of the Targeted Surveys (Table 8)
Dates of surveys	11-13 April 2007 16-20 April 2007 4 May 2007 8 May 2007
Mapping of survey sites	Figure 11
Size, orientation and dimensions of quadrat or length of transect	*N/A*
Survey start and finish times	8.30 am to 4.30pm

Survey to ground-truth plant communities and potential habitat for threatened flora.	
Task	**Details**
Surveyor name and phone number	Nathan Smith, Sian Wilkins, Brendan Smith, Katherine Nelson and Jeff Drudge, botanists with Biosis Research. (02) 9690 2777
Plant identification	Biosis Research Herbarium of NSW (as required)

Table 7. Flora Survey: Quadrats and Transects

Survey to determine composition of plant communities	
Task	**Details**
Targeted subject species	All plant communities and subject plant species
Survey technique	Quadrats and Transects
Time invested (excludes vehicle movements and survey planning time)	44 person hours during current survey 373.5 person hours during previous surveys (this includes seasonal surveys of fixed monitoring quadrats and transects within the Study Area since October 2003)
Dates of surveys	11-13 April 2007 16-18 April 2007 20 April 2007 September 2006 May 2006 April 2006 October 2005 September 2005 May 2005 April 2005 November 2004 October 2004 May 2004 October 2003
Mapping of Quadrats and transects	Figure 11
Size, orientation and dimensions of quadrat or length of transect	Quadrats – 20 x 20 m (400 m2), 35 locations. Transects – 0.5 m x 15 m (7.5 m2), 15 locations.
Survey start and finish times	8.30 am to 4.30pm
Surveyor name and phone number	Nathan Smith, Sian Wilkins, Brendan Smith, Katherine Nelson and Jeff Drudge, botanists with Biosis Research. (02) 9690 2777
Plant identification	Biosis Research Herbarium of NSW (as required)

Table 8. Flora Survey: Targeted Surveys for Threatened Species

Survey to determine presence of subject plant species.	
Task	**Details**
Targeted subject species	All subject species (Table 3).
Survey technique	Random meanders focussing on areas of potential habitat within the Study Area.
Time invested (excludes vehicle movements and survey planning time)	244.5 person hours
Dates of surveys	11-13 April 2007 16-20 April 2007 4 May 2007 8 May 2007
Mapping of meander routes (tracks)	Figure 11
Size, orientation and dimensions of random meanders	Two persons walked in parallel lines, approximately 20 m apart, traversing potential habitat within Study Area.
Survey start and finish times	8.00 am to 4.30pm

Survey to determine presence of subject plant species.	
Task	**Details**
Surveyor name and phone number	Nathan Smith, Sian Wilkins, Brendan Smith, Katherine Nelson and Jeff Drudge, botanists with Biosis Research. (02) 9690 2777
Name of person undertaking identification	Biosis Research Herbarium of NSW

Table 9. Flora survey: Total Abundance Counts

Survey to determine the numbers of threatened plants	
Task	**Details**
Targeted subject species	*Acacia bynoeana* and *Pultenaea aristata*
Survey technique	Total counts of specimens within a defined and discrete population
Time invested	Included as part of the Targeted Surveys (Table 8).
Dates of surveys	11-13 April 2007 16-20 April 2007 4 May 2007 8 May 2007
Mapping of sites	Figure 11.
Size, orientation and dimensions of survey technique	Dependent on size and density of population.
Survey start and finish times	8.30 am to 4.30pm
Surveyor name and phone number	Nathan Smith, Sian Wilkins, Brendan Smith, Katherine Nelson and Jeff Drudge, botanists with Biosis Research. (02) 9690 2777
Plant identification	Biosis Research Herbarium of NSW (as required)

Table 10. Flora survey details: Plot Based Surveys (Quadrats)

Survey to determine extent of *Pultenaea aristata* populations	
Task	**Details**
Targeted subject species	*Pultenaea aristata*
Survey technique	10 X 10 m sampling-quadrats
Time invested	14 person hours
Dates of surveys	4 May 2007 7 May 2007
Description of site location	Upland Swamps
Survey point marked on a map	Figure 11
Size, orientation and dimensions of plots	Plots measuring 10 x 10 m at four locations
Survey start and finish times	8.30 am to 4.30pm
Surveyor name and phone number	Nathan Smith, Brendan Smith and Jeff Drudge, botanists with Biosis Research, 9690 2777
Plant identification	Biosis Research Herbarium of NSW

5.3.2 Fauna Survey Effort

Table 11 shows the total effort achieved during previous (within four years) fauna monitoring surveys conducted by Biosis Research within the Dendrobium Area 3 Study Area. Table 12 shows the survey effort achieved during the current study. In addition to the tabulated survey effort, numerous habitat based assessments have been conducted by Biosis Research within or nearby the Study Area. Many of these habitat-based surveys included active searching and listening for incidental fauna or fauna traces.

The total survey effort as shown in Table 11 for '*Diurnal Bird Surveys*' is 288.5 hrs; '*Nocturnal Frog Surveys*' at least 270 hrs (duration of some targeted Littlejohn's Tree Frog surveys unknown); and, '*Habitat Assessments*' at least 15 individual assessments conducted.

Table 11: Survey effort of fauna monitoring previously conducted within the Dendrobium Area 3 Study Area

Note: all surveyors are from Biosis Research (02 9690 2777) unless stated otherwise.

Survey Technique	Location	Date	Surveyors	Survey Effort
Dendrobium Area 2 Pilot Surveys				
Diurnal Bird Survey	Waratah Creek (upstream of 6C)	11.05.2005	Jennifer Charlton and Mark Venosta	Two x 1 hr bird surveys. General habitat notes.
Nocturnal Frog Survey	Waratah Creek (upstream of 6C)	11.05.2005	Jennifer Charlton and Mark Venosta	Two x 15 min frog surveys (with 2 people).
	Waratah Creek (upstream of 6C)	17.05.2005	Mark Venosta and Matt Beitzel	One 1 hr frog survey (with 2 people).
Targeted Littlejohn's Tree Frog Surveys				
Diurnal Habitat Search	Waratah Creek up & down stream of Fire Road 6C	8.06.2005	Jennifer Charlton and Matt Beitzel	General habitat notes, incidental bird list, tadpoles noted, photos taken.
	Fern Tree Creek	8.06.2005	Jennifer Charlton and Matt Beitzel	General habitat notes, incidental bird list, photos taken.
	Wongawilli Creek (upsteam from Fire Road 6 for approx 100 m)	9.06.2005	Jennifer Charlton and Matt Beitzel	General habitat notes, incidental bird list.
	Wongawilli Creek (downsteam of Fire Road 6)	9.06.2005	Rhidian Harrington and Glenn Muir	General habitat notes.
	Donald's Castle Creek (upstream of Fire Road 6 approx 50 m)	9.06.2005	Jennifer Charlton and Matt Beitzel	General habitat notes.
	Donald's Castle Creek (downstream of Fire Road 6)	9.06.2005	Rhidian Harrington and Glenn Muir	General habitat notes.
	Cascade Creek (upstream of monitoring points)	20.06.06	Jennifer Charlton and Rachel Blakey	General habitat notes.
	Between Banksia Creek (monitoring point 3) and Swamp 15b	19.06.2006	Glenn Muir and Bernadette Knight	General habitat notes.
	Banksia Creek from Swamp 15a monitoring point 3 to intersection with BCC	20.06.2006	Glenn Muir and Bernadette Knight	General habitat notes.
	Wongawilli Creek (upstream of Fire Road 6)	20.06.2006	Terri English and Katie Cartner	General habitat notes.
	Wongawilli Creek and WC21	20.06.2006	Terri English and Katie Cartner	General habitat notes.
	Swamp 13	19.06.2006	Terri English and Katie Cartner	General habitat notes.
	Waratah Creek and tributary accessed from seismic line (east of 6C)	31.07.2007	Jennifer Charlton and Katie Cartner	General habitat notes.
	Fern Tree Creek (upstream of monitoring points)	31.07.2007	Jennifer Charlton and Katie Cartner	General habitat notes and incidental bird list.
	Creek LC5	31.07.2007	Jennifer Charlton and Katie Cartner	General habitat notes and incidental bird list. Needs nocturnal survey.

Survey Technique	Location	Date	Surveyors	Survey Effort
Nocturnal Stream Search	Waratah Creek upstream of 6C	8.06.2005	Jennifer Charlton and Matt Beitzel	Frogs and tadpoles recorded.
	Waratah Creek downstream of 6C	8.06.2005	Jennifer Charlton and Matt Beitzel	No frogs or tadpoles recorded.
	Fern Tree Creek upstream of 6C	8.06.2005	Jennifer Charlton and Matt Beitzel	Frogs recorded.
	Fern Tree Creek downstream of 6C	8.06.2005	Jennifer Charlton and Matt Beitzel	No frogs or tadpoles recorded.
	Sandy Creek (upstream of 6C approx 30 m)	8.06.2005	Jennifer Charlton and Matt Beitzel	Frogs and tadpoles recorded.
	Sandy Creek (downstream of 6C to waterfall)	8.06.2005	Jennifer Charlton and Matt Beitzel	Frogs and tadpoles recorded.
	Sandy Creek from intersection with Fern Tree Creek, upstream to Cascade Creek waterfall	8.06.2005	Jennifer Charlton and Matt Beitzel	Frogs and tadpoles recorded.
	Waratah Creek (upstream of 6C)	19.06.2006	Jennifer Charlton and Rachel Blakey	One hour with 2 people. Frogs and tadpoles recorded.
	Waratah Creek (downstream of 6C)	19.06.2006	Jennifer Charlton and Rachel Blakey	Incidental frog recording.
	Cascade Creek (upstream of monitoring points)	20.06.2006	Jennifer Charlton and Rachel Blakey	Half an hour with 2 people. Frogs and tadpoles recorded.
	Between Banksia Creek (monitoring point 3) and Swamp 15b	19.06.2006	Glenn Muir and Bernadette Knight	Three hours with 2 people. Frogs and tadpoles recorded.
	Banksia Creek from Swamp 15a monitoring point 3 to intersection with BCC	20.06.2006	Glenn Muir and Bernadette Knight	Three hours with 2 people. Frogs and tadpoles recorded.
	Wongawilli Creek (upstream of Fire Road 6)	20.06.2006	Terri English and Katie Cartner	Five minutes with 2 people. No frogs recorded.
	Waratah Creek and tributary (east of 6C)	31.07.2007	Jennifer Charlton and Katie Cartner	One and three quarter hours with 2 people. Frogs, tadpoles and eggs recorded.
	Cascade Creek beyond monitoring points	31.07.2007	Jennifer Charlton and Katie Cartner	One and three quarter hours with 2 people. Frogs, tadpoles and eggs recorded.
	Banksia Creek from Swamp 15a monitoring point 3 to intersection with BCC	1.08.2007	Jennifer Charlton and Katie Cartner	Three hours with 2 people. Frogs recorded.
	BCC upstream from intersection with Banksia Creek to Swamp 15b	1.08.2007	Jennifer Charlton and Katie Cartner	One and three quarter hours with 2 people. Frogs and tadpoles recorded.
Elouera Colliery Fauna Monitoring				
Point Count Bird Surveys (Diurnal)	Swamp 11	Spring 2003 to Autumn 2005	Terri English, Mark Venosta, Aaron Organ, Jennifer Charlton, Katie Cartner and Matt Beitzel	Eight x 3 half hour bird surveys.

Survey Technique	Location	Date	Surveyors	Survey Effort
	Swamp 15b	Spring 2003 to Autumn 2005	As above	Seven x 3 half hour bird surveys.
Frog Surveys (Nocturnal)	Swamp 11	Spring 2003 to Autumn 2005	As above	Eight x 3 half hour frog surveys.
	Swamp 15b	Spring 2003 to Autumn 2005	As above	Eight x 3 half hour frog surveys.
Dendrobium Area 2 Fauna Monitoring				
Point Count Bird Surveys (Diurnal)	Swamp 11	Winter 2005 to Autumn 2007	Mark Venosta, Jennifer Charlton, Glenn Muir, Katie Cartner, Terri English, Matt Beitzel, Errol Nye (Biosis Research) and Mick Welsh (Fauna Consultant - 0439 436 535)	Sixteen x 3 half hour bird surveys.
	Swamp 15a	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour bird surveys.
	Swamp 15b	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour bird surveys.
	Donald's Castle Tributary (DC4)	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour bird surveys.
	Swamp 1b (north-west corner)	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour bird surveys.
	Swamp 1b (south-east section)	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour bird surveys.
	Sandy Creek	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour bird surveys.
	Banksia Creek	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour bird surveys.
	Cascade Creek	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour bird surveys.
	Fern Tree Creek	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour bird surveys.
Frog Surveys (Nocturnal)	Swamp 11	Winter 2005 to Autumn 2007	Mark Venosta, Jennifer Charlton, Glenn Muir, Katie Cartner, Terri English, Matt Beitzel, Rachel Blakey, Katrina Sofo, Melissa Starling (Biosis Research) and Mick Welsh (Fauna Consultant - 0439 436 535)	Sixteen x 3 half hour frog surveys.
	Swamp 15a	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour frog surveys.
	Swamp 15b	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour frog surveys.
	Donald's Castle Tributary (DC4)	Winter 2005 to Autumn 2007	As above	Fifteen x 3 half hour frog surveys.
	Swamp 1b (north-west corner)	Winter 2005 to Autumn 2007	As above	Fifteen x 3 half hour frog surveys.
	Swamp 1b (south-east section)	Winter 2005 to Autumn 2007	As above	Fifteen x 3 half hour frog surveys.
	Sandy Creek	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour frog surveys.
	Banksia Creek	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour frog surveys.

Survey Technique	Location	Date	Surveyors	Survey Effort
	Cascade Creek	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour frog surveys.
	Fern Tree Creek	Winter 2005 to Autumn 2007	As above	Sixteen x 3 half hour frog surveys.

Table 12: Total Survey effort for current fauna surveys conducted by Biosis Research in the Study Area.

Survey Technique	(Survey Points) Survey Effort								Total Survey Points/ Transects	Total Survey Effort (Person hrs/Trap Nights)	Survey Dates	Surveys & Species ID Performed by
	Gully		Rainforest		Ridge		Upland Swamp					
Bat Call Detection	23	58 TN	1	2	-	-	3	8 TN	**27**	**68 TN**	17 - 24 April & 7 - 18 May 2007	Jennifer Charlton, Katie Cartner, Ruth Marr, Daniel Gilmore, Mark Venosta, Katrina Sofo. Biosis Research. (02) 9690 2777 **Species ID performed by:** Narawan Williams. Ecotone Ecological Consultants (02) 4968 4901
Harp Trap	10	24 TN	-	-	-	-	-	-	**10**	**24 TN**	18 - 24 April & 10 - 15 May 2007	Jennifer Charlton, Katie Cartner, Ruth Marr, Daniel Gilmore, Mark Venosta, Katrina Sofo. Biosis Research. (02) 9690 2777
Arboreal Elliots (Small - size E)	-	-	-	-	-	-	18	72 TN	**18**	**72 TN**	8 - 12 May 2007	Jennifer Charlton, Katie Cartner, Ruth Marr, Daniel Gilmore. Biosis Research. (02) 9690 2777
Arboreal Elliots (Large - size B)	-	-	-	-	-	-	18	72 TN	**18**	**72 TN**	8 - 12 May 2007	Jennifer Charlton, Katie Cartner, Ruth Marr, Daniel Gilmore. Biosis Research. (02) 9690 2777
Arboreal Hair Tubes	-	-	-	-	-	-	60	303 TN	**60**	**303 TN**	8 - 15 May 2007	Jennifer Charlton, Katie Cartner, Ruth Marr, Daniel Gilmore. Biosis Research. (02) 9690 2777 **Species ID performed by:** Barbara Triggs. Dead Finish (03) 5158 0445
Cage Traps	36	360 TN	-	-	-	-	**-**	-	**36**	**360 TN**	7 - 18 May 2007	Jennifer Charlton, Katie Cartner, Ruth Marr, Daniel Gilmore. Biosis Research. (02) 9690 2777
Diurnal Bird Surveys	15	5.12 hrs	4	1.49 hrs	19	6.61 hrs	2	0.67 hrs	**40**	**13.88 hrs**	18 - 22 April; 9 - 16 May 2007	Jennifer Charlton, Katie Cartner, Rachel Blakey, Ruth Marr, Daniel Gilmore & Mark Venosta. Biosis Research. (02) 9690 2777

Survey Technique	(Survey Points) Survey Effort								Total Survey Points/ Transects	Total Survey Effort (Person hrs/Trap Nights)	Survey Dates	Surveys & Species ID Performed by
	Gully		Rainforest		Ridge		Upland Swamp					
Diurnal Herpetofauna Search	15	15 hrs	2	1 hrs	23	22.33 hrs	2	2 hrs	**42**	**40.33 hrs**	18 - 23 April & 8 - 16 May 2007	Jennifer Charlton, Katie Cartner, Mark Venosta, Ruth Marr, Daniel Gilmore, Naomi O'Brien, Theresa Pizzuto, Melissa Starling & Brendan Smith. Biosis Research. (02) 9690 2777
Diurnal Call Playback (Frogs: Red-crowned Toadlet, Littlejohn's Tree Frog & Green and Golden Bell Frog)	5	1.06 hrs	-	-	1	0.18 hrs	4	0.81 hrs	**10**	**2.05 hrs**	19 - 23 April; 10 & 17 May 2007	Jennifer Charlton, Katie Cartner, Rachel Blakey, Mark Venosta, Ruth Marr, Daniel Gilmore, Naomi O'Brien, Theresa Pizzuto & Melissa Starling. Biosis Research. (02) 9690 2777
Diurnal Frog Habitat Search	2	1 hr	1	1 hr	-	-	2	1 hr	**5**	**3.00 hrs**	18 - 21 April 2007	Katie Cartner, Mark Venosta, Ruth Marr and Naomi O'Brien. Biosis Research. (02) 9690 2777
Nocturnal Frog Habitat Search	1	1.5 hrs	-	-	-	-	2	2 hrs	**3**	**3.5 hrs**	16 - 21 April 2007	Jennifer Charlton, Rachel Blakey & Ruth Marr. Biosis Research. (02) 9690 2777
Nocturnal Watercourse Search (Frogs)	25	47.67 hrs	1	2 hrs	-	-	-	-	**26**	**49.67 hrs**	16 - 23 April; 14 & 16 May 2007	Jennifer Charlton, Katie Cartner, Rachel Blakey, Ruth Marr, Daniel Gilmore, Mark Venosta, Naomi O'Brien & Theresa Pizzuto. Biosis Research. (02) 9690 2777
Spotlighting (Reptiles)	2	1 hrs	-	-	7	3 hrs	-	-	**9**	**4.00 hrs**	18 - 21 April 2007	Katie Cartner, Rachel Blakey, Ruth Marr & Naomi O'Brien. Biosis Research. (02) 9690 2777
Spotlighting on foot (Mammals, Reptiles & Birds)	17	17.36 hrs	3	3 hrs	30	26.38 hrs	3	2 hrs	**53**	**48.78 hrs**	16 - 23 April; 14 May & 5 - 7 June 2007	Jennifer Charlton, Katie Cartner, Rachel Blakey, Ruth Marr, Daniel Gilmore, Mark Venosta, Naomi O'Brien, Theresa Pizzuto & Anne Rutlidge. Biosis Research. (02) 9690 2777
Spotlighting from vehicle (Mammals, Reptiles & Birds)	5	3.8 hrs	-	-	9	7.42 hrs	-	-	**14**	**11.22 hrs**	18 April & 5 - 7 June 2007	Jennifer Charlton, Katie Cartner, Rachel Blakey, Naomi O'Brien, Theresa Pizzuto & Anne Rutlidge. Biosis Research. (02) 9690 2777

Survey Technique	(Survey Points) Survey Effort								Total Survey Points/ Transects	Total Survey Effort (Person hrs/Trap Nights)	Survey Dates	Surveys & Species ID Performed by
	Gully		Rainforest		Ridge		Upland Swamp					
Stag Watches	-	-	-	-	-	-	2	3 hrs	**2**	**3 hrs**	11 & 14 May 2007	Jennifer Charlton, Katie Cartner, Ruth Marr, Daniel Gilmore & Katrina Sofo. Biosis Research. (02) 9690 2777
Nocturnal Call Playback (Frogs: Red-crowned Toadlet, Giant Burrowing Frog, Littlejohn's Tree Frog & Stuttering Frog)	9	12.96 hrs	2	1.48 hrs	-	-	2	2.83 hrs	**13**	**17.27 hrs**	16 - 23 April & 16 May 2007	Jennifer Charlton, Katie Cartner, Rachel Blakey, Ruth Marr, Mark Venosta & Naomi O'Brien. Biosis Research. (02) 9690 2777
Nocturnal Opportunistic Call Playback (Frogs: Red-crowned Toadlet & Littlejohn's Tree Frog)	4	0.99 hrs	-	-	-	-	2	1.08 hrs	**6**	**2.07 hrs**	18 - 22 April & 14 May 2007	Jennifer Charlton, Katie Cartner, Rachel Blakey, Daniel Gilmore & Naomi O'Brien. Biosis Research. (02) 9690 2777
Nocturnal Call Playback (Mammals: Koala, Squirrel Glider & Yellow-bellied Glider)	-	-	-	-	-	-	2	3.32 hrs	**2**	**3.32 hrs**	21 & 23 April 2007	Jennifer Charlton, Rachel Blakey, Mark Venosta & Naomi O'Brien. Biosis Research. (02) 9690 2777
Nocturnal Call Playback (Owls: Grass Owl, Barking Owl, Sooty Owl, Masked Owl & Powerful Owl)	2	15.10 hrs	-	-	-	-	2	15.04 hrs	**4**	**30.14 hrs**	16 - 23 April & 16 May 2007	Jennifer Charlton, Katie Cartner, Rachel Blakey, Ruth Marr, Mark Venosta, Naomi O'Brien & Theresa Pizzuto. Biosis Research. (02) 9690 2777
Nocturnal Call Playback (Bush Stone-curlew)	1	0.33 hrs	-	-	1	0.33 hrs	-	-	**2**	**0.66 hrs**	23 April 2007	Jennifer Charlton & Rachel Blakey. Biosis Research. (02) 9690 2777
Koala Search	-	-	-	-	2	1.83 hrs	-	-	**2**	**1.83 hrs**	19 April and 12 May 2007	Jennifer Charlton, Mark Venosta & Ruth Marr. Biosis Research. (02) 9690 2777
Habitat Assessments	Throughout Study Area										All Survey Dates	Jennifer Charlton, Katie Cartner, Rachel Blakey, Ruth Marr, Daniel Gilmore, Mark Venosta & Naomi O'Brien. Biosis Research. (02) 9690 2777

Survey Technique	(Survey Points) Survey Effort				Total Survey Points/ Transects	Total Survey Effort (Person hrs/Trap Nights)	Survey Dates	Surveys & Species ID Performed by
	Gully	Rainforest	Ridge	Upland Swamp				
Incidental Observations	Throughout Study Area						All Survey Dates	Jennifer Charlton, Katie Cartner, Rachel Blakey, Ruth Marr, Daniel Gilmore, Mark Venosta, Naomi O'Brien, Theresa Pizzuto, Melissa Starling, Anne Rutlidge, Sian Wilkins, Nathan Smith, Brendan Smith, Melanie Thompson & Jamie Reeves. Biosis Research. (02) 9690 2777
Scat Collection	Throughout Study Area						All Survey Dates	Jennifer Charlton, Katie Cartner, Rachel Blakey, Ruth Marr, Daniel Gilmore, Mark Venosta, Naomi O'Brien, Theresa Pizzuto, Melissa Starling, Anne Rutlidge, Sian Wilkins, Nathan Smith, Brendan Smith, Melanie Thompson & Jamie Reeves. Biosis Research. (02) 9690 2777 **Species ID performed by:** Barbara Triggs. Dead Finish (03) 5158 0445

5.4 Specific Survey Requirements

Survey methodologies employed in this SIS are consistent with DEC (2004c).

The Study Area provides many different habitat types for flora and fauna. The possible mechanisms and physical effects of subsidence are unlikely to impact on all these habitats types within the Study Area. Therefore, the current survey effort targeted those habitats where identified subsidence mechanisms could result in impacts to significant features such as creek and drainage lines, ridge lines, riparian vegetation, Uplands Swamps, gullies, rocky outcrops and overhangs, steep slopes and cliffs.

5.4.1 Specific Flora Survey Requirements

Flora surveys for the current studies were undertaken during early Autumn. Numerous flora surveys by Biosis Research have previously been undertaken in all seasons throughout the Study Area. Spring and Autumn surveys at fixed sample sites have been conducted in the Study Area since October 2003 as a component of the Dendrobium ecological monitoring program. The extent of surveys in the Study Area and Locality has facilitated the development of an intimate knowledge of the subject plant species by Biosis Research.

Large portions of the Study Area have previously been burnt (December 2001 – January 2002). Wildfire is likely to reduce the detectability of some subject species. Subject species that were not detected during the field surveys for this study, but may have potential habitat within the Study Area, have been considered for further assessment.

5.4.2 Specific Fauna Survey Requirements

Performing targeted surveys for the subject species of this study involved taking into account specific survey requirements which may influence the species detectability, including seasonal and environmental variables. In addition targeted surveys were focused on habitats that were most likely to be impacted by subsidence (e.g. ridges, creeks, riparian vegetation, swamps, gullies and rocky outcrops) and animal species likely to utilise these habitats.

The targeted surveys were conducted over three survey periods, between April and June. This autumn-winter season survey is supplemented by extensive survey work within and adjacent to the Study Area by Biosis Research during all seasons as part of the Dendrobium monitoring program and other studies. In addition, where targeted surveys were undertaken outside peak activity periods and potential habitat occurs within the Study Area, a precautionary approach has been taken, and it is assumed that the species is present in the area.

Targeted surveys for all amphibians (Littlejohn's Tree Frog, Giant Burrowing Frog, Stuttering Frog, Giant Barred Frog, Green and Golden Bell Frog and Red-crowned Toadlet) were conducted during the autumn survey period. Although many frogs are not active during this period, some are, including Littlejohn's Tree-frog's, which breeds from autumn to late winter, hence this was an appropriate time to survey for this species. Giant Burrowing Frog, Green and Golden Bell Frog, Stuttering Frog and Giant Barred Frog are mainly active in the warmer summer months when they are breeding. Biosis has undertaken extensive surveys within the Study Area across all seasons and in both creek and Upland Swamp habitat types, hence providing adequate data on the potential habitat and presence/absence of these threatened frog species within the Study Area.

The Red-crowned Toadlet is an opportunistic breeder dependant on suitable rainfall. The optimal weather conditions of heavy rains were only encountered briefly during the field surveys in this study, thus reducing the likelihood of recording Red-crowned Toadlet. Rainfall of 5 mm has been found to increase likelihood of detection of the Red-crowned Toadlet (Penman *et al.* 2006).

Diurnal bird surveys were conducted during April and May. Most of the diurnal bird subject species targeted in this study are detectable all year round except the Black Bittern. The best time to survey for this species is at dusk and night (DEC 2005c)) in Spring and Summer. In order to get a representation of all seasons, bird data from the Dendrobium fauna monitoring program has been included as part of the survey effort. During the current surveys, care was taken to maximise use of peak activity periods (dawn and dusk) as far as possible.

Call-playback for nocturnal birds (Grass Owl, Powerful Owl, Masked Owl, Sooty Owl, Barking Owl and the Bush-stone Curlew) were undertaken during April. In addition to the call-playback, stag-watching (observations of potential roost hollows) for owls was undertaken in May. These methods can be used to detect these species throughout the year, although best results are often achieved during the breeding period. Given the survey period was outside the breeding season for Barking Owl, Powerful Owl and Bush Stone-curlew, call playback was undertaken early evening and or before dusk (for owls) and diurnally and or at dusk (for Bush Stone-curlew) in order to maximise the results, as per the threatened Biodiversity Survey and Assessment draft guidelines (DEC 2004e).

Based on the DECC species profiles, most of the subject mammal species can be surveyed all year round with the exception of the Koala. Targeted surveys for the Koala largely focused on call-playback; searching for evidence of Koalas such as scat and tracks and identifying key habitat features such as foraging resources. The Eastern Pygmy-possum has a low detection rate during autumn and winter; in order to maximise survey effort for this species traps were placed in areas of greatest potential activity/habitat such as those with high numbers of nectar and pollen producing plants including Banksias, eucalypts and callistamons. It should be noted that the Eastern Pygmy-possum has been previously recorded within the Study Area during winter by Biosis Research.

Bat surveys were conducted in the autumn survey period. This is not recognised as the best time to survey for these species as summer is generally the period of greatest activity. However, all microchiropteran subject species targeted during the surveys can also be surveyed in spring and autumn. In order to maximise the results, harp traps and ultrasonic recorders were placed in areas of high activity including flyways (e.g. tracks) and watering points (e.g. creeks). In addition, a review of any past records was undertaken to determine if possible roost sites occur within the Study Area (DEC 2004e).

The Grey-headed Flying–fox (megachirpoteran species) was surveyed from April to June. Although this species is often more active in summer, spotlighting techniques used to detect this species can be undertaken all year round (DEC 2004e). In addition to the spotlighting surveys, analysis of foraging resources available in the Study Area was also undertaken to determine areas of potential habitat, as per the threatened Biodiversity Survey and Assessment draft guidelines (DEC 2004e).

The Broad-headed Snake and Rosenberg's Goanna were surveyed during the autumn/winter period. This season is appropriate to survey the Broad-headed Snake because it is much more easily detected in its late autumn to winter habitat (within crevices in west-facing sandstone rocky outcrops) than its cryptic summer habitat (within tree hollows). Rosenberg's Goanna is best surveyed during the summer period as this is its period of greatest activity (King and Green 1993), although it is very hard to trap/detect. Surveys for Rosenberg's Goanna focused on identifying areas of potential habitat and key habitat features (e.g. termite mounds) and searching for other signs of this species, such as tracks. Furthermore, data from previous surveys across all seasons has been considered to support this survey effort.

No targeted surveys were undertaken for the Giant Dragonfly. The Giant Dragonfly was recently recorded in the Locality and potential habitat for this species occurs within the Upland Swamps and heath within the Study Area (Ian Baird, pers. comm.). Although opportunistic surveys were undertaken, the Giant Dragonfly is highly cryptic and therefore a precautionary approach has been undertaken for this species, whereby it is assumed the Giant Dragonfly is present where potential habitat exists.

5.5 Survey Results

5.5.1 Flora Survey Results

A total of 373 vascular plant species were recorded from quadrats during the current surveys in the Study Area (Appendix 4, Tables 18-21). No weed species were recorded within quadrat samples of the Study Area.

Subject Species

Two subject plant species were recorded in the Study Area during the field surveys, *Acacia bynoeana* and *Pultenaea aristata*. Survey results discussing conservation status, habitat utilisation and local and regional abundance are included in Section 6.3.5. The location of subject plant species recorded during the surveys is shown in Figure 16.

<u>*Acacia bynoeana*</u>

During the current surveys *Acacia bynoeana* was recorded from various locations within the Study Area. These recordings were in habitat types in concordance with those stated by DEC (2005a) and were concentrated in open, disturbed sites including trail margins, edges of roadside spoil mounds, areas disturbed by ants, and in relatively open areas that had been recently burnt (< 5 yr). The species was recorded in deep sandy soils on broad flat ridges and plateaus, generally in areas where sandstone outcropping was absent. Soils were notably bare with low leaf litter coverage.

Known habitat within the Study Area is predominantly within or adjacent to disturbed remnants of Exposed Sandstone Scribbly Gum Woodland. Typical vegetation associations included a dominant canopy of *Eucalyptus racemosa, Corymbia gummifera* and *E. oblonga* with a sparse understorey of shrubs to 3 metres high including *Leptospermum trinervium* and *Acacia linifolia, Banksia spinulosa* and ground layer including *Cyathochaeta diandra, Patersonia glaberata* and *Lepyrodia scariosa.*

Acacia bynoeana was recorded from four locations within the Study Area (Figure 16). A total of 221 plants of *Acacia bynoeana* were recorded in the Study Area during the current surveys, with:

- 191 plants recorded along or adjacent to the Fire Road 6 easement; and
- 30 plants recorded off Fire Road 6A adjacent to the Maldon Dombarton railway line in the centre of the Study Area, associated with an Upland Swamp and previous disturbance from seismic work.

Pultenaea aristata

Pultenaea aristata is discussed further in Section 6.3.5 (Affected Threatened Flora Profiles).

ROTAPs within the Study Area (Briggs and Leigh 1996)

Some plant species recorded within the Study Area during the field surveys or during previous flora surveys include those that are listed as ROTAPs (Rare or Threatened Australian Plants, Briggs 1996). Two ROTAP species, *Lomandra fluviatilis* and *Darwinia grandiflora* were recorded in the Study Area. Despite their respective listings as ROTAPs, *Lomandra fluviatilis* and *Darwinia grandiflora* are not listed on either the TSC or EPBC Acts, and as such, species profiles (Section 6.3.5) and Assessments of Significance (Section 9.1) have not been conducted for these species.

5.5.2 Fauna Survey Results

A total of 129 vertebrate animal species were recorded within the Study Area during the current surveys, comprising 127 (98%) native species and two (2%) introduced species (Appendix 5). A total of 176 animal species were detected during previous surveys conducted by Biosis Research and records from the Birds Australia Atlas Database. A list of all animal species recorded during the current and previous surveys is included in Appendix 5.

Subject Fauna Species

Of the 55 fauna subject species listed in Section 4.4, 22 species were recorded in the Study Area, either during this study or during previous studies conducted by Biosis Research. Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Gang-gang Cockatoo, Glossy Black-cockatoo, Barking Owl, Eastern Freetail Bat, Grey-headed Flying-fox, Eastern Bentwing-bat, Large-eared Pied Bat, and Southern Myotis were recorded within the Study Area during the current surveys. The locations of subject fauna species recorded during the current and previous surveys are shown on Figure 17.

Biosis Research also recorded the following threatened microbats within the Study Area during the current surveys with 'probable' certainty: Little Bentwing-bat, Eastern False Pipistrelle, Yellow-bellied Sheathtail-bat and Greater Broad-nosed Bat; and 'possible' certainty: Golden-tipped Bat and Eastern Cave Bat.

Olive Whistler, Powerful Owl, Eastern Pygmy-possum, Koala and Rosenberg's Goanna have also been recorded within the Study Area by Biosis Research during previous surveys.

6.0 ASSESSMENT OF LIKELY IMPACTS ON THREATENED SPECIES AND POPULATIONS

As discussed in Section 3.2, the environmental impacts of the Proposal are associated with subsidence resulting from longwall mining techniques, as well as all supporting activities such as environmental studies, ongoing monitoring and mitigation and rehabilitation of subsidence impacts. Section 6.0 (this section) discusses these impacts in relation to the subject species.

6.1 Assessment of Species Likely to be Affected

Based on the current surveys, habitat assessment, previous surveys within the Locality (Section 5.2), review of literature and consideration of likely impacts, the list of subject species identified in Section 4.3 and 4.4 has been refined to a list of Affected Subject Species. Affected Subject Species are those considered likely to be affected by the Proposal.

Where potential habitat for threatened biota has been recorded within the Study Area, there may be no known mechanism in which that particular habitat type may be impacted by subsidence (see Section 3.1.2). In the absence of direct or indirect impacts on potential habitat for threatened biota, Species Profiles (Sections 6.3.5 and 6.3.6) and Assessments of Significance (Section 9.0) under the TSC Act have not been conducted for these species.

6.1.1 Determination of Affected Flora

Table 13 is the list of Subject Plant Species derived from the analysis of previous records and potential habitat within the Study Area as described in Section 4.3.1. The Affected Flora have been derived from an additional analysis of the Subject Plant Species (Section 4.3.1) against the potential impacts of subsidence on their habitat within the Study Area (Table 13). Where there is no potential impact from subsidence predicted in a species' habitat, the species is not considered to be Affected Flora, and as such, has not been considered further in the SIS. Where there is potential for impact from subsidence to a species' habitat, the plant species is considered to be Affected Flora and is considered further in the SIS.

Table 13 illustrates that four plant species, *Cryptostylis hunteriana*, *Epacris purpurascens* var. *purpurascens*, *Leucopogon exolasius* and *Pultenaea aristata* are considered to be Affected Flora. As such, Species Profiles (Section 6.3.5) have been included and Assessments of Significance (Section 9.1) conducted for these plant species.

Table 13. Determination of Affected Flora

Scientific Name	Potential Habitat in Study Area			Previously Recorded (Notes on Potential Habitat)	Affected Flora (Justification for Further Consideration in SIS)
	Upland Swamps	Creek Lines	Ridge Lines		
Acacia baueri ssp. *aspera*	No	No	Yes	No. Potential habitat for this species is considered to be present within Exposed Sandstone Scribbly Gum Woodland (ESSW) and *Rock Plate Heath-Mallee* (RPHM) plant communities within the Study Area.	No. The possible mechanisms and physical effects of subsidence are unlikely to alter ridge plant communities within the Study Area.
Acacia bynoeana	No	No	Yes	Yes. Previously recorded by Biosis Research in large populations within the ridge line plant community ESSW.	No. The possible mechanisms and physical effects of subsidence are unlikely to alter ridge plant communities within the Study Area.
Cryptostylis hunteriana	Yes	Yes	Yes	Yes. This species does not appear to have well defined habitat preferences and has been recorded from a range of plant communities, including swampy heaths and steep bare hillsides in tall eucalypt forest. Many locations appear to be on well drained sandy soils from both moist and dry habitats (Bell 2001). On this basis, potential habitat within the Study Area is conservatively applied to all plant communities in the Study Area, except Coachwood Warm Temperate Rainforest.	**Yes.** Based on potential habitat within Upland Swamp and Creek Line plant communities within the Study Area.
Epacris purpurascens var. *purpurascens*	Yes	Yes	Yes	No. Potential habitat is considered to be within Sandstone Gully Peppermint Forest (SGPF), Upland Swamps Banksia thicket (USBT), Upland Swamps Fringing Eucalypt Woodland (USFEW), Upland Swamps Sedgeland Heath Complex (USSHC), Upland Swamps: Tea-tree Thicket (USTT), Transitional Shale Stringybark Forest (TSSF), Nepean Sandstone Gully Forest (NSGF) and Sandstone Riparian Scrub (SRS) plant communities within the Study Area.	**Yes.** Based on potential habitat within Upland Swamp and Creek Line plant communities within the Study Area.
Grevillea parviflora ssp. *parviflora*	No	No	Yes	No. Marginal potential habitat is considered to be within TSSF plant community within the Study Area.	No. The possible mechanisms and physical effects of subsidence are unlikely to alter ridge plant communities within the Study Area.

Scientific Name	Potential Habitat in Study Area			Previously Recorded (Notes on Potential Habitat)	Affected Flora (Justification for Further Consideration in SIS)
	Upland Swamps	Creek Lines	Ridge Lines		
Leucopogon exolasius	No	Yes	No	No. Potential habitat is considered to be within SGPF, NSGF and SRS plant communities within the Study Area.	**Yes.** Based on potential habitat within Creek Line plant communities.
Melaleuca deanei	No	No	Yes	No. Potential habitat is considered to be within ESSW and RPHM plant communities within the Study Area.	No. The possible mechanisms and physical effects of subsidence are unlikely to alter ridge plant communities within the Study Area.
Persoonia acerosa	No	Yes	Yes	No. Recorded by Biosis Research (March, 2007) within the Locality. Potential habitat is considered to be within ESSW and RPHM plant communities within the Study Area.	No. The possible mechanisms and physical effects of subsidence are unlikely to alter ridge plant communities within the Study Area.
Persoonia bargoensis	No	No	Yes	No. Potential habitat is considered to be within TSSF and ESSW plant communities within the Study Area.	No. The possible mechanisms and physical effects of subsidence are unlikely to alter ridge plant communities within the Study Area.
Persoonia hirsuta	No	No	No	Yes. Potential habitat is considered to be within TSSF and ESSW plant communities within the Study Area.	No. The possible mechanisms and physical effects of subsidence are unlikely to alter ridge plant communities within the Study Area.
Pultenaea aristata	Yes	Yes	Yes	Yes. Previously recorded by Biosis Research in large populations within the Upland Swamps and adjacent areas of impeded drainage within ESSW and SGPF plant communities within the Locality.	**Yes.** Based on known and potential habitat within Upland Swamp plant communities of the Study Area.

6.1.2 Determination of Affected Fauna

Table 14 is the list of Subject Animal Species derived from the analysis of previous records and potential habitat within the Study Area as described in Section 4.4.1.

The Affected Fauna have been derived from an additional analysis of the Subject Animal Species (Section 4.4.1) against the potential impacts of subsidence on their habitat within the Study Area (Table 14). Where there is no potential for impact from subsidence to a species' habitat, the species is not considered to be Affected Fauna and is not considered further in the SIS. Other criteria used as a basis to exclude some species from further consideration as Affected Fauna include: the Study Area is not within the species' normal range and or the species has not been recorded recently within the Locality and is thought to be locally extinct. Where there is potential for a species' habitat to be impacted by subsidence, the animal species is considered to be Affected Fauna and is considered further in the SIS.

Table 14 illustrates that 32 animal species are considered to be Affected Fauna. As such, Species Profiles (Section 6.3.6) have been included and Assessments of Significance (Section 9.2) conducted for these animal species.

Table 14: Determination of Affected Fauna

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Amphibians							
Litoria littlejohni	Littlejohn's Tree Frog	Yes	Yes	Yes	No	Yes. Biosis Research has recorded a large population and other smaller populations of this species within the Study Area. Approximately 30 individuals were recorded during the current surveys over eight different sites (Donald's Castle Creek, Creek LA4, Native Dog Creek, Banksia Creek, Sandy Creek, Creek LC7 and Upland Swamp's 7 and 15b) occurring within SGPF, USSHC, USFEW and ESSW. The species is regularly encountered by Biosis Research during monitoring and targeted surveys and is possibly the largest population ever recorded. The most recent targeted surveys (winter 2007) recorded 77 individuals, although these surveys did not cover all known locations within the Study Area. The largest population recorded within the Study Area occurs within the Sandy Creek Catchment (within SGPF, TOPBF, USSHC, USBT and ESSW plant communities). Biosis Research has also recorded the species at five locations outside the Sandy Creek Catchment, within the Study Area. Other plant communities that may provide potential habitat include USTT, RPHM, NSGF and MGF.	Yes. Direct impacts on the species (individuals and populations) are likely. The loss of surface flow and deep pools from creek lines, changes to water flow regimes and water quality, and hydrological changes within Upland Swamps are likely to impact on the life-cycle of the species, if such events occur. Indirect impacts are also possible. For example, a creek bed fracture occurring above a longwall within the Subject Site may lead to impacts further downstream.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Heleioporus australiacus	Giant Burrowing Frog	Yes	Yes	Yes	No	Yes. Biosis Research recorded two individuals during the current surveys; one along Donald's Castle Creek (SGPF and USSHC) and one on a ridge line (ESSW) within the Donald's Castle Creek Catchment. Biosis Research has also recorded the species during monitoring surveys along two creek lines (Banksia Creek and SC10C) within Upland Swamp habitat (USSHC). Other plant communities that may provide potential habitat include USBT, USFEW, USTT, RPHM, TOPBF, NSGF and MGF.	Yes. Direct impacts on the species (individuals and populations) are likely. The loss of surface flow and deep pools from creek lines, changes to water flow regimes and water quality, and hydrological changes within Upland Swamps are likely to impact on the life-cycle of the species, if such events occur. Indirect impacts are also possible. For example, a creek bed fracture occurring above a longwall within the Subject Site may lead to impacts further downstream. The Giant Burrowing Frog is considered to be an "uncommon resident" within the Greater Southern Sydney Region.
Mixophyes balbus	Stuttering Frog	No	No	Yes	Yes	No. Potential habitat is considered to be within CWTR in the Study Area.	Yes. Direct impacts on the species are possible. If the species is present, the loss of surface flow and deep pools from creek lines and changes to water flow regimes and water quality within rainforest habitat could impact on the life-cycle of the species. Indirect impacts are also possible. For example, a creek bed fracture occurring above a longwall within the Subject Site may lead to impacts further downstream.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Mixophyes iteratus	Giant Barred Frog	No	No	Yes	Yes	No. Potential habitat is considered to be within CWTR in the Study Area.	No. Direct or indirect impacts on the species are unlikely. The Study Area occurs well outside the species' current known limit of distribution, with the closest record occurring 120 km to the north-east of the Study Area. Furthermore, the species is considered to be extinct within the Greater Southern Sydney Region (including the Study Area) (DEC 2005Ž).
Pseudophryne australis	Red-crowned Toadlet	Yes	Yes	Yes	No	Yes. Biosis Research made 25 observations of Red-crowned Toadlet during the current surveys at five different sites within SGPF, TOPBF and USSHC (LC8, WC21, SC10C, Upland Swamp 10 and an unnamed drainage line near Upland Swamp 15b). It should be noted that two sites were surveyed more than once and therefore the same individuals may have been recounted. Biosis Research has also recorded the species during previous surveys along drainage line SC10C and a second unnamed drainage line (both SGPF), adjacent to Upland Swamp 15b (USSHC) within the Study Area, as well as within the Locality (on ridge lines). Other plant communities that may provide potential habitat include ESSW, USBT, USFEW, USTT, RPHM, MGF and NSGF.	Yes. Direct impacts on the species (individuals and populations) are likely. Changes to water flow regimes and water quality in ephemeral drainage lines and Upland Swamps are likely to impact on the life-cycle of the species, if such events occur. Indirect impacts are also possible. For example, a creek bed fracture occurring above a longwall within the Subject Site may lead to impacts further downstream (DEC 2005Ž).
Birds							

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Ixobrychus flavicollis	Black Bittern	No	No	Yes	Yes	No. Potential habitat is considered to be within SGPF, CWTR, TOPBF, MGF and NSGF plant communities where there is permanent water and dense vegetation.	Yes. If the species is present, impacts are possible. Loss of water from otherwise permanent watercourses and vegetation die-back as a result of gas emissions (which may cause dense riparian vegetation to thin-out) may impact potential habitat for this species. However, vegetation die-back due to gas emissions has only been observed once in the Southern Coalfields (within the Cataract River) and is not expected to be significant within the Study Area.
Burhinus grallarius	Bush Stone-curlew	No	Yes	Yes	No	No. Potential habitat is considered to be within ESSW, SGPF and TSSF where there is a sparse grassy layer and fallen timber.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area. Furthermore, the species is presumed to be locally extinct within the Greater Southern Sydney Region (DEC 2005Ž).

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Callocephalon fimbriatum	Gang-gang Cockatoo	Yes	Yes	Yes	Yes	Yes. Biosis Research recorded approximately 30 individuals during the current surveys within ESSW, SGPF, USSHC, USBT and USFEW plant communities. The species is also regularly encountered during monitoring surveys and has been recorded within SGPF, USFEW, USSHC and TOPBF plant communities within the Study Area, as well as within the Locality (along creek and ridge lines). Other plant communities that may provide potential habitat include USTT, TSSF, MGF, NSGF and CWTR.	Yes. The Proposal has the potential to directly impact foraging resources for this species. The species was recorded foraging in trees along the banks of Wongawilli Creek and other watercourses within the Study Area. Possible impacts include vegetation die-back due to gas emissions and therefore loss of feed trees. However, vegetation die-back due to gas emissions has only been observed once in the Southern Coalfields (within the Cataract River) and is not expected to be significant within the Study Area. The Proposal is unlikely to impact on breeding and roosting habitat (e.g. tree hollows).
Calyptorhynchus lathami	Glossy Black-cockatoo	No	Yes	Yes	No	Yes. Biosis Research recorded six Glossy Black-cockatoos during the current surveys all within the SGPF plant community. The species has also been recorded during previous surveys within ESSW, SGPF and USFEW in the Study Area, as well as within the Locality (on ridge lines). Other plant communities that may provide potential habitat include RPHM, TSSF and NSGF.	Yes. The Proposal has the potential to directly impact foraging resources for this species. The species was recorded foraging in Allocasuarina trees along the banks of Wongawilli Creek and other watercourses within the Study Area. Possible impacts include vegetation die-back due to gas emissions and therefore loss of feed trees. However, vegetation die-back due to gas emissions has only been observed once in the Southern Coalfields (within the Cataract River) and is not expected to be significant within the Study Area. The Proposal is unlikely to impact on breeding and roosting habitat (e.g. tree hollows).

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	No	Yes	Yes	No	No. Potential habitat is considered to be within ESSW, SGPF and TSSF where there is an open grassy understorey and fallen timber.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area.
Coracina lineata	Barred Cuckoo-shrike	No	Yes	Yes	Yes	No. Potential habitat is considered to be within ESSW, SGPF, CWTR, TOPBF and MGF plant communities, particularly along timbered watercourses.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area. Furthermore, the DECC do not consider the species to be of conservation concern for the region (DEC 2005Ž).
Ptilinopus magnificus	Wompoo Fruit-Dove	No	No	Yes	Yes	No. Potential habitat is considered to be within SGPF, CWTR, TOPBF and MGF plant communities where suitable fruit-bearing trees are present.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its foraging, breeding or roosting resources within the Study Area. Furthermore, the record occurring with 10 km of the Study Area is from 1920 and the species is considered to be “locally extinct" within the Greater Southern Sydney Region (DEC 2005Ž). The species’ main distribution occurs north of the Hunter Valley (DEC 2005‘).

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Ptilinopus regina	Rose-crowned Fruit-Dove	No	No	No	Yes	No. Potential habitat is considered to be within the CWTR plant community where suitable fruit-bearing trees are present.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its foraging, breeding or roosting resources within the Study Area. Furthermore, the records occurring with 10 km of the Study Area are likely to be vagrants as the species' main distribution occurs further north (DEC 2005…).
Ptilinopus superbus	Superb Fruit-Dove	No	No	Yes	Yes	No. Potential habitat is considered to be within SGPF, CWTR, TOPBF and MGF plant communities where suitable fruit-bearing trees are present.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its foraging and roosting resources within the Study Area. Furthermore, the species only breeds in northern NSW (DEC 2005Œ) and therefore has no potential breeding habitat within the Study Area.
Grantiella picta	Painted Honeyeater	No	Yes	Yes	No	No. Potential habitat is considered to be within ESSW, SGPF, RPHM, TOPBF, MGF and NSGF plant communities where mistletoes are present.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area. Furthermore, the species is presumed to be locally extinct within the Greater Southern Sydney Region (DEC 2005Ž).

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	No	Yes, but suboptimal	Yes, but suboptimal	No	Yes. Previously recorded by Biosis Research within the Locality on one occasion on a ridge line. Potential habitat within the Study Area is considered to be within ESSW, SGPF, USTT, TOPBF and NSGF plant communities, but is suboptimal due to the lack of preferred feed trees.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area. Furthermore, the Study Area only provides suboptimal potential habitat for this species.
Xanthomyza phrygia	Regent Honeyeater	Yes, but suboptimal	Yes, but suboptimal	Yes, but suboptimal	No	No. Potential habitat is considered to be within ESSW, SGPF, TSSF, NSGF, SRS and Upland Swamp plant communities, but is suboptimal due to the lack of preferred feed trees.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its foraging and roosting resources within the Study Area. Furthermore, the potential foraging and roosting resources within the Study Area are suboptimal for this species. The Study Area is unlikely to provide potential breeding habitat for this species.
Lophoictinia isura	Square-tailed Kite	Yes	Yes	Yes	Yes	No. Potential habitat is considered to occur within all plant communities in the Study Area, particularly along timbered watercourses.	No. Direct or indirect impacts on the species are unlikely. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential breeding and/or roosting habitat for this species. Whilst prey species may be potentially impacted by subsidence, this is considered unlikely to impact on the Square-tailed Kite, given its large hunting range of more than 100 km^2 (DEC 2005Š).

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Pachycephala olivacea	Olive Whistler	Yes	Yes	Yes	Yes	Yes. Previously recorded by Biosis Research on one occasion within ESSW adjacent to USSHC (Upland Swamp 1b). Further potential habitat occurs within SGPF, CWTR, USBT, USFEW, USTT, RPHM, TSSF, TOPBF, MGF and NSGF plant communities.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area. Furthermore, the species is presumed to be a rare visitor to the Greater Southern Sydney Region (DEC 2005Ž) and therefore unlikely to be wholly dependent on resources within the Study Area for continued survival.
Pyrrholaemus sagittatus	Speckled Warbler	Yes	Yes	Yes	No	No. Potential habitat is considered to be within ESSW, SGPF, RPHM, TSSF and Upland Swamp plant communities particularly where there is a grassy understorey, rocky ridge or gully.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area.
Stagonopleura guttata	Diamond Firetail	Yes	Yes	Yes	No	No. Potential habitat is considered to be within ESSW, SGPF, TSSF, SRS and Upland Swamp plant communities particularly where there is a grassy understorey and watercourse nearby.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Lathamus discolor	Swift Parrot	No	Yes	Yes	No	No. Potential habitat is considered to be within ESSW, SGPF, RPHM, TSSF, TOPBF, NSGF and SRS plant communities.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its foraging and roosting resources within the Study Area. Furthermore, the species only breeds in Tasmania (DEC 2005) and therefore has no potential breeding habitat within the Study Area.
Neophema pulchella	Turquoise Parrot	No	Yes	Yes	No	No. Potential habitat is considered to be within ESSW, SGPF, RPHM, TSSF and SRS plant communities where suitable hollow-bearing trees and foraging resources are available.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area.
Pezoporus wallicus wallicus	Eastern Ground Parrot	Yes	No	No	No	No. Potential habitat is considered to be within the Upland Swamp and RPHM plant community.	Yes. Changed hydrology and water quality within Upland Swamps as a result of subsidence within the Study Area may impact on the species, if present. However, significant changes to vegetation within the swamps are not anticipated and have not previously been observed within swamps that have been mined beneath.
Dasyornis brachypterus	Eastern Bristlebird	Yes	No	No	No	No. Potential habitat is considered to be within the Upland Swamp and RPHM plant community.	Yes. Changed hydrology and water quality within Upland Swamps as a result of subsidence within the Study Area may impact on the species, if present. However, significant changes to vegetation within the swamps are not anticipated and have not previously been observed within swamps that have been mined beneath.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	No	Yes	Yes	No	No. Potential habitat is considered to be within ESSW, SGPF, RPHM, TSSF and SRS plant communities.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area.
Petroica rodinogaster	Pink Robin	No	No	Yes	Yes	No. Potential habitat is considered to be within SGPF, CWTR, TOPBF, MGF and NSGF plant communities particularly in densely vegetated gullies.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area.
Ninox connivens	Barking Owl	Yes	Yes	Yes	No	Yes. Biosis Research recorded one Barking Owl during the current surveys within ESSW. The species has also been previously recorded once during previous surveys within SGPF. Further potential habitat occurs within RPHM, TSSF, TOPBF, MGF, NSGF, SRS and Upland Swamp plant communities.	Yes. The Proposal may result in indirect impacts on this species. Whilst breeding and roosting habitat (i.e. tree hollows) are unlikely to be impacted by subsidence, some prey species reliant on Upland Swamps, creek lines and ridge lines may be impacted by the Proposal. Therefore, foraging resources of the Barking Owl may be impacted. It should be noted however, that a significant reduction in prey items due to subsidence-related events is considered highly unlikely.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Ninox strenua	Powerful Owl	Yes	Yes	Yes	Yes	Yes. Previously recorded by Biosis Research once within the Study Area in SGPF adjacent to USSHC (Upland Swamp 15a). The species has also been recorded a number of times within the Locality by Biosis Research in gully habitat. Further potential habitat occurs within ESSW, CWTR, RPHM, TSSF, TOPBF, MGF, NSGF, SRS and Upland Swamp plant communities in the Study Area.	Yes. The Proposal may result in indirect impacts on this species. Whilst breeding and roosting habitat (i.e. tree hollows) are unlikely to be impacted by subsidence, some prey species reliant on Upland Swamps, creek lines and ridge lines may be impacted by the Proposal. Therefore, foraging resources of the Powerful Owl may be impacted. It should be noted however, that a significant reduction in prey items due to subsidence-related events is considered highly unlikely.
Tyto capensis	Grass Owl	Yes, but suboptimal	No	No	No	No. Potential habitat is considered to be within Upland Swamp plant communities, but is suboptimal.	Yes. Changed hydrology and water quality within Upland Swamps as a result of subsidence within the Study Area may impact on the species, if present. However, significant changes to vegetation within the swamps are not anticipated and have not previously been observed within swamps that have been mined beneath. Furthermore, the potential habitat within the Study Area is suboptimal for this species. In addition, the closest record of the Grass Owl is approximately 126 km north of the Study Area. The DECC do not consider the species to be of conservation concern for the region (DEC 2005Ž).

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Tyto novaehollandiae	Masked Owl	Yes	Yes	Yes	Yes	No. Potential habitat is considered to be within ESSW, SGPF, CWTR, RPHM, TSSF, TOPBF, MGF, NSGF, SRS and Upland Swamp plant communities.	Yes. The Proposal may result in indirect impacts on this species. Whilst potential breeding and roosting habitat (i.e. tree hollows) are unlikely to be impacted by subsidence, some prey species reliant on Upland Swamps, creek lines and ridge lines may be impacted by the Proposal. Therefore, potential foraging resources of the Masked Owl may be impacted. It should be noted however, that a significant reduction in prey items due to subsidence-related events is considered highly unlikely.
Tyto tenebricosa	Sooty Owl	Yes	Yes	Yes	Yes	No. Previously recorded by Biosis Research at least five times within the Locality in rainforest habitat. Further potential habitat occurs within ESSW, SGPF, CWTR, RPHM, TSSF, TOPBF, MGF, NSGF, SRS and Upland Swamp plant communities in the Study Area.	Yes. The Proposal may result in indirect impacts on this species. Whilst potential breeding and roosting habitat (i.e. tree hollows) are unlikely to be impacted by subsidence, some prey species reliant on Upland Swamps, creek lines and ridge lines may be impacted by the Proposal. Therefore, potential foraging resources of the Sooty Owl may be impacted. It should be noted however, that a significant reduction in prey items due to subsidence-related events is considered highly unlikely.
Mammals							

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Cercartetus nanus	Eastern Pygmy-possum	Yes	Yes	Yes	Yes	Yes. Previously recorded by Biosis Research on four separate occasions: twice along Banksia Creek (in SGPF) and twice within Upland Swamp habitat (USBT and USSHC) in Upland Swamps 15b and 135. Further potential habitat occurs within ESSW, USFEW, USTT, CWTR, RPHM, TSSF, MGF, TOPBF and NSGF plant communities, particularly where Banksia species are present.	Yes. The Proposal has the potential to impact foraging resources for this species; Changed hydrology and water quality within Upland Swamps may result in a reduction in the availability of feed trees (Banksias). However, significant changes to vegetation within the swamps are not anticipated and have not previously been observed within swamps that have been mined beneath. The Proposal is unlikely to impact on breeding and roosting habitat (e.g. tree hollows and abandoned bird's nests).
Dasyurus maculatus	Spotted-tailed Quoll	Yes	Yes	Yes	Yes	No. Potential habitat is considered to be within ESSW, SGPF, CWTR, RPHM, TOPBF, MGF, NSGF and Upland Swamp plant communities where suitable den sites and foraging resources are present, within the Study Area.	Yes. Direct impacts on the species are possible. If the species is present, rock falls, the collapse of rock crevices, boulder piles and animal burrows may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding and roosting habitat. Potential foraging resources may be indirectly impacted where prey species rely on Upland Swamp, creek line or ridge line habitats. It should be noted however, that a significant reduction in prey items due to subsidence-related events is considered highly unlikely.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Petrogale penicillata	Brush-tailed Rock-Wallaby	Yes	Yes	Yes	Yes	No. Potential habitat is considered to be within ESSW, SGPF, CWTR, RPHM, TOPBF, MGF, NSGF and Upland Swamp plant communities that occur within 200 m of rocky areas.	Yes. Direct impacts on the species are possible. If the species is present, rock falls, the collapse of caves (if present), steep slopes, rock crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding and roosting habitat. Some potential foraging resources may be impacted (e.g. Upland Swamps).
Macropus parma	Parma Wallaby	Yes	Yes	Yes	Yes	No. Potential habitat is considered to be within ESSW, SGPF, CWTR TOPBF, MGF, NSGF and Upland Swamp plant communities with thick, shrubby understoreys and grassy areas nearby.	No. Direct or indirect impacts on the species are unlikely. The possible mechanisms of subsidence and physical effects of subsidence are unlikely to alter potential breeding and roosting habitat for this species within the Study Area. Any impacts on potential foraging resources are likely to be negligible for this species. Furthermore, the species is considered to be extinct within the Greater Southern Sydney Region (DEC 2005Ž).
Mormopterus norfolkensis	Eastern Freetail Bat	No	Yes	Yes	No	Yes, with *definite* certainty. This species was detected a number of times throughout the Study Area with varying levels of confidence. The highest level recorded was *definite* certainty in creek line habitats within SGPF. Further potential habitat occurs within ESSW, TSSF, TOPBF, MGF and NSGF plant communities.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	Yes	Yes	Yes	No	No. A single record exists within the Study Area from 1997 and occurs within ESSW (DECC Atlas of NSW Wildlife). Potential habitat is considered to be within ESSW, SGPF, RPHM, TSSF, NSGF and Upland Swamp plant communities where there is a heathy understorey on sandy soil.	Yes. Direct impacts on the species are possible. The collapse of rock ledges, rock crevices and burrows may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding and roosting habitat. Some potential foraging resources may be impacted (e.g. Upland Swamps).
Petaurus australis	Yellow-bellied Glider	No	No	Yes, but limited	No	No. Potential habitat within the Study Area is considered to be limited, but does occur within SGPF, TOPBF and MGF where suitable hollow-bearing trees are present.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area.
Petaurus norfolcensis	Squirrel Glider	Yes	Yes	Yes	No	No. Potential habitat within the Study Area is considered to be within ESSW, SGPF, RPHM, TSSF, TOPBF, MGF, NSGF and Upland Swamp plant communities where suitable hollow-bearing trees and foraging resources are present.	Yes. The Proposal has the potential to impact foraging resources for this species; changed hydrology and water quality within Upland Swamps may result in a reduction in the availability of feed trees (Banksias). However, significant changes to vegetation within the swamps are not anticipated and have not previously been observed within swamps that have been mined beneath. The Proposal is unlikely to impact on breeding and roosting habitat (e.g. tree hollows).

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Phascolarctos cinereus	Koala	No	Yes	Yes	No	Yes. Previously recorded by Biosis Research on at least five separate occasions: all within woodland (ESSW) adjacent to Upland Swamp habitat (USSHC). Further potential habitat occurs within TSSF, SGPF and NSGF plant communities.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area.
Potorous tridactylus	Long-nosed Potoroo	Yes	Yes	Yes	Yes	No. Potential habitat within the Study Area is considered to be within ESSW, SGPF, CWTR, RPHM, TSSF, NSGF and Upland Swamp plant communities where there is a dense, heathy understorey on sandy soil, with occasional open areas.	Yes. Changed hydrology and water quality within Upland Swamps as a result of subsidence within the Study Area may impact on the species, if present, by reducing their available potential habitat. However, significant changes to vegetation within the swamps are not anticipated and have not previously been observed within swamps that have been mined beneath.
Pteropus poliocephalus	Grey-headed Flying-fox	No	Yes	Yes	Yes	Yes. This species was recorded once during the current surveys in ridge habitat (ESSW). It has also been previously recorded by Biosis Research within gully habitat (SGPF) at Fern Tree Creek. Further potential habitat occurs within CWTR, TSSF, TOPBF, MGF and NSGF plant communities.	No. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to alter potential habitat for this species in a way that would impact its breeding, foraging and/or roosting resources within the Study Area.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Miniopterus australis	Little Bentwing-bat	Yes	Yes	Yes	Yes	Yes, with *probable* certainty. This species was recorded once within Upland Swamp habitat (USFEW) although it may be confused with Chocolate Wattled Bat. Potential habitat for the Little Bentwing-bat occurs within ESSW, SGPF, CWTR, RPHM, TSSF, TOPBF, MGF, NSGF and Upland Swamp plant communities.	Yes. Direct impacts on the species are possible. If the species is present, the collapse of caves, rock crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). However, the Study Area occurs outside the species' current known limit of distribution with the closest record occurring 120 km to the north-east of the Study Area. Furthermore, the DECC do not consider the species to be of conservation concern for the region (DEC 2005Ž).
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Yes	Yes	Yes	Yes	Yes, with *definite* certainty. This species was detected many times throughout the Study Area with varying levels of confidence. The highest level recorded was *definite* certainty in creek line habitats within SGPF. Further potential habitat occurs within ESSW, CWTR, RPHM, TSSF, TOPBF, MGF, NSGF and Upland Swamp plant communities.	Yes. Direct impacts on the species are possible. The collapse of caves, rock crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding and roosting habitat. Any impacts on potential foraging resources are likely to be negligible for this species.
Chalinolobus dwyeri	Large-eared Pied Bat	Yes	Yes	Yes	No	Yes, with *definite* certainty. This species was recorded once within an Upland Swamp (USSHC) with *definite* certainty. Further potential habitat occurs within ESSW, SGPF, TSSF, TOPBF, MGF, NSGF and Upland Swamp plant communities.	Yes. Direct impacts on the species are possible. The collapse of caves, rock crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding and roosting habitat. Any impacts on potential foraging resources are likely to be negligible for this species.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Yes	Yes	Yes	Yes	Yes, with *probable* certainty. This species was detected a number of times throughout the Study Area with varying levels of confidence. The highest level recorded was 80% *probable* in rainforest (CWTR) followed by 70% *probable* in creek line habitats within SGPF. Further potential habitat occurs within ESSW, CWTR, TSSF, TOPBF, MGF and Upland Swamp plant communities.	Yes. Direct impacts on the species are possible. The collapse of caves, rock crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding and roosting habitat. Any impacts on potential foraging resources are likely to be negligible for this species.
Kerivoula papuensis	Golden-tipped Bat	Yes	Yes	Yes	Yes	Yes, with *possible* certainty. This species was *possibly* recorded twice within the Study Area: once within a creek line (SGPF) and once within an Upland Swamp (USFEW). Further potential habitat occurs within ESSW, CWTR, TSSF, TOPBF, MGF, NSGF and Upland Swamp plant communities.	Yes. Direct impacts on the species are possible. If the species is present, the collapse of caves, rock crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). The loss of riparian rainforest vegetation may impact roosting habitat. Any impacts on potential foraging resources are likely to be negligible for this species. Although the Study Area does occur within the species' current known distribution, the closest confirmed record lies approximately 138.5 km north-east of the Study Area.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Myotis macropus (Myotis adversus)	Southern Myotis (Large-footed Myotis)	No	Yes	Yes	No	Yes, with *definite* certainty. This species was detected a number of times throughout the Study Area with varying levels of confidence. The highest level recorded was *definite* certainty in creek line habitats within SGPF. Further potential habitat occurs within ESSW, TOPBF, MGF and NSGF plant communities.	Yes. Direct impacts on the species are possible. The collapse of caves, rock crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding and roosting habitat. The Proposal has the ability to impact foraging resources as well through the loss of surface flow from creek lines, as the species prefers to forage over watercourses.
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	Yes	Yes	Yes	Yes	Yes, with *probable* certainty. This species was recorded once within a creek line (SGPF) with *probable* certainty. Further potential habitat occurs within ESSW, CWTR, RPHM, TSSF, TOPBF, MGF, NSGF and Upland Swamp plant communities.	Yes. Direct impacts on the species are possible. If the species is present, the collapse of caves, rock crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential roosting habitat. Any impacts on potential foraging resources are likely to be negligible for this species.
Scoteanax rueppellii	Greater Broad-nosed Bat	Yes	No	Yes	Yes	Yes, with *probable* certainty. This species was detected a number of times throughout the Study Area with varying levels of confidence. The highest level recorded was 80% *probable* in creek lines (SGPF) followed by 70% *probable* in Upland Swamp (USFEW). Further potential habitat occurs within CWTR, TOPBF, MGF, NSGF and Upland Swamp plant communities.	Yes. The Proposal has the ability to impact on this species. Whilst potential breeding and roosting habitat (i.e. tree hollows) are unlikely to be impacted by subsidence, potential foraging resources (e.g. creek lines) may be impacted through the loss of surface flow.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Vespadelus troughtoni	Eastern Cave Bat	Yes	Yes	Yes	Yes	Yes, with *possible* certainty. This species was *possibly* recorded once within a creek line (SGPF) but it was considered more likely to have been a Chocolate Wattled Bat. Potential habitat for the Eastern Cave Bat occurs within ESSW, SGPF, CWTR, RPHM, TSSF, TOPBF, MGF, NSGF and Upland Swamp plant communities.	Yes. Direct impacts on the species are possible. If the species is present, the collapse of caves, rock crevices, cliffs and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). However, the Study Area occurs outside the species' current known limit of distribution, with the closest confirmed record occurring 124.5 km to the south of the Study Area.
Reptiles							
Hoplocephalus bungaroides	Broad-headed Snake	No	Yes	Yes	No	No. Previously recorded by Biosis Research within the Locality on several occasions, including one record just outside the Study Area in Dendrobium Area 2 on a ridge line (SGPF). The other records from within the Locality occurred in ridge habitat (ESSW). Further potential habitat within the Study Area occurs within ESSW, RPHM and NSGF plant communities.	Yes. Direct impacts on the species are possible. The collapse of cliffs, rock outcrops, crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential winter breeding and roosting habitat. Impacts are also possible to winter foraging resources such as geckos and skinks which also inhabit rock outcrops and cliff lines.

Scientific Name	Common Name	Potential Habitat				Previously Recorded (Notes on Potential Habitat)	Affected Fauna / (Justification for Further Consideration in SIS)
		Upland Swamps	Ridge Lines	Creek Lines	Rainforest		
Varanus rosenbergi	Rosenberg's Goanna	Yes	Yes	Yes	No	Yes. Previously recorded by Biosis Research on a few occasions within the Study Area (ESSW). The species has also been previously recorded by Biosis Research within the Locality. Further potential habitat within the Study Area occurs within SGPF, RPHM, TSSF, TOPBF, MGF, NSGF and Upland Swamp plant communities.	Yes. Direct impacts on the species are possible. The collapse of rock crevices, overhangs and burrows may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential roosting habitat. Any impacts on potential foraging resources are likely to be negligible for this species.
Invertebrates							
Petalura gigantea	Giant Dragonfly	Yes	No	No	No	The species has previously been recorded in the Locality. Potential habitat is considered to be within the Upland Swamp plant communities of the Study Area.	Yes. Hydrological changes within Upland Swamps as a result of subsidence within the Study Area may impact on the species, if present.

6.2 Assessment of Habitat

6.2.1 Description of Vegetation

Thirteen plant communities as mapped by (NPWS 2003) were identified as occurring in the Study Area (Figure 10); Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Coachwood Warm Temperate Rainforest, Sandstone Riparian Scrub, Upland Swamps Banksia thicket, Upland Swamps Fringing Eucalypt Woodland, Upland Swamps Sedgeland Heath Complex, Upland Swamps: Tea-tree Thicket, Rock Plate Heath-Mallee, Transitional Shale Stringybark Forest, Tall Open Peppermint-Blue Gum Forest, Moist Gully Gum Forest and Nepean Sandstone Gully Forest. These plant communities were classified according to Specht (1970) and named according to the descriptions in *The Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments* (NPWS 2003).

The area of each plant community within the Locality, Subject Site and Study Area is listed in Table 15.

Table 15: Extent of plant communities mapped within the Locality, Study Area and Subject Site

[1]Map Unit	Plant Community	Area Within Locality (ha)	Area within Study Area (ha)	Area within Subject Site (ha)
MU29	Exposed Sandstone Scribbly Gum Woodland (ESSW)	10,238.5	1,733.4	1,721.0
MU26	Sandstone Gully Peppermint Forest (SGPF)	4,732.2	1,240.0	1,191.4
MU2	Coachwood Warm Temperate Rainforest (CWTR)	778.3	15.6	13.5
MU42	Upland Swamps Banksia thicket (USBT)	219.2	46.1	45.4
MU45	Upland Swamps Fringing Eucalypt Woodland (USFEW)	291.8	29.4	26.3
MU44	Upland Swamps Sedgeland Heath Complex (USSHC)	477.5	83.3	80.9
MU43	Upland Swamps: Tea-tree Thicket (USTT)	5.1	0.6	0.6
MU39	Rock Plate Heath-Mallee (RPHM)	81.3	5.2	5.2
MU23	Transitional Shale Stringybark Forest (TSSF)	234.0	10.2	10.2
MU14	Tall Open Peppermint-Blue Gum Forest (TOPBF)	1,230.4	38.8	36.9
MU8	Moist Gully Gum Forest (MGF)	981.1	9.0	8.3
MU27	Nepean Sandstone Gully Forest (NSGF)	2,048.2	58.2	52.8
MU4	Sandstone Riparian Scrub	41.4	8.1	5.8
Total Area (ha)		**21,359.0**	**3,277.9**	**3,198.3**

1. Map Unit according to NPWS (2003) mapping.

Ground-truthing of NPWS (2003) Vegetation Mapping

Highlands Shale Tall Open Forest was mapped in the Study Area by NPWS (2003) in the middle western portion of the Study Area. The area mapped as supporting this plant community was ground-truthed during the current surveys, with two quadrats and random meander searches undertaken. The ground-truthing revealed that the structure and composition of the native vegetation in this area did not represent Highlands Shale Tall Open Forest and was more closely aligned to Tall Open Peppermint-Blue Gum Forest. The lack of mesic species in the understorey, which are characteristic of Tall Open Blue Gum Forest, is likely to be due to the recent fire (2001/2002).

A number of areas mapped by NPWS (2003) as supporting Upland Swamps were found to support different sub-communities than what was mapped. For example, Sedgeland – Heath Complex mapped on the drier edges of the swamps were sometimes found to support Banksia thicket and Sedgeland-Heath complex mapped in the wetter gullies at the headwaters of creeks were found to support Tea-tree thicket.

Potential Impacts to Plant Communities

Plant communities independent of groundwater, such as those occurring on ridgetops and upper slopes, are not likely to be significantly impacted by subsidence, as changes to species composition are unlikely to occur. Plant communities that are dependant on groundwater, such as riparian vegetation and upland swamps, are more likely to be impacted by subsidence.

Riparian habitats may be affected by subsidence through surface water diversions, gas emissions, the fracturing of bedrock and the cracking of soils (MSEC 2007). These impacts, however, are predicted to be minor, and are unlikely to result in significant changes to species composition of the riparian vegetation communities in the long-term.

Upland Swamps (all variations) may be subject to impacts from subsidence. These impacts may include changes to the distribution of local vegetation within the swamp due to changes in water levels. Generally, however, the surfaces of swamps are free draining, and it is not anticipated that significant changes to ponding would occur as a result of differential subsidence (MSEC 2007). Significant long-term changes to species composition within Upland Swamp vegetation are therefore unlikely to occur.

Plant Community Descriptions

Brief descriptions of each plant community, including their location within the Study Area, structure, composition, condition and previous disturbance is provided below.

Exposed Sandstone Scribbly Gum Woodland (ESSGW)

Location: Exposed Sandstone Scribbly Gum Woodland was the dominant plant community recorded in the Study Area, occurring along the exposed ridge tops, upslope of Wongawilli Creek, Sandy Creek, Lake Avon and Lake Cordeaux, and associated tributaries.

Structure: This plant community is classified as a woodland (Specht 1970), with canopy trees ranging in height from 10 to 20 m, with 30% canopy cover. The small tree layer reached a height of 5 to 10 m and had a projective foliage cover of 10 to 40%. The shrub layer was dense, with 30 to 60% projective foliage cover and reached a height of between 1 and 4 m. The ground layer was variable, with between 20 and 40% projective foliage cover and reached a maximum height of 1 m.

Canopy trees: *Eucalyptus sieberi*, *Corymbia gummifera*, *E. racemosa*, *E. piperita* and *E. oblonga.*

Midstorey: *Corymbia gummifera, Xylomelum pyriforme, Banksia spinulosa, B. serrata* and *Leptospermum trinervium.*

Shrubs: *Acacia myrtifolia, A. linifolia, Banksia ericifolia, B. spinulosa, Bossiaea heterophylla, Dillwynia retorta, Grevillea sphaerocephala, Hakea dactyloides, H. sericea, Kunzea ambigua, Isopogon anemonifolius, Lambertia formosa, Leptospermum polygalifolia, Petrophile pulchella* and *Platysacea linearifolia.*

Ground layer: *Caustis flexuosa, Cyathochaeta diandra, Entolasia stricta, Lepidosperma laterale, Lepyrodia scariosa, Lomandra longifolia, Patersonia glabrata, Pimelea linifolia* and *Ptilothrix deusta.*

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. Existing disturbances include relatively recent fire in some areas, cleared tracks, transmission easements and the existing Maldon-Dombarton Railway. No weed species were detected in this plant community within the Study Area.

Sandstone Gully Peppermint Forest (SGPF)

Location: This was the dominant plant community along the creeks and gullies of the Study Area and was recorded within Wongawilli Creek, Sandy Creek, sheltered areas adjoining Lake Avon and Lake Cordeaux and tributaries associated with these waterbodies. This vegetation community typically occurs below the break of slope, below the sandstone outcrops at the valley edge.

Structure: This plant community was classified as an open forest (Specht 1970). The canopy was variable and reached a height of between 10 to 20 m, with a projective foliage cover of between 15 and 40%. Steeper sections of the gully supported taller trees (to 30 m), at a higher density (up to 55% projective foliage cover). The midstorey generally reached a height of approximately 10 m and was relatively sparse in some areas (projective foliage cover of 15%) and more dense in other areas (40% projective foliage cover). Steeper areas supported taller trees in the midstorey (up to 20 m). Underneath is a dense shrub layer (20 to 50% projective foliage cover), to a maximum height of 3 m and up to 5 m in steeper areas. The ground layer was dense, supporting a mix of herbaceous species, with a projective foliage cover of approximately 40% in most areas, but up to 70% in more swampy parts.

Canopy trees: *Eucalyptus racemosa, E. punctata* and *E. piperita,* with *Corymbia gummifera* also occurring on higher slopes.

Midstorey: *Allocasuarina littoralis, A. torulosa, Acacia rubida, A. terminalis, Backhousia myrtifolia, Banksia serrata, B. ericifolia, Ceratopetalum apetalum, C. gummiferum, Persoonia levis, Leptospermum trinervium, Lomatia myricoides* and *Melaleuca linearifolia,* with juvenile *Eucalyptus* spp. (canopy dominants) also occurring.

Shrubs: *Acacia terminalis, A. linifolia, A. longifolia, Astrotricha longifolia, B. ericifolia, B. spinulosa, B. paludosa, Dodonaea triquetra, Persoonia levis, P. levis, Petrophile sessilis, P. pulchella, Pimelea linifolia, Leptospermum polygalifolium, L. trinervium, L. lanigerum, Grevillea mucronulata, Lambertia formosa, Hakea sericea, H. dactyloides, Isopogon anemonifolius, Telopea speciosissima* and *Pultenaea flexilis.*

Ground layer: *Lomandra longifolia, L. multiflora, L. filiformis* subsp. *filiformis, Baumea microphylla, Entolasia marginata, Pteridium esculentum, Calochlaena dubia, Cyathochaeta diandra, Gleichenia dicarpa, Gonocarpus teucrioides, Lepidosperma laterale, Lepyrodia scariosa, Leptocarpus tenax, Schoenus apogon* and *S. melanostachys. Sticherus flabellatus* and *Todea Barbara* were also recorded in this plant community along the edge of creeklines.

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. Existing disturbances include fire and cleared tracks. No weed species were recorded in this plant community.

Rock Plate Mallee Heath (RPHM)

Location: This plant community occurred as small scattered patches on ridgetops, where large rock platforms occur under a thin layer of soil.

Structure: This plant community was classified as a low woodland (Specht 1970). The canopy reached a height of 8 m, with a projective foliage cover of less than 5%. The midstorey reached a height of between 2 and 4 m, with a projective foliage cover of 40%. Underneath is a sparse shrub layer (15% projective foliage cover), to a maximum height of 1 m. The ground layer was dense, with a projective foliage cover of approximately 60%.

Canopy trees: *Eucalyptus racemosa*.

Midstorey: *Eucalyptus stricta* and *Leptospermum trinervium*.

Shrubs: *Allocasuarina nana, Baeckea imbricata, Banksia ericifolia, Isopogon anemonifolius, Kunzea ambigua, Hakea gibbosa, H. dactyloides* and *Pultenaea* spp.

Ground layer: *Cyathochaeta diandra, Darwinia grandiflora, Goodenia dimorpha, Lepyrodia scariosa* and *Patersonia glabrata*.

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. The only visible disturbance was fire. No weed species were recorded in this plant community.

***Coachwood Warm Temperate Rainforest* (CWTRF)**

Location: This plant community occurred in the steep sections of Wongawilli gorge.

Structure: This plant community was classified as a closed forest (Specht 1970). The canopy reached a height of 20 m, with a projective foliage cover of up to 75%. The midstorey reached a height of between 4 and 12 m, with a projective foliage cover of 40%. Underneath is a sparse shrub layer (10% projective foliage cover), to a maximum height of 2 m. The ground layer supported a layer of ferns, with a projective foliage cover of approximately 10%.

Canopy trees: *Ceratopetalum apetalum*.

Midstorey: *Doryphora sassafras, Ceratopetalum apetalum, Lomatia myricoides, Cyathea australis* and *Stenocarpus salignus*.

Shrubs: *Doryphora sassafras* and *Ceratopetalum apetalum.*

Ground layer: *Sticherus flabellatus, Blechnum cartilagineum* and *Todea barbara*.

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. There were no visible disturbances to this plant community and no weed species were recorded.

Habitat for Affected Flora: No threatened plant species were recorded in this plant community. Potential habitat for *Acacia baueri*, *Gyrostemon thesioides* and *Leucopogon exolasius* also occurs in this plant community. This plant community is not listed as an EEC on the TSC or EPBC Acts.

Sandstone Riparian Scrub

Location: This plant community occurred in the rocky sections of Wongawilli Gorge.

Structure: This plant community was classified as an open scrub (Specht 1970). The canopy reached a height of 4 m, with a projective foliage cover of up to 30%. The shrub layer reached a height of between 0.5 and 1.5 m, with a projective foliage cover of 20%. Underneath is a sparse ground layer (10% projective foliage cover), to a maximum height of 0.5 m.

Canopy trees: *Lomatia myricoides*, *Tristaniopsis laurina*, *Acacia obtusifolia* and *Allocasuarina littoralis*.

Shrubs: *Tristaniopsis neriifolia*, *Callitris rhomboidea* and *Bauera rubiifolia.*

Ground layer: *Lomandra fluviatilis* and *Gleichenia dicarpa*.

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. The only visible disturbance was that of fire. No weed species were recorded.

***Transitional Shale Stringybark Forest* (TSSF)**

Location: This plant community occurred in the northwestern section of the Study Area on the ridgetop where there was a shale influence in the soil.

Structure: This plant community was classified as an open forest (Specht 1970). The canopy reached a height of between 20 and 35 m, with a projective foliage cover of up to 45%. The midstorey reached a height of between 4 and 12 m, and was relatively sparse in some areas and more dense in others (projective foliage cover of between <5 and 20%). Underneath is a relatively dense shrub layer (20 to 40% projective foliage cover), to a maximum height of 3 m. The ground layer was also dense, with a projective foliage cover of approximately 40%.

Canopy trees: *Eucalyptus globoidea* and *Corymbia gummifera.*

Midstorey: *Allocasuarina littoralis* with juvenile canopy trees were also dominant.

Shrubs: *Persoonia linifolia, P. levis, Banksia spinulosa, Acacia linifolia, Grevillea mucronulata* and *Lambertia formosa.*

Ground layer: The ground layer was dominated by *Patersonia glabrata, Lomatia silaifolia, Entolasia stricta, Lomandra* spp. and *Xanthorrhoea media.*

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. Disturbances included fire, fire trails and the Maldon-Dombarton Railway. No weed species were recorded.

Upland Swamps: Tea-tree Thicket

Location: This plant community occurs in areas of impeded drainage at the bottom of gullies, at the headwaters of a number of creeks and tributaries in the Study Area.

Structure: This plant community was classified as a closed scrub (Specht 1970). Where a tree canopy existed, it was sparse (projective foliage cover of <5%). The dominant structural layers were the small tree and shrub layer, reaching a height of approximately 5 m and a projective foliage cover of up to 80%. The ground layer was also dense, with a projective foliage cover of approximately 70%.

Canopy trees: *Eucalyptus piperita* and *E. racemosa.*

Midstorey: *Acacia rubida, Banksia robur, Melaleuca linearifolia, L. juniperinum* and *Leptospermum polygalifolium.*

Shrubs: *Leptospermum lanigerum, Bauera rubioides, Banksia robur, B. ericifolia, Petrophile pulchella, Platysace linearifolia, Pultenaea elliptica* and *Conospermum tenuifolium.*

Ground layer: *Baumea teretifolia, Gahnia sieberi, Lepidosperma limicola, Leptocarpus tenax, Entolasia stricta, Gleichenia dicarpa, Dillwynia floribunda* and *Empodisma minus.*

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. The main disturbance to this plant community was fire, which had altered the drainage in some areas. No weed species were recorded.

Upland Swamps: Sedgeland Heath Complex

Location: This plant community occurs in areas of impeded drainage, at the headwaters of a number of creeks and tributaries in the Study Area.

Structure: This plant community was classified as an open heathland (Specht 1970). A small tree layer was present at some sites to a height of 6 m and a projective foliage cover of 10%. The shrub layer, reached a height of approximately 4 m and a projective foliage cover of up to 70%. In some areas, the shrub layer was sparse (projective foliage cover of <10%). The ground layer was dense, with a projective foliage cover of up to 100%.

Midstorey: *Acacia rubida, Banksia robur, B. spinulosa* and *Hakea dactyloides.*

Shrubs: *Baeckea linifolia, Banksia robur, B. ericifolia, Leptospermum juniperinum, L. polygalifolium, L. lanigerum, L. continentale, L. squarrosum, Gymnoschoenus sphaerocephalus* and *Conospermum tenuifolium.*

Ground layer: *Baeckea imbricata, Gahnia sieberi, Lepidosperma limicola, Lepyrodia scariosa, Leptocarpus tenax, Conospermum tenuifolium, Gleichenia dicarpa, Gonocarpus teucrioides, Selaginella uliginosa, Schoenus melanostachys, S. brevifolius* and *Dillwynia floribunda.*

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. Disturbances include fire and clearing for tracks. No weed species were recorded.

Upland Swamps: Banksia Thicket

Location: This plant community occurs on the drier edges of swamps, usually adjoining Upland Swamps: Fringing Eucalypt Woodlands.

Structure: This plant community was classified as an open heathland (Specht 1970). A sparse tree canopy was present at some sites, to a height of 15 m. A small tree layer was also present at some sites to a height of 5 m and a projective foliage cover of up to 30%. The shrub layer reached a height of approximately 4 m and a projective foliage cover of between 60 and 90%. The ground layer was mostly dense, with a projective foliage cover of up to 90%, but was sparse at some sites (projective foliage cover as little as 15%).

Canopy: *Eucalyptus sieberi, E. racemosa* and *Corymbia gummifera.*

Midstorey: *Acacia terminalis, Banksia ericifolia, Leptospermum trinervium* and *Hakea dactyloides.*

Shrubs: *Acacia suaveolens, A. linifolia, Banksia ericifolia, Hakea teretifolia, Leptospermum polygalifolium, L. juniperinum, L. squarrosum, Eucalyptus stricta, Petrophile pulchella, Pultenaea aristata* and *Viminaria juncea.*

Ground layer: *Actinotus minor, Bauera rubioides, Baeckea imbricata, Epacris microphylla, Empodisma minus, Platysace linearifolia, Cyathochaeta diandra, Gymnoschoenus sphaerocephala, Hibbertia riparia, Lepidosperma limicola, Lepyrodia scariosa, Leptocarpus tenax, Gleichenia dicarpa, Gonocarpus teucrioides, Saropsis fastigiata, Sprengelia incarnata, Schoenus brevifolius* and *Dillwynia floribunda.*

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. The main disturbance was fire. Evidenced by the thicket of dead stems, fire had resulted in the death and subsequent regeneration of a dense layer of *Banksia ericifolia*. No weed species were recorded.

Upland Swamps: Fringing Eucalypt Woodland

Location: This plant community occurs on the drier edges of swamps, usually adjoining Exposed Sandstone Scribbly Gum Woodland.

Structure: This plant community was classified as a woodland (Specht 1970). A tree canopy to a height of 15 m and up to 35% projective foliage cover was present in some areas. A small tree layer was also present to a height of 8 m and a projective foliage cover of up to 30%. The shrub layer reached a height of approximately 3 m and a projective foliage cover of between 10 and 70%. The ground layer was mostly dense, with a projective foliage cover of between 40 and 90%, but was sparse at some sites (projective foliage cover as little as 20%).

Canopy: *Eucalyptus piperita, E. racemosa* and *Corymbia gummifera.*

Midstorey: *Acacia rubida, Banksia ericifolia, Leptospermum trinervium* and *Hakea dactyloides.*

Shrubs: *Acacia linifolia, Banksia ericifolia, B. spinulosa, Hakea dactyloides, H. sericea, Isopogon anemonifolius, Leptospermum polygalifolium, Persoonia levis, Melaleuca thymifolia* and *Viminaria juncea.*

Ground layer: *Caustis flexuosus, Entolasia stricta, Pimelea linifolia, Cyathochaeta diandra, Lepyrodia scariosa, Leptocarpus tenax, Lindsaea linearis, Gonocarpus teucrioides, Patersonia sericea, Ptilothrix deusta, Schoenus brevifolius* and *Xanthosia pilosa.*

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. The main disturbance was fire. No weed species were recorded.

Tall Open Peppermint-Blue Gum Forest (TOPBGF)

Location: This plant community occurred at the bottom of a sheltered gully along a tributary of Wongawilli Creek and in the southeastern section of the Study Area along sheltered creeklines with a shale influence.

Structure: This plant community was classified as a tall open forest (Specht 1970). The canopy reached a height of between 20 and 30 m, with a projective foliage cover of up to 50%. The midstorey was sparse (projective foliage cover of up to 10%) and reached a height of between 5 and 12 m. Underneath is a relatively dense shrub layer (20 to 50% projective foliage cover), to a maximum height of 3 m. The ground layer was also dense, with a projective foliage cover of approximately 65%.

Canopy trees: *Eucalyptus piperita* and *E. eugenioides*, with *Corymbia gummifera* also occurring.

Midstorey: *Allocasuarina littoralis, Ceratopetalum gummiferum, Schizomeria ovata, Persoonia linearis, P. levis, Livistona australis* and *Banksia serrata*. Immature canopy species were common.

Shrubs: *Acacia terminalis, Acronychia oblongifolia, Banksia spinulosa, Dodonaea triquetra, Goodenia ovata, Hakea dactyloides, Leptospermum polygalifolium, Pomaderris intermedia, Persoonia linearis, Rhodamnia rubescens, Synoum glandulosum, Pultenaea daphnoides* and *P. flexilis.*

Ground layer: *Gonocarpus teucrioides, Entolasia marginata, Lomandra longifolia, Blechnum cartilagineum, Oplismenus imbecilis, Hibbertia aspera, Calochlaena dubia* and *Pteridium esculentum.*

Condition/Disturbances: This plant community was considered to be in good condition, with high native species diversity and all structural layers intact. The main disturbances to this plant community were fire and clearing for fire trails. No weed species were recorded.

Moist Gully Gum Forest (MGGF)

Location: This plant community occurred in the southeastern section of the Study Area along sheltered creeklines.

Structure: This plant community was classified as a tall open forest (Specht 1970). The canopy reached a height of between 20 and 35 m, with a projective foliage cover of up to 35%. The midstorey was dense (projective foliage cover of up to 40%) and reached a height of between 8 and 12 m. Underneath is a relatively dense shrub layer (20 to 40% projective foliage cover), to a maximum height of 3 m. The ground layer was dense in some areas and sparse in others (projective foliage cover ranging between 15 to 60%).

Canopy trees: *Eucalyptus piperita* and *E. smithii*.

Midstorey: *Cryptocarya glaucescens, Acmena smithii, Ceratopetalum apetalum, Schizomeria ovata* and *Trochocarpa laurina*. Immature canopy species were sometimes present.

Shrubs: *Acronychia oblongifolia, Prostanthera incisa, Astrotricha latifolia, Helichrysum elatum, Tristaniopsis collina, Notelaea longifolia* and *Claoxylon australe.*

Ground layer: The ground layer was dominated by *Lomandra longifolia, Pteridium esculentum, Calochlaena dubia, Morinda jasminoides, Pellaea falcata, Doodia aspera* and *Oplismenus imbecilis.*

Condition/Disturbances: This plant community was considered to be in good to moderate condition. Good condition patches of Moist Gully Gum Forest are found high in the gully's fringing Lake Cordeaux. Weeds are prevalent within the drainage lines in these gullies where they meet the Lake Cordeaux foreshore area. The main disturbance to this plant community was fire.

***Nepean Sandstone Gully Forest* (NSGF)**

This plant community was not surveyed in the current assessment, as it only occurs in a small area in the western section of the Study Area. The following description follows that of NPWS (2003).

Location: This plant community occurs along the tributaries draining to Lake Avon in the western section of the Study Area.

Structure: This plant community is classified as an open forest (Specht 1970). The canopy reached a height of between 6 and 10 m, with a projective foliage cover of approximately 10%. The shrub layer is relatively sparse (16% projective foliage cover), to an average height of 1.5 m. The ground layer reaches a height of approximately 1 m, with a projective foliage cover of 25%.

Canopy trees: *Corymbia gummifera, Eucalyptus punctata, E. piperita, E. agglomerata, E. globoidea, E. oblonga* and *E. sieberi.*

Shrubs: *Allocasuarina littoralis, Elaeocarpus reticulatus, Leucopogon lanceolatus, Banksia spinulosa, Persoonia linearis, P. levis, Ceratopetalum gummiferum, Astrotricha latifolia* and *Banksia ericifolia.*

Ground layer: *Pteridium esculentum, Entolasia stricta, Dianella caerulea, Lepidosperma laterale, Lomatia silaifolia* and *Blechnum cartilagineum.*

Condition/Disturbances: This plant community was assessed as having a low disturbance, indicating there were no visible signs of disturbance from the air (NPWS 2003).

6.2.2 Description of Fauna Habitat

Please refer to Section 6.2.1 above for information relating to the vegetation habitat values as they relate to each plant community, including location, structure, floristics (dominant species within each stratum), condition, disturbance history and potential habitat for threatened species. A discussion of fauna habitat values and fire history is provided below.

Fauna Habitats

Fauna habitats within the Study Area were in good condition, as were surrounding habitats to the west, east, south and north. Broadly, these habitats comprise mostly woodland and open forest with smaller components of rainforest and heath. Finer scale habitat features include rock outcrops, caves, overhangs, tree hollows, hollow logs, riparian habitats including creeks, ephemeral drainage lines, dams and temporary ponds and soaks. These habitats and species associations are discussed in further detail below.

Although the Study Area has been previously disturbed by vegetation loss from fire trails, the Maldon-Dombarton Railway, power easements, seismic lines and boreholes, it is mostly intact and provides habitat resources for a wide range of species.

Rainforest, Open Forest and Woodland

Temperate rainforest habitat occurs along the steeper sections of the Wongawilli Creek valley and Sandy Creek with woodland and open forest habitats occurring along the ridgelines. These habitats provide a wide range of food and shelter for vertebrate fauna. Myrtaceaeous trees, mostly eucalypt species, generally dominate the upper canopy in these areas and supply direct (foliage, nectar, exudates) and indirect food (arthropods) for a range of vertebrates, particularly birds and arboreal mammals.

Tree hollows (formed in stags, mature and or senescent trees) provide nesting and roosting habitat for hollow-dwelling fauna and are important habitat components of native forests. A variety of tree hollows were recorded throughout the Study Area, which reflects the mature stage of most sections of woodland and forest. These are likely to provide suitable den and nesting habitat for a range of common birds (e.g. Sulphur-crested Cockatoo *Cacatua galerita*), arboreal mammals (e.g. Sugar Glider *Petaurus breviceps*) and forest dwelling micro-bats (e.g. Chocoalte Wattled Bat *Chalinolobus morio*). Locally recorded threatened species requiring tree-hollows for roosting and/or breeding include the Powerful Owl, Glossy Black-cockatoo, Squirrel Glider and Eastern Pygmy-possum.

Understorey Vegetation

Areas of dense understorey and shrub vegetation were common within sheltered gullies, wet and dry heath and slopes with southern and south-eastern aspects. These areas provide important habitat for a range of species. These include small birds (e.g. fairywrens and scrubwrens) and ground-dwelling mammals, such as marsupials (e.g. *Antechinus* sp. and *Sminthopsis* sp.) and rodents (*Rattus* sp. and *Pseudomys* sp.).

Fallen Timber and Bark

Fallen branches and bark were abundant within wooded areas and provide refuge and nesting habitat for a range of terrestrial animals. Many invertebrates and amphibians rely on these ‘moisture-retaining’ microhabitats to over-winter or as refuge during periods of drought. Similarly, many reptiles rely on ground litter and debris for shelter and foraging. Larger hollow logs provide potential denning and nesting habitat for small to medium sized mammals including the threatened Spotted-tailed Quoll *Dasyurus maculatus*.

Rocky outcrops, Caves and Overhangs

Characteristic of the local geology, sandstone outcrops were featured throughout the Study Area, including overhangs, exfoliating surfaces and deep cracking. These habitats provided refuge for a range of reptile species including Blind Snake *Ramphotyphlops nigrescens*, Southern Leaf-tailed Gecko *Phyllurus platurus*, Lesueur’s Velvet Gecko *Oedura lesueurii* and the threatened Broad-headed Snake and Rosenberg’s Goanna. The latter species require these habitats for over-wintering, thermoregulation and shelter and as a refuge for neonates, juveniles and prey species.

Overhangs generally occur along the creek lines below cliff lins. These areas can provide roosting and nursery habitat for cave-dwelling micro-bats, including threatened species such as the Large-eared Pied Bat, Eastern Bentwing-bat, Little

Bentwing-bat and Eastern False Pipistrelle. Small caves and crevices may provide den habitat for the threatened Spotted-tailed Quoll.

Creeks and Drainage Lines

There are numerous creeks and tributaries within the Study Area. The larger creeks include Wongawilli Creek, Sandy Creek and Donald's Castle Creek. Fauna habitats along these creeks and their tributaries vary with the changing fluvial geomorphology. In some areas there are steep rocky banks providing shelter and basking habitat for reptiles, such as the Eastern Water Dragon *Physignathus lesueurii*. Other sections of the bank are flat and heavily vegetated.

All of the creeks and tributaries are considered to be in good condition providing a range of key habitat features including rock platforms, boulders, emergent vegetation, sandy substrate, riffles and pools. These key features would provide shelter and/or foraging resources for a range of reptile, frogs and small mammals. In particular, deep pools are considered an important component of the breeding habitat for threatened frog species such as Littlejohn's Tree Frog and Giant Burrowing Frog.

Wet depressions (heath/sedgeland) and drainage lines provided optimal habitat for a range of vertebrate (frogs, reptiles and small ground-dwelling mammals) and invertebrate species. These areas were observed, in various forms, throughout the Study Area, particularly within Upland Swamp habitat (discussed below). Suitable habitat for the Red-crowned Toadlet occurs within these areas and between rock outcrops as small ephemeral drainage lines and within drainage channels along access tracks and upper gully slopes within catchment areas.

Artificial lacustrine habitats (permanent lakes and dams) occur at Lakes Cordeaux and Avon within the Study Area. These lakes provide altered riparian habitats along their margins. Species likely to use these habitats include White-bellied Sea Eagle *Haliaeetus leucogaster* and Southern Myotis *Myotis macropus*.

The water habitats including creeks, lakes and wet depressions within the Study Area are likely to provide potential habitat for threatened frog species such as Red-crowned Toadlet, Littlejohn's Tree Frog and Giant Burrowing Frog.

Upland Swamps

Upland Swamps provide important refuge and foraging habitat for a range of birds, mammals, reptiles and frogs. Species that may frequent this type of habitat include the regionally significant Southern Emu-wren *Stipiturus malachurus* and Buff Banded Rail *Gallirallus philippensis* and the threatened Rosenberg's Goanna, Littlejohn's Tree Frog and Giant Burrowing Frog.

Fire History

Fire history records covering the Study Area are maintained by the Sydney Catchment Authority (SCA). Fire history records on the Woronora Plateau include five major wildfire seasons in 1965/66, 1968/69, 1990/91, 2001/02 and 2005. The last major fire in the Dendrobium Area 3 Study Area started December 2001 and burnt through the Study Area until January 2002.

Fire severity mapping undertaken by the SCA is based on vegetation loss resulting from the fire and indicates that the vast majority of the Study Area was burnt during the 2001/2002 fires. The SCA's fire severity mapping indicates that the majority of Upland Swamps were subject to extreme fire severity during the 2001/2002 fires. The mapping indicates that all plant communities (including riparian plant communities) in the Study Area were burnt during the 2001/2002 fires, except Coachwood Warm Temperate Rainforest present in the upper reaches of Wongawilli Creek.

Based on current and previous surveys of the Study Area, evidence of significant fire events in the recent past (presumably 2001/2002) was observed in the Study Area and broadly supports the SCA's fire severity mapping. Physical evidence of historic fire included a considerable quantity of burnt debris, fire scaring on tree trunks, extensive epicormic growth on trees and the re-shooting of fire resistant vegetation. Large areas of even aged stands of fire sensitive plant species such as *Banksia ericifola* (especially within Upland Swamps) provided further evidence of the extent of the 2001/2002 fires.

6.2.3 Corridors

Wildlife Corridors and Connectivity

Wildlife corridors can be best defined as "retained and/or restored systems of (linear) habitat which, at a minimum enhances connectivity of wildlife populations and may help them overcome the main consequences of habitat fragmentation" (Wilson and Lindenmayer 1995). Alternatively they can be defined as "linear habitats that differ from a more extensive surrounding matrix. Frequently, they link one or more patches of habitat in the landscape, but they may also occur as isolated lines of habitat" (Bennett 1990).

A corridor serves a number of different functions in terms of wildlife conservation:

- Providing increased foraging area for wide-ranging species;
- Providing cover for movement between habitat patches, and enhancing the movement of animals through sub-optimal habitats;

- Reducing genetic isolation;
- Facilitating access to a mix of habitats and successional stages to those species which require them for different activities (e.g. foraging or breeding);
- Providing refuge from disturbances such as fire;
- Providing habitat in itself; and,
- Linking wildlife populations and helping to maintain immigration and re-colonisation between otherwise isolated patches. This in turn may help reduce the risk of population extinction (Wilson and Lindenmayer 1995).

Riparian habitat as a corridor within a woodland matrix

Dendy (1987) defines a wildlife corridor as a narrow strip of hospitable territory traversing inhospitable territory providing access from one area to another. Riparian systems usually consist of wetter, denser forests, which traverse a drier landscape. They often originate in larger tracts of wet forest at their headwaters, and may encounter patches of similar habitats during their course. For animal species that require wet forests, riparian strips meet the requirements of a wildlife corridor. Corridors are also important because they maintain genetic variation and because natural corridors, such as riparian vegetation, may be important habitats in their own right (Simberloff and Cox 1987).

Corridors serve a useful, perhaps vital, function in promoting local movements of animal species (Saunders and de Rebeira 1991). It is believed that riparian habitats also serve the same functions (Dickson and Huntley 1985), but a number of factors must first be considered. Firstly, the width of riparian habitats is very variable, and dispersing species may encounter problems in narrow sections due to edge effects (Watson 1991). Secondly, rivers are rarely straight lines and therefore their associated habitats contain many doglegs and turns. Soule and Gilpin (1991) have demonstrated that a dogleg greatly reduces corridor capability. Riparian habitats probably do aid in dispersal of fauna, but their capability might not be as high as equivalent `ideal' corridors.

Corridors and Connectivity in the Area Surrounding the Proposal

The Study Area lies within a massive expanse of continuous vegetation within the Metropolitan Special Area, extending from Appin to the north (17 km), Bargo (14 km) to the west and the Illawarra Escarpment State Conservation Area (SCA) to the southeast. The Illawarra Escarpment SCA forms part of a wildlife corridor connecting remnant vegetation of the coastal plains with the protected lands of the escarpment and plateau (NPWS 2002c). The Study Area is situated approximately 1 km from the Escarpment Moist Forest Fauna Linkage which connects the moist forest of Royal NP with those of the Illawarra Escarpment SCA and Macquarie Pass NP (NPWS 2002c).

The only major interruptions (barriers) within this area of continuous vegetation are fire trails, powerline easements and Lakes Avon and Cordeaux. So with respect to corridors within the Study Area, the Proposal does not impact on these as they are not present in the form normally referred to as corridors (e.g. strips of vegetation through an otherwise cleared landscape). However, the surrounding landscape consists of more open Ridgetop Woodland that is interspersed by denser and more mesic Gully Forest along rivers and creek lines, and this Gully Forest would act as a wildlife corridor for many species moving through the broader landscape. Given the nature of the impacts and large expanse of continuous vegetation, it is unlikely that the Proposal would create a barrier for the movement of any animal species within the region.

6.3 Affected Subject Species Information

6.3.1 Discussion of Local and Regional Abundance

Please refer to the species profiles in Section 6.3.5 (Flora) and 6.3.6 (Fauna) for information specific to the known local and regional populations of each affected subject species.

6.3.2 Discussion of Known Local Populations

Please refer to the species profiles in Section 6.3.5 (Flora) and 6.3.6 (Fauna) for information specific to the known local population of each affected subject species.

6.3.3 Discussion of Habitat Utilisation

Please refer to the species profiles in Section 6.3.5 (Flora) and 6.3.6 (Fauna) for information specific to the habitat utilisation of each affected subject species.

6.3.4 Discussion of Conservation Status

Please refer to the species profiles in Section 6.3.5 (Flora) and 6.3.6 (Fauna) for information specific to the conservation status of each affected subject species.

6.3.5 Affected Threatened Flora Profiles

Unless otherwise stated, the information contained in the following species profiles has been derived from the NSW Governments Bionet database and DECC's Threatened Species Profiles and the Environmental Impact Assessment Guidelines for each species.

Cryptostylis hunteriana	**Leafless Tongue Orchid**

Discussion of Conservation Status

Cryptostylis hunteriana is listed as a Vulnerable species on the TSC and EPBC Acts.

Cryptostylis hunteriana has a wide but sporadic distribution from Rainbow Beach in Queensland, inland to the Gibraltar Ranges in NSW and south to Orbost in Victoria (DEC 2005i). Recordings include a number of localities on the NSW South Coast and in recent years at many sites between Batemans Bay and Nowra (DEC 2005i). Populations of this species that may occur within the Locality are not considered to be at the geographical limit of distribution for this species.

Cryptostylis hunteriana is known to occur within conservation reserves within NSW (Gibraltar Range, Ku-Ring-Gai Chase, Washpool and Ben Boyd National Parks) and two reserves within Victoria (Croajingalong National Park and William Hunter Flora Reserve). This species is not considered to be adequately represented in conservation reserves (Bell 2001).

Cryptostylis hunteriana is threatened by development, particularly within the coastal zone. Some populations are threatened by road works (DEC 2005i). To date (September, 2007), no NSW or national threat or recovery plans have been published for *Cryptostylis hunteriana*.

Three Key Threatening Processes (KTPs) listed on the TSC Act relevant to the Proposal that may impact on potential habitat for *Cryptostylis hunteriana* include:

- Alteration of habitat following subsidence due to longwall mining (NSW Scientific Committee 2005a) – up to 3,198.3 ha will be subject to varying levels of subsidence as part of the Proposal.

- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands (NSW Scientific Committee 2002a) – as a direct result of subsidence, alteration of natural hydrological conditions may result from the Proposal.

- Human-caused climate change (NSW Scientific Committee 2000b).

As of September 2007, no NSW threat or recovery plans have been published for *Cryptostylis hunteriana*. DEC (2005i) has listed three recommendations to help recover this species, these are:

- Co-operatively develop (local governments and DECC) guidelines for survey and assessment, to be followed by developers, consultants and approval authorities;
- Alert road maintenance staff to the presence of this species; and,
- Monitor populations to determine the most appropriate timing and frequency of burning.

The Proposal is not considered likely to interfere with the above listed recommendations.

Discussion of Habitat Utilisation

Cryptostylis hunteriana was not recorded within the Study Area despite current and previous targeted surveys. The species has been considered further on the presence of potential habitat within the Study Area.

This species does not appear to have well defined habitat preferences and has been recorded from a range of plant communities, including swampy heaths and steep bare hillsides in tall eucalypt forest. Based on literature by Bell (2001) and Clarke (2004), all plant communities within the Study Area (except Coachwood Warm Temperate Rainforest) may provide potential habitat for this species.

Recorded locations appear to be on well drained sandy soils from both moist and dry habitats (Bell 2001). According to a study on the preferred habitat of this species within the Shoalhaven LGA (Clarke *et al.* 2004), 24 per cent of known records occur on Berry and Hawkesbury Sandstone formations, Ordovician Sediments and Quaternary Sands. On this basis, all geological units within the Study Area (Hawkesbury Sandstone) are considered to reflect potential habitat for *Cryptostylis hunteriana.*

DEC (2005i) suggests larger populations typically occur in woodland dominated by *Eucalyptus sclerophylla, E. sieberi, Corymbia gummifera* and *Allocasuarina littoralis*. The species appears to prefer open areas in the understorey of these woodlands, often in association with *Cryptostylis subulata* and *C. erecta* (DEC 2005i). Clarke (2004) suggests that the following plant species have a high frequency of occurrence in association with *C. hunteriana*; *Lomandra filiformis, Pimelia linifolia, Xanthosia tridentata, Lomandra obliqua, Lambertia formosa,* *Dampiera stricta, Hakea dactyloides, Entolasia marginata, Isopogon anemonifolius* and *Kunzea capitata*. Eight of the ten plant species are abundant in ridge line and gully plant communities within the Study Area.

Discussion of Local Abundance

Cryptostylis hunteriana has not been recorded within the Study Area or Locality. No records of this species are listed within 10 km of the Study Area (DECC 2007b).

Discussion of Regional Abundance

The species appears to be most common within the Shoalhaven area (Clarke *et al.* 2004) to the south-east of the Study Area, where it has been recorded from 25 locations. The largest known population in the Shoalhaven LGA includes a record of 150 plants.

Populations have also been recorded from the Central Coast region at Freemans Waterhole (15 plants) within the Awaba State Forest, Vales Point – Wyee (3 plants), Wyee Road (1 plant), Charmhaven (30 plants) and Chain Valley Bay (1 plant) (Bell 2001). The largest population within the central coast region is at Charmhaven where 30 plants were recorded in 1979, but have not since been detected at the Study Area. Populations on the north coast include Alum Mountain, Nelson Bay (30-40 plants) and Lemon Tree Passage (50 plants).

Epacris purpurascens var. *purpurascens*

Discussion of Conservation Status

Epacris purpurascens var. *purpurascens* is listed as a Vulnerable species on Schedule 2 of the TSC Act. The species has a ROTAP listing of 2KC- (Briggs and Leigh 1996), suggesting a geographic range of less than 100 km and that the population is reserved, but the adequacy of the reservation is unknown.

The species is known from Gosford in the north, to Narrabeen in the east, Silverdale in the west and the Avon Dam vicinity in the south (DEC 2005q). The southern-most geographical limit of distribution for this species is near Avon Dam (Bionet 2007). The Study Area is therefore near the southern limit of known distribution of the species.

According to DEC (2005q), *Epacris purpurascens* var. *purpurascens* has been recorded from Ku-Ring-Gai Chase National Park, Berowra Valley Regional Park, Muogamarra Nature Reserve and Brisbane Waters National Park, with unconfirmed records from Gulger Nature Reserve and Bents Basin State

Recreation Area. Large populations exist in protected water supply catchment lands in the vicinity of Picton Road, Wilton.

The conservation status of *Epacris purpurascens* var. *purpurascens* may also be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs listed on the TSC Act relevant to the Proposal that may impact on potential habitat for *E. purpurascens* var. *purpurascens* in the Study Area include:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands (NSW Scientific Committee 2002a) – the Proposal may potentially impact on a number of ephemeral drainage lines and creeklines, including parts of Wongawilli Creek and Sandy Creek and their tributaries.

- Alteration of habitat following subsidence due to longwall mining (NSW Scientific Committee 2005a) – the Proposal is likely to cause subsidence related impacts in the Study Area.

- Human-caused climate change (NSW Scientific Committee 2000b).

To date, no recovery plan or threat abatement plan has been prepared for this species. DEC (2005q) has listed four priority actions to help recover this species:

- Liaise with land managers to encourage the preparation of site management plans and the implementation of appropriate threat abatement measures, such as weed control/bush regeneration, site protection (fencing/signage) and fire management;

- Identify priority sites for formal habitat protection;

- Monitor known populations, so that potential local extinctions are detected before they occur and mechanisms can be put in place to reverse trends; and,
- Identify and survey potential habitat to detect new populations – potential habitat for the species in the Study Area has been identified and mapped (Figure 10). The species was not recorded in these areas despite targeted surveys.

Discussion of Habitat Utilisation

Epacris purpurascens var. *purpurascens* was not recorded within the Study Area despite current and previous targeted surveys. The species is known to occur in a range of habitat types, most of which have a strong clay influence, including ridgetop drainage depressions supporting wet heath within or adjoining shale cap communities, riparian zones draining into Sydney Sandstone Gully Forest, shale lenses within sandstone habitats and colluvial areas overlying or adjoining sandstone or tertiary alluvium (DEC 2005q).

The lifespan of *Epacris purpurascens* var. *purpurascens* is thought to be 5-20 years, requiring 2-4 years before seed is produced in the wild. The species is killed by fire and re-establishes from soil-stored seed (DEC 2005q).

The species is considered to have potential habitat within the following plant communities in the Study Area: Sandstone Gully Peppermint Forest, Upland Swamps, Transitional Shale Stringybark Forest, Nepean Sandstone Gully Forest and Sandstone Riparian Scrub.

Discussion of Local and Regional Abundance

Extant populations of *Epacris purpurascens* var. *purpurascens* contain between one and an estimated 15,000+ individuals (NPWS 2002b). Abundance of the species on any particular site ranges from widespread and occasional to locally abundant. The abundance of the species and the population structure is influenced by past disturbance history with fire being the main agent of disturbance (NPWS 2002b).

Local Abundance

Epacris purpurascens var. *purpurascens* was not recorded within the Study Area despite current and previous targeted surveys. The species has previously been recorded from approximately 36 locations within 10 km of the Study Area (DECC 2007a), all of which occur to the north and northwest. The nearest known records are within the Metropolitan Catchment Area approximately 2 km to the north of the Study Area. The number of individuals at these sites is unknown.

Regional Abundance

The species is restricted to the Sydney Basin Bioregion. Records of the species are concentrated in two disjunct areas to the north and south of the Sydney Basin Bioregion. The greatest number of records appear between Sydney and Gosford on the Central Coast, with a comparatively lesser number of records on the Woronora Plateau to the south of Sydney (Bionet 2007).

Leucopogon exolasius

Discussion of Conservation Status

Leucopogon exolasius is listed as a Vulnerable species on both the TSC and EPBC Acts. The species has a ROTAP listing of 2VC- (Briggs and Leigh 1996), suggesting a geographic range of less than 100 km and that the population is reserved, but the adequacy of the reservation is unknown.

The species is found along the upper Georges River area and in Heathcote National Park (DEC 2005). The southern-most geographical limit of distribution for this species is near Cordeaux Dam (Bionet 2007). Therefore, the Study Area is near the southern limit of known distribution of the species.

Recordings in conservation reserves include Dharawal State Conservation Area and Heathcote National Park. Populations also exist in protected water supply catchment lands in the vicinity of Woronora Plateau. An additional recorded location affording limited protection for the species includes sites within the Holsworthy Military Base (French 2000). The species is considered unlikely to be adequately represented in conservation reserves in the region.

The conservation status of this species may also be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs listed on the TSC Act relevant to the Proposal that may impact on potential habitat for *Leucopogon exolasius* in the Study Area include:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands (NSW Scientific Committee 2002a) – the Proposal may potentially impact on a number of ephemeral drainage lines and creeklines, including Wongawilli Creek and Sandy Creek.

- Alteration of habitat following subsidence due to longwall mining (NSW Scientific Committee 2005a) – the Proposal is likely to cause subsidence related impacts in the Study Area.

- Human-caused climate change (NSW Scientific Committee 2000b).

To date, no recovery plan or threat abatement plan has been prepared for this species. DECC (2005) has listed seven priority actions to help recover this species. Those that are considered relevant to the Proposal include:

- Undertake surveys of known sites and potential habitat, particularly on Department of Defence land and along Georges River – potential habitat for the species within the Study Area has been identified and mapped (Figure 10). The species has not been recorded in the Study Area despite targeted surveys within potential habitat.

Discussion of Habitat Utilisation

Leucopogon exolasius was not recorded within the Study Area despite current and previous targeted surveys. The species is known to occur in woodland on sandstone (DEC 2005). Locally this species has been recorded from the Woronora River where it occurs within the rocky, bare riparian zone where alluvial soils are almost absent (M. Richardson, Biosis Research Pty. Ltd., *pers. comm.*). The species is considered to have potential habitat in the Study Area in gullies within Sandstone Gully Peppermint Forest, Nepean Sandstone Gully Forest and Sandstone Riparian Scrub.

Discussion of Local and Regional Abundance

Little information is available on the abundance of this species.

Local Abundance

Leucopogon exolasius has not been previously recorded within 10 km of the Study Area, although the species is known to occur approximately 25 km north within Dharawal State Conservation Area (DECC 2007b).

Regional Abundance

The species is restricted to the Sydney Basin Bioregion. Records of the species are concentrated to the south of the Sydney Basin Bioregion. A total of 20 recorded locations exist across the Sydney Basin Bioregion (Bionet, 2007).

Pultenaea aristata	**Prickly Bush Pea**

Discussion of Conservation Status

Pultenaea aristata is listed as Vulnerable on both the TSC and EPBC Acts and is restricted to the Woronora Plateau ranging from Helensburgh to Mt Keira (DEC 2005,).

Pultenaea aristata has limited representation within formally reserved lands, the only reserve it has been recorded from being within Dharawal State Conservation Area. Protection is afforded to the species within the Sydney Metropolitan Catchment Areas, where numerous populations are known to the authors.

The conservation status of *Pultenaea aristata* may also be affected by KTPs as listed under Schedule 3 of the TSC Act. Two KTPs listed on the TSC Act relevant to the Proposal that may impact on potential habitat for *Pultenaea aristata* include:

- Alteration of habitat following subsidence due to longwall mining (NSW Scientific Committee 2005a) - up to 3,198.3 ha will be subject to varying levels of subsidence as part of the Proposal.

- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands (NSW Scientific Committee 2002a) – as a direct result of subsidence, alteration of natural hydrological conditions may result from the Proposal.

- Human-caused climate change (NSW Scientific Committee 2000b).

The KTP, Infection of native plants by *Phytophthora cinnamomi,* specifically lists *Pultenaea aristata* as a species which may be affected by this disease (NSW Scientific Committee 2003b). The Proposal is not expected to result in the spread of this disease, but as a precaution, recommendations have been included in this report to minimise disease transmission during any surface activities conducted in the Study Area.

To date, no recovery plan or threat abatement plan has been prepared for this species. DEC (2005,) has listed two recommendations to help recover this species:

- Review fire management requirements – the Proposal will have no influence on fire regimes in the Study Area.

- Confirm location details of existing records – known and potential habitat for the species has been identified as part of the current and previous surveys within and surrounding the Study Area.

Discussion of Habitat Utilisation

Pultenaea aristata is known to occur in both dry sclerophyll woodlands and wet heath on sandstone (DEC 2005,). During current and previous surveys of the Study Area, *P. aristata* was recorded within the Upland Swamp vegetation only. During previous surveys conducted in the Locality the species has also been recorded in areas of impeded drainage within vegetation mapped by NPWS (2003) as Exposed Sandstone Scribbly Gum Woodland and Sydney Sandstone Gully Peppermint Forest. The majority of records within the Study Area and Woronora Plateau are within the Upland Swamp sub-communities; including Banksia Thicket, Cyperoid Heath and Restoid Heath.

Within the Upland Swamps, the most common associate species included a sparse shrub layer dominated by *Banksia ericifolia, Hakea dactyloides, Leptospermum trinervium, Petrophile pulchella,* and *P. sessilis* with a dense ground layer dominated by sedges and small shrubs, including *Dillwynia rudis*, *Cyathochaeta diandra*, *Lepyrodia scariosa* and *Leptocarpus tenax.*

Discussion of Local Abundance

Bionet (Accessed Dec, 2006) indicates two occurrences of this species within the Study Area. During surveys of the Study Area, the species was found to be locally abundant at some sites within the Avon Catchment. Previous Biosis Research records in the Locality also include two large populations of undetermined size immediately south of the Study Area, within the Lake Cordeaux Catchment.

During the current surveys, the species was recorded at two locations within one Upland Swamp in the south-west of the Study Area and a number of other Upland Swamps to the south of the Study Area. *Pultenaea aristata* was recorded as a dominant shrub within two of the Upland Swamps during the current surveys. Due to the density of the species at locations it occurs within the Study Area, it was not feasible to undertake total abundance counts. The abundance of the species recorded within a 10 x 10 m quadrat ranges from 177 to 424 individuals. Based on abundance counts of *P. aristata* populations, density estimates have an average abundance of ~27,550 individuals per hectare. This estimate was established by averaging the counts from the 10 x 10 m quadrat data and extrapolating these numbers to cover a 1 ha area.

Discussion of Regional Abundance

As previously discussed, this species is confined to the Woronora Plateau. Bionet (Accessed January 2007) records list approximately 26 occurrences of the species across its distribution. A large abundance of the species has recently been recorded within Upland Swamps in Dharawal State Conservation Area (Biosis Research 2007f). At least 2,000 individuals were estimated to be present in an Upland Swamp within Dharawal State Conservation Area to the east of Appin.

6.3.6 Affected Threatened Fauna Profiles

Unless otherwise stated the information contained in the following species profiles has been derived from the NSW Government's Bionet database and DECC's Threatened Species profiles and/or Environmental Impact Assessment Guidelines for each species.

Littlejohn’s Tree Frog	***Litoria littlejohni***

Discussion of Conservation Status

Littlejohn’s Tree Frog is listed as Vulnerable on Schedule 2 of the TSC Act and as Vulnerable on the EPBC Act.

Outside the Study Area, Littlejohn's Tree Frog is only known from 13 locations in New South Wales. Of these locations, six occur in conservation areas: Blue Mountains National Park, Royal National Park, Barren Grounds Nature Reserve, Morton National Park, Budawang National Park and Wadbilliga National Park (Scientific Committee 2000). Given the paucity of records for this species and the lack of scientific knowledge, it is unknown whether the species is adequately represented in conservation reserves.

The conservation status of Littlejohn's Tree Frog may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for Littlejohn's Tree Frog include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – known and potential habitat for Littlejohn’s Tree Frog occurs within creek lines, ridge lines and Upland Swamps; all of which are known and/or may be vulnerable to the effects of subsidence;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – Littlejohn’s Tree Frog require permanent, slow-flowing creek lines with deep pools for breeding. Loss of water or changes to flow patterns could impact on the species; and,

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Littlejohn’s Tree Frog.

There is currently no Commonwealth or NSW recovery plan for Littlejohn’s Tree Frog. However, the DECC has prepared 13 Priority Actions to help recover this species. Those relevant to the Proposal are outlined below.

- Develop management strategies where possible that protect existing water flow and quality or restore natural water flows and water quality – subsidence has the potential to impact on water flow and water quality of known habitat for Littlejohn’s Tree Frog;

- Develop strategies for providing supplementary breeding habitat at selected locations throughout the species range – subsidence has the potential to impact known and potential breeding sites within the Study Area;

- Retain riparian native vegetation – subsidence has the potential to impact riparian vegetation by gas emissions and water loss although, such impacts are predicted to be unlikely and/or insignificant;

- Investigate methods of ameliorating or attenuating chytrid action – appropriate gear and vehicle washdown procedures should be followed at all times; and

- Undertake survey in some of the less surveyed parts of the species distribution.

There is currently no NSW threat abatement plan for Littlejohn's Tree Frog, but the species is considered in the Commonwealth threat abatement plan 'Infection of amphibians with chytrid fungus resulting in chytridiomycosis'. The plan states that there have been no reports of Chytrid Fungus in Littlejohn's Tree Frog but that also no surveys have been performed to test for the pathogen in this species (DEH 2006). Therefore, Littlejohn's Tree Frog should be considered susceptible to infection by Chytrid Fungus. The aim of the threat abatement plan is to reduce the impacts of the KTP 'Infection of frogs by amphibian chytrid causing the disease chytridiomycosis' and to maximise the chances of the long-term survival of affected species, particularly listed threatened species. The current Proposal is unlikely to exacerbate the infection or spread of Chytrid Fungus however, if the fungus is present in frog populations within the Study Area (the disease is known to occur in Dendrobium Area 1 adjacent to the Study Area), these populations would be more susceptible to other threatening processes such as loss and degradation of habitat (NSW Scientific Committee 2003a).

Discussion of Habitat Utilisation

Littlejohn's Tree Frog appears to be restricted to sandstone woodland and heath communities from 100 to 950 m above sea level (White and Ehmann 1997) and is not known from coastal habitats (NPWS 2002c). It is not associated with any specific plant communities and appears to breed in wet forest margins (NPWS 2002c).

A variety of breeding habitat has been described, including temporary pools, deep permanent pools in slow creeks and slow, rock-lined rivers and dams (White and Ehmann 1997). It forages in the tree canopy and on the ground (NPWS 2002c). Where the species occurs when it is not breeding is virtually unknown although it has been observed sheltering under rocks on high exposed ridges during summer (NSW Scientific Committee 2000a).

Littlejohn's Tree Frog has been recorded many times within the Study Area within Upland Swamp (Upland Swamps 7, 15a and 15b), gully (Sandy Creek, Banksia Creek, SC10C, Cascade Creek, Waratah Creek, Fern Tree Creek, LC7, Donald's Castle Creek, LA4 and Native Dog Creek) and ridge (Banksia Creek) habitat. Sites where the species has been recorded include permanent, slow-flowing, rocky streams (often with sandy banks) with fringing vegetation. Breeding sites (i.e. where eggs, tadpoles, metamorphs and/or adults in amplexus have been observed) occur within Banksia Creek, SC10C, Cascade Creek and Waratah Creek (and associated Upland Swamps 15a and 15b) where permanent deep pools, fringing vegetation and submerged debris (e.g. twigs) are present. Littlejohn's Tree Frog has been recorded to both the east and west of Wongawilli Creek with the largest population in the Study Area (and possibly NSW) occurring in the Sandy Creek Catchment (in DA3A). Breeding sites have only been observed within the Sandy Creek Catchment. Further potential habitat for this species exists in the Study Area within other Upland Swamps, ridge-top woodlands and gully forests.

Discussion of Local and Regional Abundance

Local

Littlejohn's Tree Frog has been recorded a number of times within the Study Area and the Locality. Sandy Creek Catchment within the Study Area supports possibly the largest population of Littlejohn's Tree Frog ever recorded. The NSW Scientific Committee found that "sightings of more than ten frogs have been recorded from only three locations (Watagan State Forest, Ourimbah State Forest and Barren Grounds Nature Reserve) and most sightings are of no more than three frogs at one time" (NSW Scientific Committee 2000a). During the most recent targeted surveys for Littlejohn's Tree Frog within the Study Area (winter 2007), 77 individuals were recorded over two nights. Approximately 50 individuals were recorded over two nights during the winter 2006 targeted surveys. Furthermore, the targeted surveys did not cover all known sites within the Study Area. The species is also regularly encountered during the Dendrobium Area 2 fauna monitoring with over 90 records made during the winter 2005 surveys (Biosis Research 2005c). The species has been recorded within the Locality where the creek lines mentioned in this profile extend beyond the Study Area (Biosis Research), as well as in two other locations, recorded in 1995 and 1997 (DECC Atlas of NSW Wildlife).

Littlejohn's Tree Frog is probably moderately common within areas of suitable habitat in the Study Area and Locality.

Regional

Littlejohn's Tree Frog has a distribution that includes the plateaus and eastern slopes of the Great Dividing Range from Watagan State Forest south to Buchan in Victoria (DEC 2005z). The species' distribution is scattered, probably reflecting its very specific habitat requirements. It is a rare species (DEW 2007) and is considered to be an "extremely rare resident" within the Greater Southern Sydney Region whose "known breeding sites should be treated as being of very high conservation value" (DEC 2005Ž).

The Study Area is not at the limits of known distribution for this species.

Giant Burrowing Frog	***Heleioporus australiacus***

Discussion of Conservation Status

The Giant Burrowing Frog is listed as Vulnerable on Schedule 2 of the TSC Act and as Vulnerable on the EPBC Act.

The Giant Burrowing Frog has been recorded throughout regional conservation reserves including the Illawarra Escarpment State Conservation Reserve; Blue Mountains, Ben Boyd, Brisbane Water, Budderoo, Dharug, Garigal, Heathcoat, Jervis Bay, Ku-ring-gai Chase, Marramarra, Morton, Nattai, Royal, Wollemi and Yengo National Parks; Barren Grounds, Nadgee and Nattai Nature Reserves; and Dharawal State Conservation Area (NPWS 2001a). However, it remains unclear how adequately represented this species is within conservation reserves, possibly due its cryptic behaviour. Furthermore, the Giant Burrowing Frog is believed to be declining at a number of known locations throughout NSW (Rescei 1997).

The conservation status of the Giant Burrowing Frog may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Giant Burrowing Frog include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – known and potential habitat for the Giant Burrowing Frog occurs within creek lines with sandy soils, ridge lines and Upland Swamps; all of which are known and/or may be vulnerable to the effects of subsidence;

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – Giant Burrowing Frogs require first or second order creeks and ponded drainage lines for breeding. Loss of water or changes to flow patterns could impact on the species; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Giant Burrowing Frog.

There is currently no Commonwealth or NSW recovery plan for the Giant Burrowing Frog. However, the DECC has prepared 24 Priority Actions to help recover this species. Those relevant to the Proposal are outlined below.

- Develop best practice management strategies that buffer and protect important breeding sites from changes to water flow, flow regimes and water quality changes – subsidence has the potential to impact on water flow and water quality of breeding sites for the Giant Burrowing Frog; and

- Investigate methods of ameliorating or attenuating chytrid action – appropriate gear and vehicle washdown procedures should be followed at all times.

There is currently no NSW threat abatement plan for the Giant Burrowing Frog, but the species is considered in the Commonwealth threat abatement plan ‘Infection of amphibians with chytrid fungus resulting in chytridiomycosis’. The plan states that archived specimens of Giant Burrowing Frog have tested positive for Chytrid Fungus (DEH 2006). The aim of the threat abatement plan is to reduce the impacts of the KTP ‘Infection of frogs by amphibian chytrid causing the disease chytridiomycosis’ (NSW Scientific Committee 2003a) and to maximise the chances of the long-term survival of affected species, particularly listed threatened species. The current Proposal is unlikely to exacerbate the infection or spread of Chytrid Fungus however, if the fungus is present in frog populations within the Study Area (the disease is known to occur in Dendrobium Area 1 adjacent to the Study Area), these populations would be more susceptible to other threatening processes such as loss and degradation of habitat (NSW Scientific Committee 2003a).

Discussion of Habitat Utilisation

The Giant Burrowing Frog prefers hanging swamps on sandstone shelves adjacent to perennial non-flooding creeks (Daly 1996a, Rescei 1997). It can also occur within shale outcrops within sandstone formations. In the southern part of its range the Giant Burrowing Frog can occur in wet and dry forests, montane sclerophyll woodland and montane riparian woodland (Daly 1996a). Individuals can be found around sandy creek banks or foraging along ridge-tops during or directly after heavy rain. Males often call from burrows located in sandy banks next to water (Barker *et al.* 1995).

The Giant Burrowing Frog has been recorded within the Study Area within Upland Swamp, gully and ridge habitat. The species has been recorded to both the east and west of Wongawilli Creek. Known and potential habitat for this species exists in the Study Area within the Upland Swamps, ridge-top woodlands and gully forests.

Discussion of Local and Regional Abundance

The Giant Burrowing Frog is a cryptic species spending significant periods in burrows or deep leaf litter (NPWS 2001a). The species is most often seen after heavy rain.

Local

The Giant Burrowing Frog has been recorded within the Study Area and Locality. The species is possibly moderately common within areas of suitable habitat in the Study Area and Locality. However, the species' cryptic behaviour makes it difficult to estimate abundance.

Regional

The distribution of the Giant Burrowing Frog extends from the NSW Central Coast south to eastern Victoria, but is most common on the Sydney sandstone. The species has been found from the coast to the Great Dividing Range (DEC 2005r).

Within the Greater Southern Sydney Region, records of the Giant Burrowing Frog are localised and uncommon (DEC 2005Ž).

The Study Area is not at the limits of known distribution for this species.

Stuttering Frog	***Mixophyes balbus***

Discussion of Conservation Status

The Stuttering Frog is listed as Endangered on Schedule 1 of the TSC Act and as Vulnerable on the EPBC Act.

The Stuttering Frog has been recorded within Blue Mountains, Morton, Dorrigo, Gibraltar, Washpool, New England and Werrikimbee National (DEW 1997). Within the southern portion of its range, the Stuttering Frog appears to have declined dramatically in recent times (NSW Scientific Committee 2002b). It is unknown if it is adequately represented in conservation reserves.

The conservation status of the Stuttering Frog may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Stuttering Frog include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – potential habitat for the Stuttering Frog occurs within rainforest creek lines in the Study Area. Creek lines are known to be vulnerable to the effects of subsidence;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Stuttering Frog requires permanent, flowing streams with deep pools for breeding. Loss of water or changes to flow patterns could impact on the species; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Stuttering Frog.

There is currently no Commonwealth or NSW recovery plan the Stuttering Frog. However, the DECC suggests a number of recovery strategies to help recover this species. Those relevant to the Proposal are outlined below.

- Maintain natural stream channel morphology and flows – subsidence has the potential to impact on water flow and water quality of potential habitat for the Stuttering Frog;

- Retain riparian native vegetation – subsidence has the potential to impact riparian vegetation by gas emissions and water loss although, such impacts are predicted to be unlikely and/or insignificant; and

- Investigate methods of ameliorating or attenuating chytrid action – appropriate gear and vehicle washdown procedures should be followed at all times.

There is currently no NSW threat abatement plan for the Stuttering Frog, but the species is considered in the Commonwealth threat abatement plan ‘Infection of amphibians with chytrid fungus resulting in chytridiomycosis’. The plan states that Chytrid Fungus is endemic in Stuttering Frog populations in NSW (DEH 2006). The aim of the threat abatement plan is to reduce the impacts of the KTP ‘Infection of frogs by amphibian chytrid causing the disease chytridiomycosis’ and to maximise the chances of the long-term survival of affected species, particularly listed threatened species. The current Proposal is unlikely to exacerbate the infection or spread of Chytrid Fungus however, if the fungus is present in frog populations within the Study Area (the disease is known to occur in Dendrobium Area 1 adjacent to the Study Area), these populations would be more susceptible to other threatening processes such as loss and degradation of habitat (NSW Scientific Committee 2003a).

Discussion of Habitat Utilisation

The Stuttering Frog is usually associated with mountain streams, wet mountain forests and rainforests (Barker *et al.* 1995). It rarely wanders very far from the banks of permanent forest streams, although it will forage on nearby forest floors. Eggs are deposited in leaf litter on the banks of streams to be washed into the water during heavy rains (Barker *et al.* 1995) or on rock shelves or shallow riffles in small, flowing streams (DEC 2005‹). As the tadpoles grow they move to deep permanent pools and take approximately 12 months to metamorphose.

The Stuttering Frog has not been recorded within the Study Area or the Locality. Potential habitat for this species however, occurs within the rainforest areas of the Study Area.

Discussion of Local and Regional Abundance

Local

The Stuttering Frog has not been recorded within a 10 km radius of the Study Area. The closest records occur approximately 18 km to the south-west and were recorded in the year 2000 (Bionet). If the species occurs within the Locality, it is probably very rare and isolated.

Regional

The distribution of the Stuttering Frog extends along the east coast of Australia from southern Queensland to north-eastern Victoria. The southern portion of the Stuttering Frog's range appears to be separated from the northern portion by the Hunter Valley (NSW Scientific Committee 2002b). The species has suffered a marked decline in distribution and abundance, particularly in south-east NSW (DEC 2005‹). Within the Sydney Basin Bioregion the Stuttering Frog is uncommon and occurs in isolated clusters.

Within the Greater Southern Sydney Region, the Stuttering Frog is considered to be an “extremely rare resident” (DEC 2005Ž).

The Study Area is not at the limits of known distribution for this species however, does occur where the species’ abundance and range has declined drastically in recent times (NSW Scientific Committee 2002b).

Red-crowned Toadlet	***Pseudophryne australis***

Discussion of Conservation Status

The Red-crowned Toadlet is listed as Vulnerable on Schedule 2 of the TSC Act.

The Red-crowned Toadlet has been recorded throughout regional conservation reserves (including the Illawarra Escarpment State Conservation Reserve; Blue Mountains, Bouddi, Brisbane Water, Dharug, Garigal, Heathcoat, Ku-ring-gai Chase, Lane Cove, Morton, Royal, Sydney Harbour, Wollemi and Yengo National Parks; Barren Grounds and Nattai Nature Reserves; and Dharawal State Conservation Area)(NPWS 2001e) and crown land. It is likely that the species is reasonably represented in conservation reserves.

The conservation status of the Red-crowned Toadlet may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Red-crowned Toadlet include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – known and potential habitat for the Red-crowned Toadlet occurs within Upland Swamps, ephemeral creek lines and rocky slopes; all of which are known and/or may be vulnerable to the effects of subsidence;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – Red-crowned Toadlets prefer ephemeral creeks and drainage lines for breeding. Loss of water or changes to flow patterns could impact on the species; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Red-crowned Toadlet.

There is currently no recovery plan or threat abatement plan for the Red-crowned Toadlet. However, the DECC has prepared 14 Priority Actions to help recover this species. Those relevant to the Proposal are outlined below.

- Retain and protect habitat and buffers around habitat, particularly vegetation on upper slopes and ridges – subsidence may impact on potential habitat such as Upland Swamps and rocky slopes;

- Develop best practice management strategies that buffer and protect important headwater/ridge top breeding sites from changes to water flow, flow regimes and water quality changes – subsidence has the potential to impact on water flow and water quality of breeding sites for the Red-crowned Toadlet; and

- Investigate methods of ameliorating or attenuating chytrid action – appropriate gear and vehicle washdown procedures should be followed at all times.

Discussion of Habitat Utilisation

The Red-crowned Toadlet typically occurs in open forests, mostly on Hawkesbury and Narrabeen Sandstones. The species inhabits and breeds within ephemeral drainage lines below sandstone ridges where it shelters under rocks and amongst masses of dense vegetation or thick piles of leaf litter. The Red-crowned Toadlet disperses outside the breeding period to shelter under rocks and logs on sandstone ridges and to forage amongst leaf-litter (DEC 2005„).

The Red-crowned Toadlet has been recorded within the Study Area on a number of occasions, including records to both the east and west of Wongawilli Creek. Known and potential habitat for this species occurs within ephemeral drainage lines and rocky slopes in gully, ridge and Upland Swamp habitat throughout the Study Area.

Discussion of Local and Regional Abundance

Local

There are several records of the Red-crowned Toadlet both within the Study Area and the Locality. The species is considered moderately common within areas of suitable habitat in the Study Area and Locality.

Regional

The distribution of the Red-crowned Toadlet coincides with the Greater Sydney Metropolitan District, largely restricted to Hawkesbury Sandstone formations surrounding Sydney; the area covered by Sydney Triassic Sandstone geological formation (Thumm and Mahoney 1997). The species is probably moderately common within its restricted distribution.

The Study Area is close to the southern extremities of the species’ known distribution. Records become sparser farther south. The southern-most record occurs approximately 32 km from the Study Area.

Black Bittern	***Ixobrychus flavicollis***

Discussion of Conservation Status

The Black Bittern is listed as Vulnerable on Schedule 2 of the TSC Act.

The Black Bittern has been recorded within Blue Mountains, Dorrigo and Dharug National Parks, Nadgee Nature Reserve and near the Illawarra Escarpment State

Conservation Area. It is unlikely this species is adequately represented within conservation reserves.

The conservation status of the Black Bittern may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Black Bittern include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – potential habitat for the Black Bittern within the Study Area includes creek lines and riparian vegetation, which may be affected by subsidence;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Black Bittern inhabits rivers, streams, floodplains and wetlands, foraging and nesting in these habitats. Subsidence due to longwall mining may alter the natural flow regimes of water sources important to this species; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Black Bittern.

There is currently no threat abatement plan or recovery plan for this species. However, the DECC has developed two Priority Actions to help recover this species in NSW. One relevant to the Proposal is outlined below.

- In areas of suitable breeding habitat, seek to retain and manage riparian vegetation – subsidence has the potential to impact riparian vegetation by gas emissions. However, no significant gas emissions are predicted for the Proposal.

Discussion of Habitat Utilisation

The Black Bittern inhabits coastal wetlands and littoral habitats. Freshwater wetlands, fringed with dense vegetation such as Melaleuca and Casuarina are preferred (Marchant and Higgins 1990). The species will utilise billabongs, pools, and estuaries and tidal reaches of coastal creeks and rivers with fringing vegetation, which may only form a narrow band of cover (Marchant and Higgins 1990).

The species nests in trees over wetlands and watercourses in densely vegetated areas (Marchant and Higgins 1990). It will forage in low, marshy vegetation, or in shadows over shallow water and roost on the ground or in leafy trees (Marchant and Higgins 1990).

The Black Bittern has not been recorded within the Study Area although it has been previously recorded approximately 1 km south-east of the Study Area. Potential habitat for this species occurs within creek lines and rainforest areas of the Study Area.

Discussion of Local and Regional Abundance

Local

The Black Bittern has not been recorded in the Study Area, but has been recorded once in the Locality. Three records also exist on the coast approximately 12 km from the Study Area. The species is probably uncommon in the Locality.

Regional

The Black Bittern has been recorded from the coast around Wollongong and from areas surrounding the Illawarra Escarpment State Conservation Area. The species was a regular summer breeder in the Hawkesbury area during the 1960s (SFNSW 1995), however the species is now considered rare in the region. Records become sparser south of Sydney.

The Study Area is not at or near the limits of distribution for this species.

Gang-gang Cockatoo	***Callocephalon fimbriatum***

Discussion of Conservation Status

The Gang-gang Cockatoo is listed as Vulnerable on Schedule 2 of the TSC Act.

Gang-gang Cockatoos have been recorded in various reserves throughout eastern and central NSW (including the Illawarra Escarpment State Conservation Reserve). It is considered to be adequately represented in reserves within the Sydney Basin Bioregion (DEC 2005Ž).

The conservation status of the Gang-gang Cockatoo may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Gang-gang Cockatoo include:

- ‘Alteration of habitat following subsidence due to longwall mining’(NSW Scientific Committee 2005a) – the Proposal has limited potential to directly impact foraging resources for this species. Possible impacts include vegetation die-back and therefore loss of feed trees. However, vegetation die-back due to gas emissions has only been observed once in the Southern Coalfields (within the Cataract River) and is not expected to be significant within the Study Area. Known and potential foraging habitat for the Gang-gang Cockatoo occurs in the Study Area; and

- 'Human-caused climate change' (NSW Scientific Committee 2000b) - climate change may alter the extent and nature of the cool temperate vegetation that the species utilises.

No recovery or threat abatement plans have been prepared for the Gang-gang Cockatoo to date. However, the DECC has prepared eight Priority Actions to help to recover the species. One relevant to the Proposal is outlined below.

- Monitor utilisation of the relevant forested areas as to nesting, foraging and other habitat uses – subsidence has limited potential to impact known foraging habitat.

Discussion of Habitat Requirements

In summer, the Gang-gang Cockatoo occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests (Higgins 1999). It also occurs in subalpine Snow Gum woodland and occasionally in temperate or regenerating forest (Forshaw and Cooper 1981). In winter, it 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). Gang-gang Cockatoos nest in tree hollows, preferring live trees often near water with hollows between 70-200 cm deep and approximately 25 cm in diameter. These trees often occur in mature sclerophyll forest with a dense shrubby understorey.

The Gang-gang Cockatoo forages for seeds in the canopies of native and introduced trees, especially eucalypts. Little is known about the movements of this species, although they are considered to be mobile and known to migrate in response to food availability.

Approximately 30 individuals were recorded during the current surveys within woodland, forest and Upland Swamp plant communities. The Gang-gang Cockatoo is also regularly encountered during monitoring surveys and has been recorded within various plant communities within the Study Area, as well as within the Locality (along creek and ridge lines). Rainforest may also provide potential habitat within the Study Area. The species was recorded foraging in trees along the banks of Wongawilli Creek and other watercourses within the Study Area.

Discussion of Local and Regional Abundance

Local

The Gang-gang Cockatoo has been recorded many times in the Study Area and Locality. The species is probably moderately common within the local area.

Regional

In New South Wales, 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. The species has been recorded as far north as Coffs Harbour and south well into Victoria. Hundreds of records exist within the Sydney Basin Bioregion, occurring along the coast and along the Great Dividing Range. The species is considered a moderately common resident within the region (DEC 2005Ž).

The Study Area is not at the boundaries of the species' current distribution.

Glossy Black-cockatoo	***Calyptorhynchus lathami***

Discussion of Conservation Status

The Glossy Black-cockatoo is listed as Vulnerable on Schedule 2 of the TSC Act.

Glossy Black-cockatoos have been recorded in various reserves throughout eastern and central NSW (NPWS 1999e) including Blue Mountains, Nattai, Ku-ring-gai Chase, Dharug and Morton National Parks, Barren Grounds Nature Reserve and Dharawal State Conservation Area (Bionet). The species is probably adequately represented in reserves within the Sydney Basin Bioregion.

The conservation status of the Glossy Black-cockatoo may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Glossy Black-cockatoo are outlined below.

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – the Proposal has limited potential to directly impact foraging resources for this species. The species was recorded foraging in Allocasuarina trees along the banks of Wongawilli Creek and other watercourses within the Study Area. Possible impacts include vegetation die-back and therefore loss of feed trees. However, vegetation die-back due to gas emissions has only been observed once in the Southern Coalfields (within the Cataract River) and is not expected to be significant within the Study Area. The Proposal is unlikely to significantly impact on breeding and roosting habitat (e.g. hollow-bearing trees); and

- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Glossy Black-cockatoo.

No recovery or threat abatement plans have been prepared for the Glossy Black-cockatoo to date. However, the DECC has prepared nine Priority Actions to help to recover the species. Those most relevant to the Proposal are outlined below.

- Continue existing monitoring programs – to identify and assess impacts due to subsidence;
- Identify and map key breeding and foraging habitat – known and potential foraging habitat may be impacted by subsidence;
- Retain and protect areas of native forest and woodland containing she-oaks – riparian vegetation containing she-oaks may be impacted by gas emission and pool water loss;
- Prepare and distribute EIA guidelines to decision makers; and
- Utilise the Glossy Black-cockatoo as a flagship threatened species for woodland and forest conservation education and awareness programs.

Discussion of Habitat Utilisation

The Glossy Black-cockatoo inhabits forests with low nutrients, characteristically with key *Allocasuarina* spp. This species tends to prefer drier forest types (NPWS 1999e) with a middle stratum of *Allocasuarina* below *Eucalyptus* or *Angophora* and is often confined to remnant patches in hills and gullies (Higgins 1999). The Glossy Black-cockatoo breeds in hollow stumps or limbs, either living or dead (Higgins 1999) and forages primarily on the cones of *Allocasuarina* species.

Known foraging and nesting habitat for this species is present in the Study Area. Six Glossy Black-cockatoos were recorded during the current surveys all within the Sandstone Gully Peppermint Forest plant community. The species has also been recorded during monitoring surveys within other woodland and forest communities in the Study Area, as well as within the Locality (on ridge lines). Another plant community that may provide potential habitat within the Study Area is Rock Plate Heath-Mallee.

Discussion of Local and Regional Abundance

Local

The Glossy Black-cockatoo has been recorded several times within the Study Area and within 10 km of the Study Area. The species is probably moderately common within the local area.

Regional

The Glossy Black-cockatoo mainly occurs in coastal regions within NSW, it can also be found as far west as Cobar. The Glossy Black-cockatoo is considered common within the Greater Southern Sydney Region with the vast majority of habitat occurring within the reserve system (DEC 2005Ž).

The Study Area is not at the limits of the known distribution for this species.

Eastern Ground Parrot	***Pezoporus wallicus wallicus***

Discussion of Conservation Status

The Eastern Ground Parrot is listed as Vulnerable on Schedule 2 of the TSC Act.

The Eastern Ground Parrot has been recorded on the outskirts of Dharawal State Recreation Area and at Darkes Forest immediately to the south of Dharawal State Recreation Area. It has also been recorded once in the Royal National Park to the north and Budderoo National Park and Barren Grounds Nature Reserve south near Kiama. Records are sparse, but most occur in or adjacent to conservation reserves. This species is considered inadequately represented in conservation reserves due to its general rarity.

The conservation status of the Eastern Ground Parrot may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Eastern Ground Parrot include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – Eastern Ground Parrots are found inhabiting heaths and sedgelands, as they require structurally dense, low vegetation with high species diversity. Such habitat may also occur in association with Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by upsidence and closure movements, resulting is hydrological changes. It is possible that any changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not anticipated. A small portion of Rock Plate Heath-Mallee is also present in the Study Area, which may also provide potential habitat for this species. Any potential impacts to this plant community (e.g. surface cracking) are likely to be negligible for this species;

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – the Eastern Ground Parrot inhabits heaths and sedgelands. These vegetation types are dependent on certain water flows. Subsidence due to longwall mining may alter the natural flow regimes of water sources and thus alter the suitability of the habitat for this species. While it is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps, significant changes to vegetation within the swamps are not anticipated; and

- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Eastern Ground Parrot.

There is currently no threat abatement plan or recovery plan for the Eastern Ground Parrot. However, the DECC has developed a list of 13 Priority Actions and recovery strategies to help recover this species in NSW. Those actions relevant to the Proposal include:

- Undertake surveys of potential Eastern Ground Parrot habitat within Sydney Catchment Authority Special Areas and prepare management guidelines;

- Identify, protect and manage previously unknown areas of Eastern Ground Parrot heathland and sedgeland habitat – potential heathland and sedgeland habitat occurs within the Study Area and may be impacted by subsidence; and

- Protect habitat from intense and extensive fire events – potential habitat within the Study Area may be impacted by subsidence (e.g. water loss and drying out of sections of Upland Swamps) which may lead to more intensive and extensive impacts from fire.

Discussion of Habitat Utilisation

The Eastern Ground Parrot is restricted mainly to coastal heaths, estuarine flats and swamps. It is a granivore (McFarland 1989, Bryant 1991) and has specialised habitat requirements. In eastern Australia, it is largely restricted to heathlands and sedgelands with very dense cover (>80%) and a high density of food plants (Meredith *et al.* 1984). The species feeds on a variety of small seeds and fruits, preferring the seeds of Cyperaceae and Restionaceae. Pairs nest beneath very dense vegetation and are probably sedentary and territorial. Post-breeding dispersal of up to 120 km may occur.

Vegetation characteristics of the Eastern Ground Parrot habitat have been summarised by Bryant (1994) as: low (60-100 cm) closed (foliage projected cover

> 70%) sedgeland and wet and dry heathland with high species richness (typically 20 to 40 spp per 5m x 5m plot).

The species has not been recorded in the Study Area.

Potential habitat for the Eastern Ground Parrot exists in the Study Area within Upland Swamps and Rock Plate Heath-Mallee where vegetation is dense.

Discussion of Local and Regional Abundance

The Eastern Ground Parrot is rarely seen, usually obscured from sight by its cryptic appearance and behaviour as well as dense habitat. The abundance of this species based on records therefore may not be representative of the species' true abundance.

Local

The Eastern Ground Parrot has not been recorded in the Study Area, Locality, or within 10 km of the Study Area. If present, it is probably rare within the local area.

Regional

The Eastern Ground Parrot has been recorded on the outskirts of Dharawal State Recreation Area (DEC 2006a) to the north-east of the Study Area, although the age of these records is unclear. The closest population of this species is probably at Budderoo National Park, approximately 24 km to the south (Bionet). One record from 1996 exists within Royal National Park (DECC Atlas of NSW Wildlife). The species is probably rare and even locally extinct in the Greater Southern Sydney Region (DEC 2005Ž) due to massive reduction in habitat and inappropriate fire regimes.

The Study Area is not at or near the limits of known distribution for this species.

Eastern Bristlebird	***Dasyornis brachypterus***

Discussion of Conservation Status

The Eastern Bristlebird is listed as Endangered on Schedule 1 of the TSC Act and as Endangered under the EPBC Act.

The Eastern Bristlebird has been recorded in Budderoo National Park and Barren Grounds Nature Reserve, both south of the Study Area near Kiama. Records occurred adjacent to the Illawarra Escarpment State Conservation Area, but the last record was in 1959. This species rarely occurs outside of conservation reserves, but due to its rarity, it is considered inadequately represented within reserves.

The conservation status of the Eastern Bristlebird may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Eastern Bristlebird include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – Eastern Bristlebirds are found inhabiting dense vegetation such as that found in association with Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting in hydrological changes. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not anticipated;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Eastern Bristlebird inhabits dense vegetation, which may be found in association with Upland Swamps in the Study Area. Subsidence due to longwall mining may alter the natural flow regimes of water sources and thus alter the suitability of the habitat for this species. Significant changes to vegetation within the Upland Swamps are not predicted; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Eastern Bristlebird.

There is currently no threat abatement plan or recovery plan for the Eastern Bristlebird. A recovery plan is in preparation (NPWS 1999d). The DECC has developed a list of 32 Priority Actions to help recover this species in NSW. Those actions relevant to the Proposal include:

- Encourage preparation of Species Impact Statements that consider cumulative impacts on habitat;

- Close and regenerate tracks in known habitat, other than those used for fire and other management purposes; and

- Undertake surveys in potential Eastern Bristlebird habitat within Sydney Catchment Authority Special Areas.

Discussion of Habitat Utilisation

The Eastern Bristlebird is found in a restricted area of south-eastern Australia where it is primarily associated with coastal heath (Blakers *et al.* 1984). It occurs in rank vegetation bordering on heathland in coastal and mountain environments. South of Sydney, it prefers woodland with a tussocky understorey bordering heath. This species forages mainly on the ground and in the litter, taking insects and fruit. It is sedentary.

Populations of Eastern Bristlebirds in southern New South Wales have been recently studied by Baker (1992, 1996). Eastern Bristlebird habitat is characterised by dense layers of ground cover and vegetation to at least one metre in tall heathland, mallee heathland, shrubland, woodland and forest (Baker 1992, 1996).

This species has not been recorded in the Study Area.

Potential habitat for the Eastern Bristlebird exists in the Study Area within areas of Upland Swamps and Rock Plate Heath-Mallee dominated by low, dense vegetation.

Discussion of Local and Regional Abundance

The Eastern Bristlebird is a cryptic bird living in dense habitat, and it is rarely seen. The abundance of this species based on records therefore may not be representative of the species' true abundance.

Local

The Eastern Bristlebird has not been recorded in the Study Area. One record of this species exists within the Locality, approximately 3 km south of the Study Area. No further records exist within 10 km of the Study Area. The species is probably rare within the local area.

Regional

The Eastern Bristlebird occurs in restricted habitats (heaths and heathy woodlands) on the tablelands and Illawarra coastal plains. The nearest population is probably at Budderoo National Park, approximately 24 km to the south (Bionet). The species has been recorded in the Campbelltown area (Sydney Prehistory Group 1983) and in the Woronora Catchment (DECC Atlas of NSW Wildlife). The species is extremely rare within the Sydney Basin Bioregion and considered locally extinct within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is not at or near the limits of known distribution for this species.

Barking Owl	***Ninox connivens***

Discussion of Conservation Status

The Barking Owl is listed as Vulnerable on Schedule 2 of the TSC Act.

The Barking Owl has been recorded in Nattai, Royal, and Blue Mountains National Parks and in the Illawarra Escarpment State Conservation Reserve. It is unlikely this species is adequately represented in conservation reserves in NSW.

The conservation status of the Barking Owl may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Barking Owl include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – some prey species for Barking Owls are dependent on habitats such as Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting in hydrological changes. It is possible that the changes in water level within the swamps could impact the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not anticipated;

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – some prey species for the Barking Owl are dependent on the continuation of natural flow regimes; and

- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Barking Owl.

A draft NSW recovery plan has been prepared for the Barking Owl (DEC 2006b). The ultimate aim of the recovery plan for the Barking Owl is to recover the species to a position of viability in nature in NSW, and to ensure the long-term persistence of the Barking Owl. The DECC has listed 17 Priority Actions and recovery strategies to help recover this species. Those relevant to the Proposal include:

- Retain and enhance vegetation along watercourses and surrounding areas to protect roosting areas and habitat for prey – subsidence has the potential to impact riparian vegetation by gas emissions and water loss;

- Minimise visits to nests and other disturbances, including surveys using call-playback, when owls are breeding; and

- Assess the importance of the site to the species' survival. Include the linkages the site provides for the species between ecological resources across the broader landscape.

There is currently no threat abatement plan for the Barking Owl.

Discussion of Habitat Utilisation

The Barking Owl lives in forest and woodlands of tropical, temperate and semi-arid zones (Higgins 1999). Tree hollows are important for the Barking Owl as they provide habitat for hollow-dwelling arboreal marsupials, which comprise a large proportion of their diet, and nesting sites (Higgins 1999). Large mature trees with hollows at least 0.6 m deep are required for nesting (Gibbons and Lindenmayer 1997). The Barking Owl favours nesting and roosting in woodland alongside watercourses (Higgins 1999). The Barking Owl is thought to have a home range of less than 200 hectares, although no detailed studies have been conducted (Higgins 1999).

The Barking Owl has been recorded twice in the Study Area in Exposed Sandstone Scribbly Gum Woodland and in Sandstone Gully Peppermint Forest. The Study Area contains known foraging and potential nesting habitat for the species. Further potential habitat occurs within other woodland, forest, Rock Plate Heath-Mallee, Sandstone Riparian Scrub and Upland Swamp plant communities. The Barking Owl may use Upland Swamps as hunting grounds. Upland Swamps may be impacted by subsidence movements.

Discussion of Local and Regional Abundance

Scarcity of records may be a reflection of the large size of territories rather than an indication of abundance.

Local

The Barking Owl has been recorded twice in the Study Area, on the eastern side of the Study Area near Lake Cordeaux. The species appears to be rare in the Locality.

Regional

In NSW, the Barking Owl is widespread on the coastal plains and foothills and inland slopes and plains. Its distribution is sparse on the south-eastern slopes of the

Great Dividing Range and in the arid zone. It is widespread through Australia, especially in the east.

Most records for the Barking Owl in the region fall on the coast or in the Blue Mountains. Several records exist from the outer Sydney suburbs. The species appears to be uncommon in the region.

The Study Area is not at or near the limits of distribution of this species.

Powerful Owl	***Ninox strenua***

Discussion of Conservation Status

The Powerful Owl is listed as Vulnerable on Schedule 2 of the TSC Act.

Records exist for the Powerful Owl from Royal National Park, Heathcote National Park, Illawarra Escarpment State Conservation Reserve and Dharawal State Conservation Area. It is estimated that while the species is recorded in conservation reserves, just as many records of the species are from private land. It is unknown whether this species is adequately represented in conservation reserves.

The conservation status of the Powerful Owl may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Powerful Owl include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – some prey species for Powerful Owls are dependent on habitats such as Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting in hydrological changes. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not anticipated;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – some prey species for the Powerful Owl are dependent on the continuation of natural flow regimes; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Powerful Owl.

A NSW recovery plan has been prepared for the Powerful Owl (DEC 2006b). The overall objective of the NSW Large Forest Owl Recovery Plan is to ensure that the owl species incorporated in the plan persist in the wild in NSW in each region where they presently occur. The DECC has listed 21 Priority Actions and recovery strategies to help recover the Powerful Owl. Those relevant to the Proposal include:

- Protect riparian vegetation to preserve roosting areas – subsidence has the potential to impact riparian vegetation by gas emissions and water loss;
- Minimise visits to nests and other disturbances, including surveys using call-playback, when owls are breeding; and
- Assess the importance of the site to the species' survival. Include the linkages the site provides for the species between ecological resources across the broader landscape.

There is currently no threat abatement plan for the Powerful Owl.

Discussion of Habitat Utilisation

The Powerful Owl occupies wet and dry eucalypt forests and rainforests. It can occupy both un-logged and lightly logged forests as well as undisturbed forests where it usually roosts on the limbs of dense trees in gully areas. It is most commonly recorded within Red Turpentine in tall open forests and Black She-oak within open forests (Debus and Chafer 1994). Large mature trees with hollows at least 0.5 m deep are required for nesting (Garnett 1992). Tree hollows are particularly important for the Powerful Owl because a large proportion of the diet is made up of hollow-dependent arboreal marsupials (Gibbons and Lindenmayer 1997). Nest trees for this species are usually emergent with a diameter at breast height of at least 100 cm (Gibbons and Lindenmayer 1997).

The Powerful Owl has been recorded once in the south-eastern corner of the Study Area adjacent to Upland Swamp 15a. Known foraging and potential nesting habitat exists within the Study Area. The Powerful Owl utilises a variety of habitats including woodland, moist and dry eucalypt forest, rainforest and Upland Swamps. The species usually roosts in gully areas and nests in large tree hollows. It forages after sunset, often covering great distances in its search for food.

Discussion of Local and Regional Abundance

The Powerful Owl has a very large home range, which may confound estimates of abundance based on record numbers.

Local

The Powerful Owl has been recorded once in the Study Area and approximately 12 times within 10 km of the Study Area. The local distribution is scattered, probably reflecting the large territory size of the species.

Regional

The Powerful Owl has a wide distribution along the eastern coastal region, mainly east of the Great Dividing Range, although scattered records exist to the west (Higgins 1999). The species is considered a “common resident” within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area does not occur at or near the limit of distribution of the species.

Grass Owl	***Tyto capensis***

Discussion of Conservation Status

The Grass Owl is listed as Vulnerable on Schedule 2 of the TSC Act.

The Grass Owl has been recorded in Yengo National Park near Wyong. Three other records occur in the Sydney Basin Bioregion, but not within conservation reserves. The species is probably inadequately represented in conservation reserves.

The conservation status of the Grass Owl may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Grass Owl include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – Upland Swamps provide suboptimal roosting/nesting habitat for the Grass Owl. In addition, some prey species for Grass Owls are dependent on habitats such as Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting in hydrological changes. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not predicted;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – potential habitat for the Grass Owl and its prey species may be impacted by changes to natural flow regimes; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Grass Owl.

There has been no recovery or threat abatement plans prepared for the Grass Owl to date. There are no Priority Actions listed by the DECC that are relevant to the Proposal.

Discussion of Habitat Utilisation

Grass Owls mainly inhabit open tussock grassland, usually in treeless areas. However, they have been recorded in grassland interspersed with tree-lined creeks. This species can also occur in marshy areas within tall dense tussocks of grass in swampy depressions or on floodplains (Higgins 1999). The Grass Owl is also known from mangrove fringes, grassy plains, coastal heaths, grassy woodland, cane grass, lignum, sedges, cumbungi, cane fields and grain stubble (Pizzey and Knight 1997). The Grass Owl breeds on the ground among dense clumps of tall grasses or sedges. This species feeds primarily on rodents, foraging aerially over treeless areas, marshy ground vegetated with grass tussocks or low heath, paddocks and roadsides (Higgins 1999).

The Grass Owl has not been recorded in the Study Area or the Locality. Suboptimal potential habitat for this species occurs in the Study Area in grasslands and swampy heaths, including Upland Swamps. The Grass Owl would be likely to hunt in Upland Swamps if it were present in the Locality.

Discussion of Local and Regional Abundance

Records of the Grass Owl are rare and strictly associated with the occurrence of suitable habitat. Although this species is rarely recorded, it appears to have a widespread distribution.

Local

The Grass Owl has not been recorded in the Study Area or the Locality. It is probably rare in the Locality if it is present.

Regional

The Grass Owl has been recorded in all states, but appears most common in the country’s north and north-east (DEC 2005u). In NSW, it is most commonly found on the north coast, but records exist from farther south. Records are rare in the region, with only four throughout the entire Sydney Basin Bioregion.

The Study Area is not considered at or near the limits of distribution.

Masked Owl	***Tyto novaehollandiae***

Discussion of Conservation Status

The Masked Owl is listed as Vulnerable on Schedule 2 of the TSC Act.

The Masked Owl is known mostly from conservation reserves, with records from Nattai and Blue Mountains National Parks to the north-west, the Illawarra Escarpment State Conservation Area to the east, and the Royal National Park to the north-east. It has also been recorded in the Sydney Metropolitan Water Catchment surrounding the Study Area. Records for this species are uncommon, making it unclear how well represented this species is within conservation reserves.

The conservation status of the Masked Owl may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Masked Owl include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – some prey species for Masked Owls are dependent on habitats such as Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting in hydrological changes. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not predicted;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – some prey species for the Masked Owl are dependent on the continuation of natural flow regimes; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Masked Owl.

A NSW recovery plan has been prepared for the Masked Owl (DEC 2006b). The overall objective of the NSW Large Forest Owl Recovery Plan is to ensure that the owl species incorporated in the plan persist in the wild in NSW in each region where they presently occur. The DECC has listed 21 Priority Actions and recovery strategies to help recover the Masked Owl. Those relevant to the Proposal include:

- Protect riparian vegetation to preserve roosting areas – subsidence has the potential to impact riparian vegetation by gas emissions and water loss;
- Minimise visits to nests and other disturbances, including surveys using call-playback, when owls are breeding; and
- Assess the importance of the site to the species' survival. Include the linkages the site provides for the species between ecological resources across the broader landscape.

There is currently no threat abatement plan for the Masked Owl.

Discussion of Habitat Utilisation

The Masked Owl is often recorded in open forest and woodlands adjacent to cleared areas; preferring the tall, open woodlands. They feed on arboreal mammals that take shelter in tree hollows, but are more dependent on small, terrestrial mammals for food (Gibbons and Lindenmayer 1997, Higgins 1999). The Masked Owl inhabits a diverse range of wooded habitat that provides tall or dense mature trees with hollows suitable for nesting and roosting (Higgins 1999). They nest in hollows, in trunks and in near vertical spouts or large trees, usually living but sometimes dead (Higgins 1999). Nest hollows are usually located within dense forests or woodlands.

The Masked Owl has not been recorded in the Study Area, but has been recorded four times within 10 km of the Study Area. Potential habitat for this species occurs in the Study Area in most habitat types. Of particular interest, the species may hunt in Upland Swamps and other habitats that may be affected by subsidence.

Discussion of Local and Regional Abundance

Records are sparse, possibly due to a generally low abundance or low survey effort.

Local

Scattered records of the Masked Owl exist from the local region, mostly associated with reserves. The species appears to be rare in this region when compared to the frequency and pattern of records in other parts of the state, though this could reflect low historical survey effort.

There are four records of the Masked Owl within 10 km of the Study Area. One is within the Locality to the east of the Study Area. The other records occur approximately 8 km to the south, 8 km to the east, and 9 km to the west of the Study Area.

Regional

The Masked Owl has been recorded from most regions of NSW, particularly on the east of the Great Dividing Range (Higgins 1999). The species occurs around the coast of most of Australia, including throughout Tasmania. It has been recorded on the northern end of the Illawarra Escarpment (NPWS 1998).

The Masked Owl is considered a “rare resident” within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is not at or near the limits of distribution for this species.

Sooty Owl	***Tyto tenebricosa***

Discussion of Conservation Status

The Sooty Owl is listed as Vulnerable on Schedule 2 of the TSC Act.

The Sooty Owl has been recorded in the Illawarra Escarpment State Conservation Reserve, Heathcote National Park, Nattai National Park, Burragorang State Recreation Area, and the Blue Mountains National Park. It is uncertain how well represented this species is in conservation reserves in NSW.

The conservation status of the Sooty Owl may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Sooty Owl include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – some prey species for Sooty Owls are dependent on habitats such as Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting in hydrological changes. It is possible that the changes in water level within the swamps could impact the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not predicted;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – some prey species for the Sooty Owl are dependent on the continuation of natural flow regimes; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Sooty Owl.

A NSW recovery plan has been prepared for the Sooty Owl (DEC 2006b). The overall objective of the NSW Large Forest Owl Recovery Plan is to ensure that the owl species incorporated in the plan persist in the wild in NSW in each region where they presently occur. The DECC has listed 22 Priority Actions and recovery strategies to help recover the Sooty Owl. Those relevant to the Proposal include:

- Protect riparian vegetation to preserve roosting areas – subsidence has the potential to impact riparian vegetation by gas emissions and water loss;
- Minimise visits to nests and other disturbances, including surveys using call-playback, when owls are breeding; and
- Assess the importance of the site to the species' survival. Include the linkages the site provides for the species between ecological resources across the broader landscape.

There is currently no threat abatement plan for the Sooty Owl.

Discussion of Habitat Utilisation

The Sooty Owl has been recorded in tall old-growth forests, including temperate and subtropical rainforests. In NSW this species is mostly found on escarpments with a mean altitude less then 500 m. They nest and roost in hollows of tall emergent trees, mainly eucalypts (Higgins 1999) often located in gullies (Gibbons and Lindenmayer 1997). Nests have been located in trees 125 to 161 centimetres in diameter (Gibbons and Lindenmayer 1997). Tree hollows also provide shelter for many prey species of the Sooty Owl.

The Sooty Owl has not been recorded in the Study Area. Potential foraging and nesting habitat for this species exists in the Study Area in woodland, gully, rainforest and Upland Swamp habitats. The Sooty Owl may use Upland Swamps as hunting grounds. Upland Swamps may be impacted by subsidence movements.

Discussion of Local and Regional Abundance

Local

Records exist for the Sooty Owl along the Illawarra Escarpment near Wollongong. The species has not been recorded in the Study Area, but has been recorded approximately 22 times within 10 km of the Study Area. Approximately half of those records fall within the Locality. Most records occur east of the Study Area close to the coast. The species is probably moderately common in the Locality relative to other threatened owls (except for the Powerful Owl which is also moderately common within the Locality).

Regional

The Sooty Owl is generally confined to the east of the Great Dividing Range within a patchy distribution. The species occurs along the eastern coast of Australia, south to the Melbourne area and north to south-east Queensland. It has been suggested this species is widespread along the Illawarra Escarpment, and this region may contain the best habitat in the Sydney Basin Bioregion (NPWS 1998). The species is considered to be moderately common at a regional level.

The Study Area is not at or near the limits of distribution of this species.

Eastern Pygmy-possum	***Cercartetus nanus***

Discussion of Conservation Status

The Eastern Pygmy-possum is listed as Vulnerable on Schedule 2 of the TSC Act.

The Eastern Pygmy-possum has been recorded in a number of conservation reserves, such as Barren Grounds Nature Reserve-Budderoo National Park, Royal National Park, Heathcote National Park and Kioloa State Forest. Whilst the species has been recorded in various reserves, it is in low numbers. It remains unclear how well represented this species is in conservation reserves.

The conservation status of the Eastern Pygmy-possum may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and/or potential habitat for the Eastern Pygmy-possum include:

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – subsidence due to longwall mining has the potential to alter the natural flow regimes of watercourses, which could alter riparian vegetation in the Study Area, thus reducing the amount of potential habitat available to the Eastern Pygmy-possum in the Study Area;

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Eastern Pygmy-possum is often found in Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting is hydrological changes. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not anticipated; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Eastern Pygmy-possum.

There is currently no threat abatement plan or recovery plan for the Eastern Pygmy-possum. However, the DECC has listed seven Priority Actions to help recover the species. Those relevant to the Proposal are:

- Conduct field surveys using "Elliott" traps in trees and on the ground and pitfall traps to further delineate distribution and key populations. Avoid periods of cold weather. Areas identified for development should receive high priority; and

- Protect habitat in development areas and retain linkages across the broader landscape – subsidence has the potential to fragment and isolate areas of known and potential habitat on a small scale (really????).

Discussion of Habitat Utilisation

The Eastern Pygmy-possum inhabits a variety of habitats from rainforest through to sclerophyll forest and tree heath. Banksias and myrtaceous shrubs and trees are a favoured food source. The species also feeds on insects throughout the year; this feed source may be more important in habitats where flowers are less abundant such as wet forests (DEC 2005p).

The Eastern Pygmy-possum breeds and shelters in tree hollows, rotten stumps, holes in the ground, abandoned bird-nests, Common Ringtail Possum (*Pseudocheirus peregrinus*) dreys or thickets of vegetation, (e.g. grass-tree skirts). It will often nest in tree hollows, but can also construct its own nests (Turner and Ward 1995); nest-building appears to be restricted to breeding females. Because of its small size it is able to utilise a range of hollow sizes including very small hollows (Gibbons and Lindenmayer 1997). Individuals will use a number of different hollows and an individual has been recorded using up to nine nest sites within a 0.5 ha area over a five-month period (Ward 1990).

The Eastern Pygmy-possum appears to be mainly solitary, with each individual using several nests. Males have non-exclusive home-ranges of about 0.68 ha and females about 0.35 ha (DEC 2005p).

The Eastern Pygmy-possum has been recorded four times in the Study Area, all in the south-eastern section. It has also been recorded eight times within the Locality and a further 11 times within 10 km of the Study Area. Potential habitat occurs within woodland, gully forest, rainforest and Upland Swamp plant communities, particularly where Banksia species are present.

Discussion of Local and Regional Abundance

Local

The Eastern Pygmy-possum has been previously recorded by Biosis Research on four separate occasions: twice in Sandstone Gully Peppermint Forest and twice within Upland Swamp habitat in Upland Swamps 15b and 135. The species is possibly locally common in specific areas of suitable habitat within the Locality.

Regional

The Eastern Pygmy-possum is found in south-eastern Australia, from southern Queensland to eastern South Australia and in Tasmania (DEC 2005p). Beyond the immediate Locality, records indicate the species is present in low numbers throughout large reserves. Within the Sydney Basin Bioregion the Eastern Pygmy-possum is mostly distributed along the coast with most records occurring between Shoalhaven and the Central Coast. There are also several records from Dharawal State Conservation Area located to the north-east of the Study Area.

The Eastern Pygmy-possum is considered an “uncommon resident” within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is not at the species’ limit of distribution.

Spotted-tailed Quoll	***Dasyurus maculatus***

Discussion of Conservation Status

The Spotted-tailed Quoll is listed as Vulnerable on Schedule 2 of the TSC Act and as Endangered on the EPBC Act.

The Spotted-tailed Quoll has been recorded at various reserves throughout eastern NSW including Dharawal State Conservation Area, Royal, Heathcote, Nattai, Kanangra-Boyd and Blue Mountains National Parks. It is not known if this species is adequately represented within conservation reserves.

The conservation status of the Spotted-tailed Quoll may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Spotted-tailed Quoll include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Spotted-tailed Quoll often dens in caves, rock crevices, overhangs and boulder piles which may collapse as a result of subsidence (such impacts are predicted to occur over a small percentage of the Study Area and to be localised);

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Spotted-tailed Quoll may forage at water sources such as rivers and streams; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Spotted-tailed Quoll.

There is currently no recovery plan for the Spotted-tailed Quoll. However, the DECC has developed a list of 32 Priority Actions and recovery strategies to help recover this species in NSW. Those actions relevant to the Proposal include:

- Retain and protect large, forested areas with hollow logs and rocky outcrops, particularly areas with thick understorey or dense vegetation along drainage lines – subsidence has the potential to impact rocky outcrops, drainage lines and riparian vegetation;

- Develop environmental impact assessment guidelines for the Spotted-tailed Quoll, which includes information on adequate survey methods, survey effort, inappropriate development Proposals, and impact mitigation measures;

- Habitat requirements of Spotted-tailed Quolls are to be adequately conserved within environmental planning instruments and through other legislative protection mechanisms, including property vegetation plans; and

- Identify sites across the NSW range and within different habitat types at which long-term population monitoring can be undertaken.

The Spotted-tailed Quoll is listed as a species of medium priority in the NSW threat abatement plan ‘Predation by the Red Fox’ (NPWS 2001f). The Red Fox (*Vulpes vulpes*) has been recorded in the Study Area. The plan aims to reduce predation on native animals by the Red Fox.

Discussion of Habitat Utilisation

The Spotted-tailed Quoll uses a range of habitats including sclerophyll forests and woodlands, coastal heathlands and rainforests (Dickman and Read 1992). Habitat requirements include suitable den sites, including hollow logs, rock crevices and caves, and an abundance of food and an area of intact vegetation in which to forage (Edgar and Belcher 1995).

The Spotted-tailed Quoll has not been recorded in the Study Area. The Study Area contains suitable foraging habitat as well as suitable den sites for this species.

Discussion of Local and Regional Abundance

The Spotted-tailed Quoll is an apex predator requiring a large home range in which to hunt. If it is present, it generally occurs in low numbers, and individuals are known to move over several kilometres in one night. Abundance is therefore difficult to predict from records.

Local

The Spotted-tailed Quoll has not been recorded in the Study Area, but one record occurs within the Locality, to the south-west of the Study Area. It appears to be present in low numbers in the Locality.

Regional

The Spotted-tailed Quoll occurs on both sides of the Great Dividing Range, with a stronghold in the north-east of the State. It has a scattered distribution throughout the region. There are scattered records surrounding the Study Area including some from Mount Murray and Barren Grounds Nature Reserve-Budderoo National Park to the south, and two records from Dharawal State Conservation Area to the north-east. Records are most prevalent from Blue Mountains National Park. The species is considered a “rare resident” within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is not at the limits of the known distribution for this species.

Brush-tailed Rock-wallaby	***Petrogale penicillata***

Discussion of Conservation Status

The Brush-tailed Rock-wallaby is listed as Endangered on Schedule 1 of the TSC Act and as Vulnerable on the EPBC Act.

Of over 800 recorded sites of the Brush-tailed Rock-wallaby in NSW, 42 per cent are in conservation reserves (including Banyabba, Boonoo Boonoo, Gibraltar Range, Guy Fawkes River, Mount Kaputar, Oxley Wild Rivers, Nymboida, Tooloom, Toonumbar, Washpool, Woko, Yabbra, Blue Mountains, Goulburn River, Kanangra-Boyd, Morton, Warrumbungle, Watagan,,Wollemi and Yengo National Parks; Burragorang and Parr State Recreation Areas; and, Cambewarra, Manobalai, Demon, Sherwood, Mann River and Wingen Maid Nature Reserves

(DEC 2005l). However, historical decline of this species across its range suggests it is unlikely to be adequately represented in conservation reserves.

The conservation status of the Brush-tailed Rock-wallaby may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Brush-tailed Rock-wallaby are outlined below.

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Brush-tailed Rock-wallaby is found in habitats such as gullies and on rocky outcrops that may be subject to limited impacts resulting from subsidence.. If the species is present, rockfalls, the collapse of caves, steep slopes, rock crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding and roosting habitat. Some potential foraging resources may also be impacted (e.g. Upland Swamps); and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Brush-tailed Rock-wallaby.

A draft NSW recovery plan has been prepared for the recovery of the Brush-tailed Rock-wallaby in NSW. The specific objectives of this recovery plan are:

- To increase recruitment at priority sites;

- To decrease the rate of decline in range and abundance;

- To prevent the decline of the species to a level at which it would be at risk of becoming extinct in the wild; and

- To increase knowledge to enable more effective management of the species.

The DECC has also prepared a list of 32 Priority Actions and recovery strategies to assist in the species’ recovery in NSW. One relevant to the Proposal is outlined below.

- Conduct field research on Brush-tailed Rock-wallaby ecology to improve our understanding of how individuals, colonies and populations respond to threatening processes.

The Brush-tailed Rock-wallaby is listed as a species of high priority in the NSW threat abatement plan ‘Predation by the Red Fox’ (NPWS 2001f). The Red Fox has been recorded in the Study Area. The plan aims to reduce predation on native animals by the Red Fox. A population of Brush-tailed Rock-wallaby persists on the Bullio portions of Nattai National Park occupying rock outcropping in an area that adjoins private property. This site has been included as a DECC monitoring site as part of the threat abatement plan for predation by the Red Fox (NPWS 2001f).

Discussion of Habitat Utilisation

The Brush-tailed Rock-wallaby is found in rocky areas in a wide variety of habitats including rainforest gullies, wet and dry sclerophyll forest, and open woodland and rocky outcrops in semi-arid country. Commonly sites have a northerly aspect with numerous ledges, caves and crevices (Eldridge and Close 1995). Vegetation forms a vital component of the habitat, especially as refugia near major rock outcrops (DEC 2005Ž).

Potential habitat for the Brush-tailed Rock-wallaby may occur in parts of the Study Area containing rocky outcrops and rock crevices suitable for shelter. For example forests (including rainforests), woodlands, Rock Plate Heath-Mallee and Upland Swamp plant communities that occur within 200 metres of rocky areas.

Discussion of Local and Regional Distribution

Local

The Brush-tailed Rock-wallaby has been recorded twice within 10 km of the Study Area. One record falls near Sandy Creek just south of the Study Area and the other near the Avon River. These records are over 40 years old, and it is unlikely that the species still occurs in the area. However, the species has been recorded south in the Shoalhaven LGA as recently as 2002 (Bionet).

Regional

The Brush-tailed Rock-wallaby has suffered a severe decline in the Southern Rivers Region. Within the region, the species has a scattered and patchy distribution, with most records occurring in the Blue Mountains or further south in reserves west of Nowra. In the Sydney Basin Bioregion they form part of one of the three Evolutionary Significant Units (ESU) that describe genetically distinctive metapopulations within the species distribution. This population encompasses the sites between Kangaroo Valley, Jenolan Caves and Broke in the Hunter Valley. This central ESU is one of the most fragile in NSW and all sites are of very high conservation significance (Committee 2003). Recent records from reserves are mostly within Yengo, Wollemi and Morton National Parks.

The species' former range in NSW was large, extending from the coast to the semi-arid regions of the state. It now exists in a narrow band, extending north from Sydney to the Queensland border inland from the coast. The Study Area is not at the limits of known distribution for this species.

Southern Brown Bandicoot (eastern)	***Isoodon obesulus obesulus***

Discussion of Conservation Status

The Southern Brown Bandicoot (eastern subspecies) is listed as Endangered on Schedule 1 of the TSC Act and as Endangered on the EPBC Act.

The Southern Brown Bandicoot has only been recorded in a small number of NSW conservation Reserves: Blue Mountains, Ben Boyd, Budderoo, Garigal, Ku-ring-gai Chase and South East Forests National Parks and Nadgee Nature Reserve. The species is not considered adequately represented within conservation reserves.

The conservation status of the Southern Brown Bandicoot may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Southern Brown Bandicoot include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – the Southern Brown Bandicoot has been previously recorded within the Study Area and is found in habitats such as forests, woodlands and Upland Swamps. This habitat may be impacted by subsidence (e.g. surface cracks and hydrological changes). A change in forest structure has been recognised as a threat to the species (DEC 2005ˆ). Significant changes to vegetation within the Study Area are not predicted. The collapse of rock ledges, rock crevices and burrows may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding and roosting habitat;

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – potential habitat for the Southern Brown Bandicoot exists along water sources such as rivers and streams. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting in hydrological changes. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not predicted; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Southern Brown Bandicoot.

A NSW recovery plan has been prepared for the Southern Brown Bandicoot. The overall objective of the recovery plan is to improve the conservation status of the Southern Brown Bandicoot and maximise the opportunity for viability of this species in the wild in NSW (DEC 2006c). One specific objective of the recovery plan is to:

- Clarify the status of the species by better defining its distribution and relative abundance by continued survey in National Parks and other tenures – one recommendation is for targeted surveys using hair tubes and cage traps within the southern Avon Catchment (DEC 2005Ž).

The DECC has also identified 17 Priority Actions and recovery strategies to assist in the species’ recovery in NSW. One relevant to the Proposal is outlined below.

- Undertake intensive control of introduced predators around known extant populations.

The Southern Brown Bandicoot is listed as a species of high priority in the NSW threat abatement plan ‘Predation by the Red Fox’ (NPWS 2001f). The Red Fox has been recorded in the Study Area. The plan aims to reduce predation on native animals by the Red Fox.

Discussion of Habitat Utilisation

Southern Brown Bandicoots are generally only found in heath or open forest with a heathy understorey on sandy or friable soils (DEC 2005ˆ). They nest during the day in a shallow depression in the ground covered by leaf litter, grass or other plant material. Nests may be located under Grass trees *Xanthorrhoea* sp., blackberry bushes and other shrubs. They may also utilise rabbit burrows, rock ledges or crevices (DEC 2005ˆ).

A single record of the Southern Brown Bandicoot exists within the Study Area from 1997 and occurs within Exposed Sandstone Scribbly Gum Woodland (DECC Atlas of NSW Wildlife). Potential habitat is considered to be within forest, woodland, Rock Plate Heath-Mallee and Upland Swamp plant communities where there is a heathy understorey on sandy soil.

Discussion Local and Regional Abundance

Local

The Southern Brown Bandicoot has been recorded twice within 10 km of the Study Area; once within the Study Area (1997) and once within the Locality (1999). The species' abundance is unknown but possibly uncommon within the local area.

Regional

The Southern Brown Bandicoot has a patchy distribution. It is found in south-eastern NSW, east of the Great Dividing Range south from the Hawkesbury River, southern coastal Victoria and the Grampian Ranges, south-eastern South Australia, south-west Western Australia and the northern tip of Queensland.

In NSW, the species is rare and almost exclusively restricted to the coastal fringe of the State, from the southern side of the Hawkesbury River in the north, to the Victorian border in the south. The status of the Southern Brown Bandicoot within the Greater Southern Sydney Region is considered to be unknown and therefore, any populations are to be treated as being of the highest conservation priority (DEC 2005Ž).

The Study Area is not at the limits of known distribution of the species however its current distribution and population size is poorly understood (DEC 2005Ž).

Squirrel Glider	***Petaurus norfolcensis***

Discussion of Conservation Status

The Squirrel Glider is listed as Vulnerable on Schedule 2 of the TSC Act.

The Squirrel Glider has been recorded in conservation reserves including Blue Mountains, Brisbane Waters, Tooloom, Border Rangers, Mount Warning and Warrumbungle National Parks and Binnaway Nature Reserve (DEC 1999). However, it is not known how well this species is represented in these conservation reserves.

The conservation status of the Squirrel Glider may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Squirrel Glider include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – the Squirrel Glider is found in habitats such as sclerophyll forests, woodlands and Upland Swamps containing hollow-bearing trees. Foraging resources within these plant communities Upland Swampmay be impacted by subsidence; the distribution of local vegetation within the swamps has the potential to be impacted by changes in water level. However, significant changes to vegetation within swamps are not predicted. Breeding and roosting habitat (i.e. hollow-bearing trees) are unlikely to be impacted by subsidence;

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – potential habitat for the Squirrel Glider exists along water courses such as creeks and drainage lines within the Study Area; and
- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Squirrel Glider.

To date, no recovery or threat abatement plans have been prepared for the Squirrel Glider. However, the DECC has identified seven Priority Actions and recovery strategies to assist in the recovery of the Squirrel Glider in NSW. Those relevant to the Proposal are outlined below.

- Retain food resources, particularly sap-feeding trees and understorey feed species such as Acacias and Banksias;
- Retain and protect areas of habitat, particularly mature or old growth forest containing hollow-bearing trees and sap-feeding trees; and
- Retain den trees and recruitment trees (future hollow-bearing trees).

Discussion of Habitat Utilisation

The Squirrel Glider generally occurs in dry sclerophyll forests and woodlands, but is absent from dense coastal ranges in the southern part of its range (Suckling 1995). It requires abundant hollow bearing trees and a mix of Eucalypts, Banksias and Acacias (Quin 1995). There is only limited information available on den tree use by Squirrel Gliders, but it has been observed using both living and dead trees as well as hollow stumps (Gibbons and Lindenmayer 1997). Within suitable vegetation, at least one tree species should flower heavily in winter and one species of eucalypt should be smooth barked (Menkhorst *et al.* 1988)

The Squirrel Glider prefers mixed species stands with a shrub or Acacia midstorey which provide ideal foraging habitat; which generally consists of Acacia gum, Eucalypt sap, nectar, honeydew and manna, with invertebrates and pollen providing protein (DEC 1999). The species live in family groups of a single adult male and one or more adult females and offspring. They require abundant tree hollows for refuge and nest sites.

Potential habitat occurs in the Study Area within the forests, woodlands, Rock Plater Heath-Mallee and Upland Swamp plant communities where suitable hollow-bearing trees and foraging resources are present.

Discussion of Local and Regional Abundance

Local

The Squirrel Glider has been recorded once in the Locality and a further two records occur within 10 km of the Study Area. The species has not been recorded in the Study Area. The species is probably uncommon within the local area.

Regional

The Squirrel Glider is sparsely distributed along the east coast and immediate inland areas as far west as the Coonabarabran (DEC 1999). The species is sparsely distributed in eastern Australia, from northern Queensland to western Victoria (DEC 1999).

Within the Sydney Basin Bioregion the Squirrel Glider has a widespread and scattered distribution. The species is probably less common in the southern part of the region than in the northern part. Most records of the species within the region occur on the Central Coast and in the Hunter Valley. The species is considered an “extremely rare resident” within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is not at the species’ limit of distribution.

Long-nosed Potoroo	***Potorous tridactylus***

Discussion of Conservation Status

The Long-nosed Potoroo is listed as Vulnerable on Schedule 2 of the TSC Act and as Vulnerable on the EPBC Act.

Records of the Long-nosed Potoroo in NSW are largely restricted to conservation reserves however, it is highly unlikely to be adequately represented within these. Within the Sydney Basin Bioregion, the species has been recorded in Morton National Park, Cambewarra Range Nature Reserve and Barren Grounds Nature Reserve.

The conservation status of the Long-nosed Potoroo may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Long-nosed Potoroo include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Long-nosed Potoroo is found in habitats such as sclerophyll forests, woodlands and Upland Swamps. Subsidence due to longwall mining has the potential to impact Upland Swamps which are important habitat for the species (NSW Scientific Committee 2005b). The predicted subsidence movements at the Upland Swamps within the Study Area may result in modified water levels within the swamps. It is also likely that the extraction of the longwalls within the Study Area would result in cracking in the swamp beds, particularly where the swamp is within a incised valley. This cracking may in turn result in the diversion of surface water into strata below. However, it is not predicted that the Upland Swamps within the Study Area would drain as a result of the Proposal;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – potential habitat for the Long-nosed Potoroo exists at water sources such as creeks, drainage lines and Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting is hydrological changes. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not predicted. Any draining of pools within creek lines as a result of subsidence within the Study Area may impact on the species, if present; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Long-nosed Potoroo.

To date, no recovery or threat abatement plans have been prepared for the Long-nosed Potoroo. The DECC has identified 19 Priority Actions and recovery strategies to assist in the species’ recovery in NSW. Those relevant to the Proposal are outlined below.

- Using survey methods such as hair-tubing, trapping, scat analysis and the abundance of diggings, estimate the population sizes and relative densities of populations – the species was not recorded in the Study Area;

- Undertake fox, feral dog and cat control programs;
- Protect and maintain habitat, especially dense understorey. Provide linkages across the broader landscape; and
- Habitat Rehabilitation/Restoration and/or Regeneration: Increase habitat via revegetation work and/or establishing corridors to link multiple patches of suitable habitat to expand the effective area of habitat.

Discussion of Habitat Utilisation

The Long-nosed Potoroo inhabits coastal heath and wet and dry sclerophyll forests. It generally occurs in areas with rainfall greater than 760 mm (DEC 2005{). 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 (DEC 2005{). A sandy loam soil is also a common feature (DEC 2005{).

Potential habitat within the Study Area is considered to be within woodland, forest, Coastal Warm Temperate Rainforest, Rock Plate Heath-Mallee and Upland Swamp plant communities where there is a dense, heathy understorey on sandy soil, with occasional open areas.

Discussion Local and Regional Abundance

Local

The Long-nosed Potoroo has not been recorded in the Study Area or within 10 km of the Study Area. The closest record lies approximately 20 km south-west of the Study Area and was recorded in 1970 (Bionet). If present, the species is probably uncommon within the local area.

Regional

The Long-nosed Potoroo is found on the south-eastern coast of Australia, from Queensland to eastern Victoria and Tasmania, including some of the Bass Strait islands. There are geographically isolated populations in western Victoria.

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 (DEC 2005{). The species has been recorded in the Dharawal Nature Reserve and Dharawal State Conservation Area, although it has not been recorded there for many years (DEC 2006a). The species has also been recorded at Darkes Forest, bordering O'Hares Creek and Woronora catchments and in the upper Cordeaux Catchment (Robinson 1985). Records also exist south of the Study Area within the Barren Grounds Nature Reserve-Budderoo National Park as recent as 2002

(Bionet). The Long-nosed Potoroo is considered to be an "extremely rare resident" within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is not at the limits of known distribution for the species however the species is considered extremely rare and declining in the region (DEC 2005Ž).

Little Bentwing-bat	***Miniopterus australis***

Discussion of Conservation Status

The Little Bentwing-bat is listed as Vulnerable on Schedule 2 of the TSC Act.

The Little Bentwing-bat has been recorded within reserves such as Wollemi, Yuraygir, Bundjalung, Border Ranges, Richmond Range and Mount Pikapene National Parks; Whian Whian State Conservation Area; and, Brunswick Heads Nature Reserve, mostly within the Northern Rivers Region. It is unclear if the species is adequately represented in conservation reserves.

The conservation status of the Little Bentwing-bat may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Little Bentwing-bat include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – the Little Bentwing-bat roosts in caves, rock crevices and overhangs which may collapse as a result of subsidence (such impacts are predicted to occur over a small percentage of the Study Area and to be localised);
- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – the Little Bentwing-bat may forage at water sources such as rivers and streams; and
- 'Human-caused climate change' (NSW Scientific Committee 2000b) – global warming may lead to a range extension or distribution shift for the Little Bentwing-bat.

To date, no recovery or threat abatement plan exists for the Little Bentwing-bat. However, the DECC has prepared 24 Priority Actions to help recover this species in NSW. Those relevant to the Proposal are outlined below.

- Identify and protect significant roost habitat in artificial structures (e.g. culverts, old buildings and derelict mines); and
- Search for significant roost sites and restrict access where possible (e.g. gating of caves). Significant sites include maternity, hibernation and transient sites including in artificial structures.

Discussion of Habitat Utilisation

The Little Bentwing-bat shows a preference for well timbered areas such as moist eucalypt forest, rainforest, melaleuca swamps and dense coastal banksia scrub (Churchill 1998, DEC 2005y). They roost in caves, tunnels and sometimes tree hollows during the day, and at night forage for small insects beneath the canopy of densely vegetated habitats (DEC 2005y).

Potential habitat for the Little Bentwing-bat occurs within woodland, forest, Coachwood Warm Temperate Rainforest, Rock Plate Heath-Mallee and Upland Swamp plant communities. Roosting habitat may be limited as large caves do not occur in the Study Area.

Discussion of Local and Regional Distribution

Local

The Little Bentwing-bat was recorded once with *probable* certainty within Upland Swamp habitat in the Study Area. However, this species has not been previously recorded within 10 km of the Study Area and this recording may have been the Chocolate Wattled Bat *Chalinolobus morio*. If present, the species is probably uncommon within the local area.

Regional

The Little Bentwing-bat occurs in coastal north-eastern NSW and eastern Queensland. It is confined to the subtropical coastal belt in the southern part of its range (Churchill 1998). The nearest records lie to the north of the Study Area and occur just south-east of Gosford (recorded as recently as 2004) and one record near Port Jackson, Sydney (1992). Only two records occur south of the Study Area (1996) and are probably vagrants. The Study Area is therefore at the southern limits of the known distribution for this species.

Eastern Bentwing-bat	***Miniopterus schreibersii oceanensis***

Discussion of Conservation Status

The Eastern Bentwing-bat is listed as Vulnerable on Schedule 2 of the TSC Act.

The Eastern Bentwing-bat has been recorded in Nattai National Park, Blue Mountains National Park, Royal National Park, Burrogorang State Recreation Area, and in Heathcote National Park. However, many records of this species fall outside of conservation reserves. It is therefore unlikely that the species is adequately represented in conservation reserves.

The conservation status of the Eastern Bentwing-bat may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Eastern Bentwing-bat include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Eastern Bentwing-bat roosts in caves, rock crevices and overhangs which may collapse as a result of subsidence (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Potential impacts on foraging habitat for this species is likely to be negligible;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Eastern Bentwing-bat is known to forage along creeks and rivers. Subsidence can affect the flow of water sources; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Eastern Bentwing-bat.

To date, no recovery plan or threat abatement plan has been prepared for the Eastern Bentwing-bat. However, the DECC lists 25 Priority Actions and recovery strategies to help recover the species. One relevant to the Proposal is outlined below.

- Protect roosting sites from damage or disturbance – subsidence has the potential to directly impact roosting habitat of the Eastern Bentwing-bat (e.g. collapse of caves and rock overhangs).

Discussion of Habitat Utilisation

The Eastern Bentwing-bat uses a broad range of habitats including rainforests, wet and dry sclerophyll forests, open woodlands and open grasslands (Churchill 1998). The species roosts in caves, but can also use manmade structures such as mines and road culverts (Dwyer 1995, Churchill 1998). Specific caves are used as nursery caves, containing a large number of individuals, which can be used year after year (Dwyer 1995, Churchill 1998).

Known and potential foraging habitat occurs within the open forests, woodlands, rainforests and Upland Swamps of the Study Area. The species uses caves for roosting, but may also use abandoned mines, buildings and storm water drains. It is unknown if suitable roosting habitat exists in the Study Area, but the consistency of records suggests this is likely. The Eastern Bentwing-bat forages for flying insects above the tree canopy (DEC 2005m). The species can travel many kilometres between roost sites.

Discussion of Local and Regional Abundance

Local

The Eastern Bentwing-bat has been recorded in the Study Area during the current surveys. It has been recorded along creek lines, in gullies, and in Upland Swamps with a maximum accuracy rating of *definite* certainty. The species has also been recorded within the Locality on a number of occasions, to the north, south, east and west of the Study Area. To the south of the Study Area are two known roosting (and possibly maternity) sites of the Eastern Bentwing-bat (one within the Locality at South Kembla Colliery and one just outside the Locality at Elouera Colliery) which are of extremely high conservation significance. Biosis Research have recently (2006) recorded very high numbers of the species exiting a number of portals within the collieries. The species is probably relatively common within the local area.

Regional

The Eastern Bentwing-bat has a wide distribution throughout non-arid regions of NSW, including the Sydney Basin Bioregion. The species appears to be moderately common within the region but is most frequently found along the coast.

The Study Area is not at the limit of distribution of the Eastern Bentwing-bat.

Large-eared Pied Bat	***Chalinolobus dwyeri***

Discussion of Conservation Status

The Large-eared Pied Bat is listed as Vulnerable on Schedule 2 of the TSC Act and as Vulnerable on the EPBC Act.

The majority of records for the Large-eared Pied Bat are within conservation reserves, such as Nattai National Park, Blue Mountains National Park and Barren Grounds Nature Reserve. However, due to a lack of knowledge of the species, it is unknown whether the species is adequately represented in conservation reserves.

The conservation status of the Large-eared Pied Bat may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Large-eared Pied Bat include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Large-eared Pied Bat roosts in caves, rock crevices and overhangs which may collapse as a result of subsidence (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Potential impacts on foraging habitat for this species is likely to be negligible;

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – the Large-eared Pied Bat is known to forage in Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting is hydrological changes. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not predicted; and

- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Large-eared Pied Bat.

To date, there is no threat abatement or recovery plan for the Large-eared Pied Bat. However, the DECC has developed a list of 17 Priority Actions and recovery strategies to help recover this species in NSW. Those relevant to the Proposal include:

- Avoid damage to known roosting and maternity sites from mining activities – whilst known roosting and maternity sites have not been identified within the Study Area, the species was recorded within the Study Area during the current surveys. Subsidence due to longwall mining can impact potential habitat for the Large-eared Pied Bat;

- Determine location and attributes of maternity sites and restrict access where possible (e.g. signage; bat-friendly, preferably external, gating of caves); and

- Identify and protect roost habitat artificial structures (e.g. culverts, old buildings and derelict mines).

Discussion of Habitat Utilisation

The Large-eared Pied Bat is located in a variety of drier habitats, including the dry sclerophyll forests and woodlands to the east and west of the Great Dividing Range (Hoye and Dwyer 1995). The species can also be found on the edges of rainforests and in wet sclerophyll forests (Churchill 1998). This species roosts in caves and mines in groups of between 3 and 37 individuals (Churchill 1998).

Known and potential foraging habitat is present within the Study Area in woodland, gully forest, and Upland Swamp vegetation types. The species uses caves for roosting, but may also use abandoned mines. It is unknown if suitable roosting habitat exists in the Study Area, but it is possible. The Large-eared Pied Bat forages for small, flying insects below the tree canopy (DEC 2005w).

Discussion of Local and Regional Abundance

Local

The Large-eared Pied Bat was recorded once in the Study Area during the current surveys within Upland Swamp habitat. The species has also been recorded once (in 2005) within a 10 km radius of the Study Area (DECC Atlas of NSW Wildlife). The lack of records within the local area for this species may be due to its uncommon occurrence or due to a lack of surveys.

Regional

The distribution of the Large-eared Pied Bat extends from the northern border of NSW to the south coast as far inland as the western slopes of the Great Dividing Range. Most records within the region occur in the Blue Mountains to the north-west of the Study Area. The species is also known to inhabit Barren Grounds Nature Reserve to the south of the Study Area. The species is considered to be an “uncommon resident” within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is close to the southern extremities of the species’ known distribution. Records become sparser farther south. The southern-most record occurs approximately 58 km from the Study Area.

Eastern False Pipistrelle	***Falsistrellus tasmaniensis***

Discussion of Conservation Status

The Eastern False Pipistrelle is listed as Vulnerable on Schedule 2 of the TSC Act.

The Eastern False Pipistrelle appears to be well represented in conservation reserves across NSW. Some reserves which the species has been recorded in include: Heathcote, Blue Mountains, Royal, Goulburn River, Kosciuszko, Border Ranges, Washpool, New England, Oxley Wild Rivers, Kumbatine, Cottan-Bimbang and Richmond Range National Parks.

The conservation status of the Eastern False Pipistrelle may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Eastern False Pipistrelle include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – subsidence can affect the flow of creeks and rivers, which may alter the amount of available habitat in the Study Area for this species. The collapse of caves, rock crevices and overhangs may cause death or injury to individuals if they are roosting (such impacts are predicted to occur over a small percentage of the Study Area and to be localised);

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – subsidence can affect the flow of water sources which may alter vegetative habitats. The loss of riparian rainforest vegetation may impact foraging and roosting habitat. However, vegetation die-back due to gas emissions has only been observed once in the Southern Coalfields (within the Cataract River) and is not expected to be significant within the Study Area; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Eastern False Pipistrelle.

No recovery or threat abatement plans have been prepared for the Eastern False Pipistrelle to date. However, the DECC lists 16 Priority Actions and recovery strategies to help recover this species. Those relevant to the Proposal include:

- Retain native vegetation that is floristically and structurally diverse –

- Identify important foraging range and key habitat components for this species; and

- Undertake long-term monitoring of populations cross tenure in conjunction with other bat species to document changes.

Discussion of Habitat Utilisation

The Eastern False Pipistrelle prefers moist habitats, with trees taller than 20 m. They generally roost in eucalypt hollows, but have also been found in caves, under loose bark on trees or in buildings (Churchill 1998, DEC 2005o). The species hunt beetles, moths, weevils and other flying insects above or just below the tree canopy.

Potential habitat for the Eastern False Pipistrelle occurs within forest, woodland, Coachwood Warm Temperate Rainforest and Upland Swamp plant communities. The species roosts in tree hollows and caves.

Discussion of Local and Regional Abundance

Local

The Eastern False Pipistrelle was recorded a number of times within the Study Area during the current surveys with *probable* (up to 80%) certainty. The species has also been previously recorded twice within a 10 km radius of the Study Area. One of these records falls within the Locality. The species is probably uncommon within the local area however this may be a reflection of a lack of survey effort.

Regional

The Eastern False Pipistrelle is found on the south-east coast and ranges of Australia, from southern Queensland to Victoria and Tasmania. The Eastern False Pipistrelle is considered to be an “uncommon resident” and is rarely recorded within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is not at the limits of known distribution for this species.

Golden-tipped Bat	***Kerivoula papuensis***

Discussion of Conservation Status

The Golden-tipped Bat is listed as Vulnerable on Schedule 2 of the TSC Act.

Most records of the Golden-tipped Bat occur outside of conservation reserves. Those NSW reserves which the species has been recorded in include: Myall Lakes, Washpool, Wadbilliga and Guy Fawkes River National Parks; and, Juuga Waarri Nature Reserve.

The conservation status of the Golden-tipped Bat may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Golden-tipped Bat include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – subsidence can affect the flow of creeks and rivers, which may alter the amount of available habitat in the Study Area for this species. The loss of riparian rainforest vegetation may impact roosting habitat. However, vegetation die-back due to gas emissions has only been observed once in the Southern Coalfields (within the Cataract River) and is not expected to be significant within the Study Area. The collapse of caves, rock crevices and overhangs may cause death or injury to individuals if they are roosting (such impacts are predicted to occur over a small percentage of the Study Area and to be localised);

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – subsidence can affect the flow of natural water sources which may alter vegetative habitats. However, significant changes to vegetation within the Study Area are not predicted; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Golden-tipped Bat.

No recovery or threat abatement plans have been prepared for the Golden-tipped Bat. However, the DECC lists six Priority Actions and recovery strategies to help recover the species. Those relevant to the Proposal include:

- Retain rainforest and wet sclerophyll forest in gullies for roosting – Although this habitat won’t be cleared by the Proposal, there is limited potential that it may be affected by subsidence;

- Retain dense patches of understorey in upper-slope forest for foraging – although this habitat won’t be cleared by the Proposal, there is limited potential that it may be affected by subsidence; and,

- Undertake long-term monitoring of populations cross tenure in conjunction with other bat species to document changes.

Discussion of Habitat Utilisation

The Golden-tipped Bat is found in rainforest and adjacent sclerophyll forest. They roost in abandoned hanging Yellow-throated Scrubwren (*Sericornis citreogularis*) and Brown Gerygone (*Gerygone mouki*) nests located in rainforest gullies on small first- and second-order streams. At least one colony has been found roosting in a cave (Churchill 1998). Individuals will fly up to two kilometres from roosts to forage in rainforest and sclerophyll forest on upper-slopes. The Golden-tipped Bat is a specialist feeder on small web-building spiders.

Potential habitat for the Golden-tipped Bat occurs within gully forest, woodland, Coachwood Warm Temperate Rainforest and Upland Swamp plant communities within the Study Area. The species may breed in tree hollows and caves.

Discussion of Local and Regional Abundance

Local

The Golden-tipped Bat was recorded twice in the Study Area with *possible* certainty during the current surveys. The species has not previously been recorded in the Study Area, nor has it previously been recorded within 10 km of the Study Area. The closest confirmed record lies approximately 138 km north-east of the Study Area. If the species occurs in the local area it is likely to be rare.

Regional

The Golden-tipped Bat is distributed along the east coast of Australia in scattered locations from Cape York Peninsula in Queensland to Bega in southern NSW. Records are lacking in the region between Gosford and Batemans Bay. Within the Sydney Basin Bioregion, the species is rare except for an area between Gosford and Cessnock, where the species may occur in higher numbers.

The Study Area does occur within the species' current known distribution however is located between the limits of the northern and southern populations.

Southern Myotis	***Myotis macropus***

Discussion of Conservation Status

The Southern (Large-footed) Myotis is listed as Vulnerable on Schedule 2 of the TSC Act.

The Southern Myotis has been recorded in Dharawal State Recreation Area, Nattai, Blue Mountains and Royal National Parks. Many records for this species are from outside of conservation reserves. The extent to which this species is represented in conservation reserves is unclear, but it is probably not represented adequately.

The conservation status of the Southern Myotis may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Southern Myotis include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – the Southern Myotis often roosts in caves, which may collapse as a result of subsidence (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). It is also possible that foraging habitat for this species would be reduced by the effects of subsidence (e.g. loss of surface flow in creeks);

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Southern Myotis forages almost exclusively at water sources such as rivers and streams; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Southern Myotis.

No recovery or threat abatement plan currently exists for the Southern Myotis. However, the DECC has prepared 15 Priority Actions and recovery strategies to help recover this species in NSW. Those relevant to the Proposal are outlined below:

- Retain native vegetation along streams and rivers and around other waterbodies – subsidence has limited potential impact riparian vegetation;

- Protect roosts from damage or disturbance – subsidence has the potential to impact roosting habitat such as caves, rock crevices and overhangs; and

- Identify, protect and enhance roost habitat beneath artificial structures (e.g. bridges), especially when due for replacement, and assess effectiveness of the actions.

Discussion of Habitat Utilisation

The Southern Myotis occurs in most habitat types as long as they are near permanent water bodies, including streams, lakes and reservoirs. This species commonly roosts in caves, but can also roost in tree hollows, under bridges and in mines (Richards 1995, Churchill 1998).

Known and potential foraging and roosting habitat for the Southern Myotis occurs within the Study Area in forest and woodland habitat around water sources. The species roosts in caves and tree hollows.

Discussion of Local and Regional Abundance

The Southern Myotis is restricted to habitats containing permanent bodies of water. This should be taken into account when estimating abundance.

Local

The Southern Myotis was recorded a number of times in the Study Area during the current surveys. It was recorded in gully habitats with a maximum accuracy rating of *definite* certainty. The species has also been previously recorded six times within 10 km of the Study Area, twice within the Locality (DECC Atlas of NSW Wildlife). The species is probably moderately common for a threatened species within the Locality, when taking into consideration the species' reliance on permanent water bodies.

Regional

The Southern Myotis is a mainly coastal species with scattered records occurring along the length of NSW. Its distribution can also extend further inland along major rivers such as the Murray (Churchill 1998). The species has been recorded from the Woronora, O'Hares Creek and Metropolitan Water Catchments (Sydney Water Corporation 1997). The species is considered to be a "rare resident" within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is not at the limits of the known distribution for this species.

Yellow-bellied Sheathtail-bat	***Saccolaimus flaviventris***

Discussion of Conservation Status

The Yellow-bellied Sheathtail-bat is listed as Vulnerable on Schedule 2 of the TSC Act.

Within the Sydney Basin Bioregion the Yellow-bellied Sheathtail-bat has been recorded at Seven Mile Beach, Blue Mountains and Botany Bay National Parks. Due to the scattered and scarce records for this species, it is unknown whether it is adequately represented in conservation reserves.

The conservation status of the Yellow-bellied Sheathtail-bat may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Yellow-bellied Sheathtail-bat include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – subsidence can affect the flow of creeks and rivers, which may alter the amount of available habitat in the Study Area for this species. The collapse of caves, rock crevices and overhangs may cause death or injury to individuals if they are roosting (such impacts are predicted to occur over a small percentage of the Study Area and to be localised);

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – subsidence can affect the flow of natural water sources which may alter habitats. However, significant changes to vegetation within the Study Area are not predicted; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Yellow-bellied Sheathtail-bat.

To date, no recovery or threat abatement plans have been prepared for the Yellow-bellied Sheathtail-bat. However, the DECC lists 20 Priority Actions and recovery strategies to help recover the species. Those relevant to the Proposal include:

- Conduct searches for the species in suitable habitat in proposed development areas – the species was detected with *probable* certainty;

- Encourage regeneration and replanting of local flora species to maintain bat foraging habitat – subsidence has the potential to impact foraging habitat; and

- Assess the Study Area's importance to the species' survival, including linkages provided between ecological resources across the broader landscape – the site is part of a large expanse of native vegetation.

Discussion of Habitat Utilisation

The Yellow-bellied Sheathtail-bat is restricted to tall mature forests in regions of high rainfall. Its preferred habitats are productive, tall open sclerophyll forests where mature trees provide shelter and nesting hollows. Critical elements of habitat include sap-trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of different forest types (NPWS 1999j). They roost in tree hollows and have been found in abandoned nests of Sugar Gliders (*Petaurus breviceps*), in cracks in dry clay and under slabs of rock (Churchill 1998).

Potential habitat for the Yellow-bellied Sheathtail-bat occurs within open forests, woodlands, rainforest, Rock Plate Heath-Mallee and Upland Swamp plant communities of the Study Area. The species will forage in forested (above the canopy) as well as treeless areas, and requires tall, mature trees with hollows for breeding.

Discussion of Local and Regional Abundance

Local

The Yellow-bellied Sheathtail-bat was recorded once in the Study Area during the current surveys with *probable* certainty within a creek line. The species has not previously been recorded in the Study Area, nor has it previously been recorded within 10 km of the Study Area. The closest record of the species lies approximately 17.5 km east of the Study Area and was recorded in 1964 (Bionet).

If present within the local area, the Yellow-bellied Sheathtail-bat is probably relatively uncommon.

Regional

The Yellow-bellied Sheathtail-bat is a wide-ranging species primarily occurring through tropical Australia, but with many records extending into New South Wales. They have been reported from southern Australia only between January and June. The Yellow-bellied Sheathtail-bat has a scattered distribution within the Sydney Basin Bioregion, with the highest abundance of records occurring along the coast. It is probably uncommon in the region, except for a number of isolated coastal locations.

The Study Area is not at the limits of the species' distribution.

Greater Broad-nosed Bat	***Scoteanax rueppellii***

Discussion of Conservation Status

The Greater Broad-nosed Bat is listed as Vulnerable on Schedule 2 of the TSC Act.

The Greater Broad-nosed Bat has been recorded in Dharawal State Recreation Area, Nattai National Park and the Royal National Park. The extent to which this species is represented in conservation reserves is unclear as records are scattered and sparse. It is unlikely this species is represented adequately in conservation reserves.

The conservation status of the Greater Broad-nosed Bat may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Greater Broad-nosed Bat include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – the Greater Broad-nosed Bat is known to favour creeks and rivers as foraging sites. Subsidence can affect the flow of creeks and rivers, which may alter the amount of available habitat in the Study Area for this species;

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – the Greater Broad-nosed Bat is known to favour creeks and rivers as foraging sites. Subsidence can affect the flow of natural water sources; and

- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Greater Broad-nosed Bat.

To date, no recovery or threat abatement plans have been prepared for the Greater Broad-nosed Bat. However, the DECC has developed a list of 19 Priority Actions and recovery strategies to help to recover the species. Those relevant to the Proposal include:

- Actively encourage the conservation of the riparian vegetation and water quality of streams and rivers – subsidence has the potential to impact riparian vegetation and water courses;

- DECC should be consulted when planning developments to minimise impacts on populations;

- Conduct searches for the species in suitable habitat in development areas – the species was detected with *probable* certainty; and

- Assess the site's importance to the species' survival, including linkages provided between ecological resources across the broader landscape.

Discussion of Habitat Utilisation

The Greater Broad-nosed Bat prefers moist gullies in mature coastal forests and rainforests, between the Great Dividing Range and the coast. It is only found at low altitudes below 500 m (Churchill 1998). In dense forests they utilise natural and human-made openings in the forest for flight paths. The species roosts in hollow tree trunks and branches (Churchill 1998) and has also been found in buildings. It forages after sunset, flying slowly and directly along creek and river corridors at an altitude of 3 - 6 m. Open woodland habitat and dry open forest suits the direct flight of this species as it searches for beetles and other large, slow-flying insects; this species has been known to eat other bat species. Little is known of its reproductive cycle, however a single young is born in January; prior to birth, females congregate at maternity sites located in suitable trees, where they appear to exclude males during the birth and raising of the young.

Potential habitat for the Greater Broad-nosed Bat exists within the gully forests, rainforests and Upland Swamps of the Study Area. The species forages along creeks and small rivers and roosts in tree hollows or under bark.

Discussion of Local and Regional Abundance

Local

The Greater Broad-nosed Bat was recorded in the Study Area during the current surveys with *probable* (up to 80%) certainty. It was recorded in gully, creek, and

Upland Swamp habitats. The species has been previously recorded approximately four times within 10 km of the Study Area, including once within the Locality. The species is probably uncommon within the local area.

Regional

The distribution of the Greater Broad-nosed Bat extends east of the Great Dividing Range from the northern border of NSW to the South Coast. Records of this species are scattered throughout the Sydney Basin Bioregion, but are concentrated nearer the coast, east of the Great Dividing Range (DECC Atlas of NSW Wildlife). It is probably uncommon in most areas of the region, except for some isolated areas on the coast.

The Study Area does not occur at or near the limit of distribution of the Greater Broad-nosed Bat.

Eastern Cave Bat	***Vespadelus troughtoni***

Discussion of Conservation Status

The Eastern Cave Bat is listed as Vulnerable on Schedule 2 of the TSC Act.

The Eastern Cave Bat has not been recorded in any conservation reserves in the area. It has been recorded in Goulburn River National Park, Manobalai Nature Reserve and Wollemi National Park in the Muswellbrook area, north of Sydney. Records are uncommon for this species, and it is unlikely the species is adequately represented in conservation reserves.

The conservation status of the Eastern Cave Bat may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Eastern Cave Bat include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Eastern Cave Bat roosts in caves, which may collapse as a result of subsidence (such impacts are predicted to occur over a small percentage of the Study Area and to be localised);
- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Eastern Cave Bat may forage at water sources such as rivers and streams; and
- ‘Human-caused climate change’ (NSW Scientific Committee 2000b) – global warming may cause a range extension or distribution shift for this species.

No recovery or threat abatement plan exists for the Eastern Cave Bat to date. However, the DECC has prepared 12 Priority Actions and recovery strategies to help recover this species in NSW. Those relevant to the Proposal are outlined below:

- Avoid damage or disturbance to known roosting and maternity sites from mining activities – whilst known roosting and maternity sites have not been identified within the Study Area, the species was *possibly* recorded within the Study Area during the current surveys. Subsidence due to longwall mining can impact potential habitat for the Eastern Cave Bat;

- Identify and protect natural roost habitat such as caves and overhangs – subsidence has the potential to impact such habitats; and

- Promote roosting habitat in new artificial structures within the species range.

Discussion of Habitat Utilisation

The Eastern Cave Bat is a poorly known species. It has been recorded from a range of habitats including drier forests and tropical woodlands (Strahan 1995) where it forages mainly below the canopy. It is said to prefer tropical mixed woodland and wet sclerophyll forest close to the coast, but extends into drier forest inland (Churchill 1998). It roosts in small groups, predominantly in caves and rock overhangs but also occurs in mines and buildings. At these roost sites it does not occur deep within caves or mines, instead seems to prefer well-lit areas (Strahan 1995).

Potential habitat for the Eastern Cave Bat in the Study Area occurs within forest, woodland, Coastal Warm Temperate Rainforest, Rock Plate Heath-Mallee and Upland Swamp plant communities. It is unknown whether potential roosting habitat exists within the Study Area.

Discussion of Local and Regional Distribution

Local

The Eastern Cave Bat was recorded once within the Study Area along a creek line however, it was considered more likely to have been a Chocolate Wattled Bat *Chalinolobus morio*. The Eastern Cave Bat has not previously been recorded in the Study Area, the Locality, or within 10 km of the Study Area. If present within the local area, the Eastern Cave Bat is probably rare.

Regional

The Eastern Cave Bat inhabits eastern Australia, from Cape York to approximately mid-way down the coast of New South Wales. The species is rare in the Sydney Basin Bioregion. Only a handful of records exist. The Study Area occurs further south than the southern-most records excluding one outlier from the South Coast. The Study Area is therefore at the southern limits of known distribution for this species.

Broad-headed Snake	***Hoplocephalus bungaroides***

Discussion of Conservation Status

The Broad-headed Snake is listed as Endangered on Schedule 1 of the TSC Act and as Vulnerable on the EPBC Act.

The Broad-headed Snake is known to occur within Blue Mountains, Heathcote, Morton, Royal, Wollemi and Yengo National Parks and Parr State Recreation Area. The species is also thought to be present in Dharug and Popran National Parks and was historically known from areas now within Garigal, Ku-ring-gai Chase, Lane Cove and Marramarra National Parks (NPWS 1999c). Whilst the species was probably reasonably well represented within conservation reserves historically, it is currently unknown how adequately represented the Broad-headed Snake is within conservation reserves today.

The conservation status of the Broad-headed Snake may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Broad-headed Snake include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – potential habitat for the Broad-headed Snake occurs along ridge and creek lines in the Study Area. The species’ winter habitat (e.g. rocky outcrops) is known to be vulnerable to the effects of subsidence. However, impacts to rocky outcrops, crevices and overhangs are predicted to occur over a small percentage of the Study Area and to be localised; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Broad-headed Snake.

There is currently no Commonwealth or NSW recovery plan or threat abatement plan for the Broad-headed Snake. However, the DECC has prepared 22 Priority

Actions to help recover this species. Those relevant to the Proposal are outlined below.

- Undertake artificial or replacement rock initiatives to replace or supplement lost habitat – subsidence has the potential to impact potential habitat of the Broad-headed Snake;

- Retain sandstone rock in bushland on escarpment areas – subsidence has the potential to alter the current state of sandstone rock (e.g. rock falls) however, would not remove any sandstone rock from the Study Area; and

- Restore rocky habitat to escarpments that have been disturbed – subsidence has the potential to disturb rocky habitat.

Discussion of Habitat Utilisation

The Broad-headed Snake mainly occurs in association with communities occurring on Triassic sandstone within the Sydney Basin, and is typically found among exposed sandstone outcrops within vegetation types ranging from woodland to heath. Within these habitats, they generally shelter in rock crevices and exfoliating rock during the cooler months and tree hollows during summer (Webb and Shine 1998). Prey species such as Lesueur's Velvet Gecko *Oedura lesueurii* must be present (Webb and Shine 2000) in order to support the inactive 'wait and ambush' feeding strategy of the Broad-headed Snake (Webb and Shine 1997).

The Broad-headed Snake has been previously recorded just outside the Study Area in Dendrobium Area 2, on a ridge line. Potential habitat for this species occurs within rocky areas on ridges and in gullies where hollow-bearing trees are present, throughout the Study Area.

Discussion of Local and Regional Abundance

Local

The Broad-headed Snake has not been recorded within the Study Area. Although the species can be quite cryptic, a number of records exist within the Locality (including just outside the Study Area) and within 10 km of the Study Area. Locally, the species has a patchy distribution, probably reflecting its specific habitat requirements.

Regional

The Broad-headed Snake is largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, within approximately 250 km of Sydney (DEC 2005d). The species has a patchy distribution within the Sydney Basin Bioregion and is considered to be an "extremely rare resident" within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is not at the limits of known distribution for this species however, the Broad-headed Snake is not widespread within NSW and is confined to the Sydney Basin Bioregion. The Study Area occurs towards the southern end of the species' known distribution with the southern-most record occurring approximately 103 km from the Study Area.

Rosenberg's Goanna	***Varanus rosenbergi***

Discussion of Conservation Status

Rosenberg's Goanna is listed as Vulnerable on Schedule 2 of the TSC Act.

Most records of Rosenberg's Goanna are from conservation reserves including the Illawarra Escarpment State Conservation Reserve; Blue Mountains, Dharug, Heathcoat, Ku-ring-gai Chase, Morton, Royal, Wollemi and Yengo National Parks; and Dharawal State Conservation Area (Bionet). However, considering the restricted range of this species (Hawkesbury/Narrabeen sandstone) and the fact that many records fall close to the boundaries of conservation reserves, it is unknown if this species has an adequate representation in conservation reserves.

The conservation status of Rosenberg's Goanna may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for Rosenberg's Goanna include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – known and potential habitat for Rosenberg's Goanna occurs within Upland Swamps, creek lines and ridge lines. The collapse of rock crevices, overhangs and burrows may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Any impacts on potential foraging resources are likely to be negligible for this species; and

- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Rosenberg's Goanna.

There is currently no Commonwealth or NSW recovery plan or threat abatement plan for Rosenberg's Goanna. However, the DECC has prepared nine Priority Actions to help recover this species; one that is relevant to the Proposal is:

- Retain and protect heath, woodland and forest remnants within the known distribution of the species – subsidence has limited potential to impact known and potential habitat for this species within the Study Area.

Discussion of Habitat Utilisation

Rosenberg's Goanna is a Hawkesbury/Narrabeen sandstone outcrop specialist (Wellington and Wells 1990). It is found in woodlands, forests, and heathland and shelters in hollow logs, burrows, rock crevices, and sandstone outcrops (Wilson and Knowles 1988). Eggs are laid in active termite mounds. Based on studies conducted on Kangaroo Island, the Rosenberg's Goanna has a relatively small home range, averaging 19 ha (Green and King 1993).

Rosenberg's Goanna has been previously recorded within the Study Area, both to the east and west of Wongawilli Creek in ridge habitat. Further potential habitat occurs within Upland Swamps and creek lines, particularly where sandstone outcropping occurs.

Discussion of Local and Regional Abundance

Local

The Rosenberg's Goanna has been recorded both within the Study Area and the Locality. The species is probably moderately common within areas of suitable habitat in the Study Area and Locality.

Regional

The Rosenberg's Goanna is generally restricted to the Sydney region, with some records from the Canberra area (DEC 2005†). Most records within the Sydney Basin Bioregion tend to occur close to the coast with the exception of several records northwards of the Blue Mountains (Bionet). Otherwise, the distribution is scattered and patchy. The species is considered to be an "uncommon resident" within the Greater Southern Sydney Region (DEC 2005Ž).

The Study Area is not at or near the limits of the species' known distribution.

Giant Dragonfly	***Petalura gigantea***

Discussion of Conservation Status

The Giant Dragonfly is listed as Endangered on Schedule 1 of the TSC Act.

There are few records of the Giant Dragonfly in the southern Sydney Basin Bioregion. One record exists from Macquarie Pass and several more, relatively recent records are from Wingecarribee Swamp. A stronghold for the species in

NSW appears to be Blue Mountains National Park. The Giant Dragonfly was recently recorded in the Locality, but specific location data is not yet available. Records for this species are uncommon, making it unclear how well represented this species is within conservation reserves. However the low number of records make it likely that the Giant Dragonfly is inadequately represented in conservation reserves.

The conservation status of the Giant Dragonfly may be affected by KTPs as listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Giant Dragonfly include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – subsidence may impact Upland Swamps which provide potential habitat for the Giant Dragonfly. The predicted subsidence movements within Upland Swamps within the Study Area may modify water levels within the swamps. It is also likely that the extraction of the longwalls within the Study Area would result in cracking in the swamp beds, especially where the swamps are within deeply incised valleys. There is some potential that this fracturing could in turn result in the diversion of surface water into strata below. However, it is not predicted that the Upland Swamps within the Study Area would drain as a result of the Proposal as any fracturing is unlikely to intersect with the mine workings or any other deep storage;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – Subsidence can affect the flow of water which may alter vegetative habitats. However, significant changes to vegetation within the Study Area are not predicted; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Giant Dragonfly.

If a Giant Dragonfly population exists within the Study Area within an Upland Swamp and the habitat of that swamp is modified by hydrological changes induced by subsidence-related cracking, the dragonfly population could be impacted. Subsidence-related cracking could influence impeded drainage flow regimes, redirect ground water flows and reduce swamp catchment areas. These actions may have the potential to result in localised drying of part of or whole Upland Swamps. Where these hydrological changes occur there is potential for changes in fire regimes and increased erosion (large-scale drying up of Upland Swamps is not predicted for the Proposal). This would result in the modification or loss of potential breeding, larval development and foraging habitat for the Giant Dragonfly.

No recovery or threat abatement plan has been prepared for the Giant Dragonfly to date. However, the DECC has listed 15 Priority Actions and recovery strategies to help recover this species. Those relevant to the Proposal are:

- Identify and map potential swamp habitat;
- Survey previously known and potential new habitat for presence – targeted surveys and subsequent monitoring of any populations are recommended for the Study Area;
- Retain or reintroduce natural water flows to swamp habitats – subsidence has the potential to alter water flows and or the catchment size of Upland Swamps; and
- Protect natural swamps from modification or disturbance – subsidence has the potential to alter water flows, plant species composition and or the catchment size of Upland Swamps.

The Proposal has the potential to modify or reduce the extent of Upland Swamp habitat available to this species as well as the potential to alter natural water flow regimes, which could modify the suitability of some currently available habitat for this species, thereby potentially threatening the recovery of this species if a population or populations are present within the Study Area.

Discussion of Habitat Utilisation

Potential habitat for the Giant Dragonfly includes wetland and swamp vegetation containing areas with sufficiently moist organic/peaty soil for breeding and larval development (DEC 2005s) (NSW Scientific Committee 2004). The adults are short-lived (living only during one summer season) and spend most of the time settled on vegetation. The larval stage is unusually long (up to 10 years or more) and larvae live in a burrow they dig under the swamp (NSW Scientific Committee 2004, DECC 2005).

The Giant Dragonfly is an obligate carnivore, feeding on other invertebrates in both larval and adult life stages (DECC 2005). Nothing is known about the species larval behaviour, other than they are burrow dwelling; although they may leave their burrows to hunt during suitable weather or times of day, or may wait inside their burrow entrances to ambush prey (Ian Baird, pers. comm.). Within the Study Area, breeding/larval development habitat could consist of ground water fed creeks or soaks within the Upland Swamps.

The adult Giant Dragonfly forages aerially within swamps, along swamp margins and in adjacent areas for their flying insect prey (DECC 2005). Adult Giant Dragonflies will use adjacent vegetation communities for foraging and can at times be found perching in adjoining Banksia Thickets, Mallee-Heath and Fringing Eucalypt Woodland (Ian Baird, pers. comm.).

Discussion of Local and Regional Abundance

Records are sparse, probably at least partly due to the cryptic nature of the Giant Dragonfly. The conspicuous adult stage is very short lived, living only within one summer season. In contrast, the larval stage is very long lived (around 10 years) (DECC 2005) and difficult to detect as it spends daylight hours in underground burrows. Records have diminished over the years, suggesting that the species is now rare across its range.

Local

There are no records of the Giant Dragonfly in the Study Area, however a record of the species in the Locality has recently been confirmed (specific location data not yet available). If present in the Study Area, the species' abundance would be difficult to assess due to the cryptic nature of the Giant Dragonfly's larval stage and short-lived adult stage.

Regional

The Giant Dragonfly has previously been recorded by experienced odonate observers in Upland Swamps at similar elevations nearby to the Study Area at Uloola Swamp near Waterfall in 1969-70, in the early 1990's, and in December 1999. The nearest records for the species to the south are for the extant population at Wingecarribee Swamp and for sightings 'near Robertson' in 1969-70 (Ian Baird, pers. comm.). The Wingecarribee Swamp population lies approximately 18 km south-west of the Study Area. However, this species is difficult to detect as the adult stage is very short-lived and the long-lived larval stage is extremely cryptic.

The Study Area is not at or near the limits of the species' known distribution.

6.4 Description of Feasible Alternatives

Ongoing geological and resource exploration, subsidence prediction and mine planning will determine the final layout of longwalls within DA3B and DA3C. A description of the planning tool that will be used to determine the layout of longwalls so that the design parameter of no major impacts to Wongawilli Creek are not exceeded, has been defined in Section 3.1.1.

There are currently no feasible economic alternatives for the extraction of coal from Dendrobium Area 3.

7.0 ASSESSMENT OF LIKELY IMPACTS ON ENDANGERED ECOLOGICAL COMMUNITIES

Map Unit 23 of NPWS (2003), Transitional Shale Stringybark Forest, has been mapped in the Study Area (Figure 11). Transitional Shale Stringybark Forest forms a component of the Endangered Ecological Community (EEC), Shale Sandstone Transition Forest. Shale Sandstone Transition Forest and is listed as an EEC on both the TSC and EPBC Acts. Ground-truthing during the field survey confirmed the presence of Map Unit 23, and therefore Shale Sandstone Transition Forest is present in the Study Area. Shale Sandstone Transition Forest is listed as an EEC potentially affected by subsidence related impacts in the KTP, 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a).

The local occurrence of Shale Sandstone Transition Forest occurs in a broad raised plateau area adjacent to Fire Road 6A, approximately 420 metres above sea-level. The predicted subsidence impacts within the landscape which this vegetation community occurs is unlikely to be subject to any noticeable surface impacts. For this reason, despite the reference to this EEC in the KTP, it is considered that the local occurrence of Shale Sandstone Transition Forest is unlikely to be significantly impacted by the Proposal. Therefore, Shale Sandstone Transition Forest has not been considered further in this SIS.

8.0 DESCRIPTION OF AMELIORATIVE MEASURES

Section 3.1.1 describes the criteria that BHPBIC have used to define the layout of the proposed longwalls within DA3A and on which the design of longwalls in DA3B and DA3C will be based. These key design criteria represent significant ameliorative measures as they limit the likely expression of subsidence impacts on significant surface features which themselves often represent the most sensitive habitat features.

The following measures are further recommended to minimise the impact of the Proposal on the environment, including threatened species that occur within and adjacent to the Study Area:

- Where subsidence-related fracturing or dilation occurs, remediation works should be employed using various methods, including grouting. Grouting has been demonstrated to be an effective tool in redirecting sub-surface flows back to the surface following dilation of near surface stream bed rock resulting from subsidence. Where remediation works are to take place in or near waterways, appropriate measures must be taken to minimise the environmental impacts of the mitigation measures. This includes avoiding the infection or spread of Chytrid Fungus, following NPWS's guidelines (NPWS 2001b);

- Where surface water is lost due to subsidence induced fracturing these areas should be mitigated as soon as feasible following subsidence movements completing in order to minimise any impact on frog recruitment;

- Where surface cracks occur within general woodland and/or forest areas they should be mitigated as soon as feasible following subsidence movements completing in order to minimise impacts of fauna entrapment. Where significant cracking occurs across known preferred fauna corridors mitigation measures such as temporary fencing of cracks and/or placement of fauna egress points should be implemented where practical until remediation can take place. Fauna egress points (designed to provide fauna with a means of escape from a crack) would vary depending on the size, location and nature of the crack. Various implements could be used such as branches, piping or man-made ramps; and

- Prior to any remediation works, advice should be sought from an ecologist regarding the potential impacts of such remediation works on plant and animal populations within the area and further assessment should be conducted as required

8.1 Long Term Management Strategies

Management strategies will be devised in and reported upon as part of the SMP reporting process submitted to the DPI. These management strategies will include trigger points for the implementation of remediation of impacts within each mine area. Adaptive management strategies will be employed based on the results of ongoing monitoring.

8.2 Compensatory Strategies

Terrestrial flora and fauna compensatory measures for the mining areas are addressed in Sections 1.1 Adherence to terms of DA, EIS, etc., and 3.3.5 Subsidence impacts on threatened fish, aquatic habitat and terrestrial habitat of the Consent. The Consent requires consideration of compensatory measures to offset impacts identified by appropriate triggers.

8.3 Ongoing Monitoring

It is recommended that ongoing monitoring of impacts of the Proposal on plant and animal populations within the Study Area are undertaken as part of Subsidence Environmental Management Plans (SMPs) for Dendrobium Area 3. It is recommended that methodologies for ongoing monitoring are finalised as part of the development of SMPs for each of the mining areas. The monitoring program methodology is expected to be similar to the current monitoring program within Dendrobium Areas 1 and 2.

Targeted surveys and monitoring (as required) of known populations are recommended specifically for three animal species (Littlejohn's Tree Frog, Red-crowned Toadlet and Giant Dragonfly). Access restrictions to the Study Area during appropriate survey conditions limits the effectiveness of targeted surveys for the other two animal species (Giant Burrowing Frog and Stuttering Frog) which are considered likely to be significantly impacted at a local level by the Proposal. Should the SCA allow increased access to the Study Area during appropriate survey conditions, i.e. during and immediately following significant rainfall events, targeted surveys and monitoring would also be recommended for these two species.

Targeted surveys are expected to involve diurnal habitat assessments to locate potential habitat within the Study Area, followed by targeted searches of potential habitat to locate populations. Impacts of the Proposal on known populations should then be monitored and if trigger points are reached, as defined by the monitoring program plan, management strategies should be undertaken.

8.4 Translocation

Translocation is unlikely to be required for this Proposal as no clearing of vegetation is considered within this report.

8.5 Informing Future Land Owners

The NSW Government is likely to remain the landowner of the Study Area in perpetuity.

9.0 ASSESSMENT OF SIGNIFICANCE OF LIKELY EFFECT OF PROPOSED ACTION

An Assessment of Significance (Seven Part Test) is provided for each of the threatened biota identified as affected species in the SIS.

9.1 Assessments of Significance: Affected Flora

Unless otherwise stated the information contained in the following Assessments of Significance have been derived from the NSW Government's Bionet database and DECC's Threatened Species profiles and/or Environmental Impact Assessment Guidelines for each species.

Cryptostylis hunteriana

Cryptostylis hunteriana is a leafless saprophytic terrestrial orchid with the only above-ground growth being a 15-45 cm long green inflorescence that is present between December and February. It is listed as a Vulnerable species on Schedule 2 of the TSC Act. It is not listed on the EPBC Act.

Cryptostylis hunteriana was not recorded within the Study Area during the current or previous field surveys. All plant communities within the Study Area (except Coachwood Warm Temperate Rainforest) are considered to be potential habitat for this species. Potential habitat that is considered to be at risk of impacts resulting from subsidence includes creek line plant communities (Sandstone Gully Peppermint Forest, Moist Gully Gum Forest, Nepean Sandstone Gully Forest and Sandstone Riparian Scrub) and Upland Swamps (Banksia Thicket, Fringing Eucalypt Woodland, Sedgeland Heath Complex and Tea Tree Thicket).

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Cryptostylis hunteriana is pollinated by pseudocopulation by the Ichneumid wasp *Lissopimpla excelsa*. The dispersal method is unknown, though the numerous winged seeds produced by the capsules are probably dispersed by wind. Germination requirements are unknown, but the species does grow from seed and prefers well drained sandy soils from both moist and dry habitats (Bell 2001). Being saprophytic, its nutritional requirements are probably met by an unknown fungal associate. The species is known to exist as vegetative colonies and usually appears in areas burnt one to three years previously (Bell 2001).

Direct impacts associated with the Proposal include the potential changes in localised hydrological regimes caused by subsidence, potentially resulting in a long term change in vegetation type within a localised area. MSEC (2007) predict that some fracturing of the bedrock beneath the swamps and smaller creeks is possible, although the probability of any major damage occurring is low.

Such changes are considered unlikely to interfere with known pollination mechanisms (wasps) and likely modes of dispersal (wind) for *C. hunteriana*. Given that the species occurs in both dry and moist soils, potential changes in soil moisture conditions are considered unlikely to have an adverse impact on a viable local population of the species.

Cryptostylis hunteriana has not been recorded within the Study Area during the current or previous field surveys. Impact assessment on this species is based on potential habitat only. On the basis of MSEC (2007) predictions that minimal impacts are likely to result in the potential habitats of this species (i.e. little to no water drainage from Upland Swamps and creek/drainage lines), it is unlikely that the lifecycle of *C. hunteriana* would be disrupted such that a viable population would be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

N/A

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

N/A

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**
ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Cryptostylis hunteriana has not been recorded from within the Study Area.

Based on *Atlas of NSW Wildlife* (DEC 2007) the species has not been recorded within the Locality, however based on a search in the *EPBC Act Online Database - Environmental Reporting Tool* (DEW 2007), potential habitats within the Study Area are likely to be within the species range.

Potential habitat for *C. hunteriana* in the Locality includes:

- Approximately 20,580.7 ha in mostly good condition in the Locality;
- Approximately 3,262.3 ha in good condition within the Study Area of which approximately 1,465.7 ha are considered to include Upland Swamp or creekline plant communities.

The area of habitat that may be impacted as a result of subsidence is restricted to plant communities that are reliant on impeded waterbodies (drainage lines), including Upland Swamps and creek line plant communities. These habitats cover an area of approximately 1,465.7 ha within the Study Area. The habitat within the Study Area (Upland Swamp and creekline plant communities) equates to approximately 7.1 % of the local distribution (5 km) of potential habitats in similar condition.

The Proposal will not result in any areas of habitat fragmentation. It is considered unlikely that the Proposal would result in the isolation of populations of this species within the Study Area.

Despite the potential impacts of the Proposal, all potential habitats are likely to be well conserved in the Study Area and are likely to remain in good condition. Given the condition and size of potential habitat in the Locality, and the fact that no individuals have been recorded in the Study Area, potential impacts resulting from the Proposal are not likely to have a significant impact on the long term survival of the species in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Under the TSC Act, the Director-General of DECC maintains a Register of Critical Habitat. To date, no critical habitat has been declared for *Cryptostylis hunteriana*.

The Proposal will not have an adverse effect on critical habitat (directly or indirectly).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

To date, no NSW threat or recovery plans have been published for *Cryptostylis hunteriana*. DEC (DEC 2005i) has listed three priority actions to help recover this species, these are:

- Co-operatively develop (local governments and DECC) guidelines for survey and assessment, to be followed by developers, consultants and approval authorities;
- Alert road maintenance staff to the presence of this species; and
- Monitor populations to determine the most appropriate timing and frequency of burning.

These are not relevant to the Proposal as the species was not recorded in the Study Area. On the basis that *Cryptostylis hunteriana* was not recorded in the Study Area, the Proposal is not considered likely to interfere with above listed recommendations.

Whether the action proposed constitutes or is part of a Key Threatening Process or is likely to result in the operation of, or increase the impact of, a Key Threatening Process.

KTPs listed on the TSC Act relevant to the Proposal that may impact on potential habitat for *Cryptostylis hunteriana* include:

- Alteration of habitat following subsidence due to longwall mining (NSW Scientific Committee 2005a);
- Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands (NSW Scientific Committee 2002a); and
- Human-caused Climate Change (NSW Scientific Committee 2000b).

The Proposal will increase the potential impact of these KTPs in relation to *Cryptostylis hunteriana* in the Study Area. It should be noted that *Cryptostylis hunteriana* has not been specifically listed on these KTPs.

Conclusion

The Proposal may have the following potential impacts on *Cryptostylis hunteriana*:

- There is limited potential for up to 1465.7 ha of potential habitat (creek line plant communities and Upland Swamps) for *Cryptostylis hunteriana* to be modified due to subsidence related impacts; and

- An increase in the impacts of two KTPs on potential habitat of the species.

The Proposal is **<u>not</u>** considered likely to result in a significant impact on a local population of *Cryptostylis hunteriana*, as:

- No individuals will be removed by the Proposal;

- Impacts on the lifecycle of the species resulting from fragmentation or isolation of a population are not likely to occur within the Locality;

- The habitat to be impacted by the Proposal is not considered to be important for the long term survival of the species in the Locality; and

- The Proposal will not have an adverse effect on critical habitat (directly or indirectly).

Epacris purpurascens var. purpurascens

Epacris purpurascens var. *purpurascens* is listed as a Vulnerable species on Schedule 2 of the TSC Act. It is not listed on the EPBC Act.

Epacris purpurascens var. *purpurascens* was not recorded within the Study Area during the field surveys. The species is known to occur in a range of habitat types, most of which have a strong clay influence, including ridgetop drainage depressions supporting wet heath within or adjoining shale cap communities, riparian zones draining into sandstone gully forest, shale lenses within sandstone habitats and colluvial areas overlying or adjoining sandstone or tertiary alluvium (DEC 2005q).

The species is considered to have potential habitat within the following plant communities in the Study Area: Sandstone Gully Peppermint Forest, Upland Swamps (Banksia Thicket, Fringing Eucalypt Woodland, Sedgeland Heath

Complex, Tea-tree Thicket), Transitional Shale Stringybark Forest, Nepean Sandstone Gully Forest and Sandstone Riparian Scrub.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Epacris purpurascens var. *purpurascens* takes two to four years to reach maturity and can live for up to 20 years. The species is killed by fire and re-establishes itself from a soil-stored seedbank (DEC 2005q). Individuals grow quickly after fire where light is available (Benson and McDougall 1995).

Impacts associated with the Proposal involve the potential changes in localised hydrological regimes associated with subsidence, potentially resulting in a change in vegetation type within a localised area. MSEC (2007) predict that some fracturing is likely within gullies and creek line habitats, but that it is unlikely to be extreme due to the reasonably shallow nature of the gullies and because Wongawilli Creek and Sandy Creek will not be directly mined beneath. The report also states that some fracturing of the bedrock beneath the swamps and smaller creeks is possible although the probability of any major damage occurring is low.

Epacris purpurascens var. *purpurascens* was not recorded within the Study Area during the field surveys. Impact assessment on this species is based on potential habitat only. On the basis of MSEC (2007) prediction that minimal impacts are likely to result in the potential habitats of this species (i.e. little to no water drainage from Upland Swamps and creek/drainage lines), it is unlikely that the lifecycle of the species would be disrupted such that a viable population would be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

N/A

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

N/A

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**
ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Epacris purpurascens var. *purpurascens* was not recorded within the Study Area during the field surveys. However, the species is considered to have potential habitat present within the following plant communities in the Study Area: Sandstone Gully Peppermint Forest, Upland Swamps (Banksia Thicket, Fringing Eucalypt Woodland, Sedgeland Heath Complex, Tea-tree Thicket), Transitional Shale Stringybark Forest, Nepean Sandstone Gully Forest and Sandstone Riparian Scrub.

There are two previous recordings of the species in the Locality and numerous previous recordings of the species within 10 km of the Study Area. All previous records occur to the north of the Study Area. Potential habitat for *Epacris purpurascens* var. *purpurascens* in the Locality, includes:

- Approximately 8,049.4 ha in good condition in the Locality; and
- Approximately 1,476 ha in good condition within the Study Area.

The Upland Swamps and creek line habitats that provide potential habitat for *Epacris purpurascens* var. *purpurascens* may be impacted by potential subsidence as they are reliant on impeded waterbodies (drainage lines). These habitats cover an area of approximately 1,465.7 ha within the Study Area. The habitat within the Study Area (Upland Swamp and creekline plant communites) equates to approximately 7.1 % of the local distribution (5 km) of potential habitats in similar condition.

The Proposal will not result in any areas of habitat fragmentation. Given that large scale alteration of the habitats is considered unlikely to occur, the Proposal is not likely to result in the isolation of populations of this species within the Study Area.

Despite the potential impacts of the Proposal, all potential habitats are likely to be well conserved in the Study Area and are likely to remain in good condition. Given the condition and size of potential habitat in the Locality, and the fact that no individuals have been recorded in the Study Area, potential impacts resulting from the Proposal are not likely to have a significant impact on the long term survival of the species in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Under the TSC Act, the Director-General of DECC maintains a Register of Critical Habitat. To date, no critical habitat has been declared for *Epacris purpurascens* var. *purpurascens*.

The Proposal will not have an adverse effect on critical habitat (directly or indirectly).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

To date, no recovery plan or threat abatement plan has been prepared for this species. DECC (DEC 2005q) has listed five priority actions to help recover this species. As the species was not recorded in the Study Area, not all of these priority actions are relevant to the Proposal. Those that are considered relevant include:

- Identify and survey potential habitat to detect new populations – potential habitat for the species in the Study Area has been identified and mapped (Figure 1). The species was not recorded in these areas despite targeted surveys.

Epacris purpurascens var. *purpurascens* was not recorded in the Study Area and therefore, the Proposal is not considered likely to interfere with above listed recovery actions.

Whether the action proposed constitutes or is part of a Key Threatening Process or is likely to result in the operation of, or increase the impact of, a Key Threatening Process.

KTPs listed on the TSC Act relevant to the Proposal that may impact on potential habitat for *Epacris purpurascens* var. *purpurascens* include:

- Alteration of habitat following subsidence due to longwall mining (NSW Scientific Committee 2005a);
- Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands (NSW Scientific Committee 2002a); and
- Human-caused Climate Change (NSW Scientific Committee 2000b).

Epacris purpurascens var. *purpurascens* has been specifically listed in the final determination for the KTP 'Alteration of habitat following subsidence due to longwall mining' as a species 'known to occur in areas affected by subsidence due to longwall mining' and its habitat is considered 'likely to be altered by subsidence and mining-associated activities' (NSW Scientific Committee 2005a).

The Proposal has the potential to increase the affects of these KTPs in relation to *Epacris purpurascens* var. *purpurascens* in the Study Area.

Conclusion

The Proposal will have the following impacts on *Epacris purpurascens* var. *purpurascens*:

- Up to 1,465.7 ha of habitat for *Epacris purpurascens* var. *purpurascens* will be potentially impacted as part of the Proposal; and
- Increase in the impact of some KTPs.

The Proposal is **not** considered likely to result in a significant impact on a local population of *Epacris purpurascens* var. *purpurascens,* as:

- It is unlikely individuals will be removed by the Proposal and, as a result, an impact on the lifecycle of the species or fragmentation of a population is not likely within the Locality;
- The habitat to be impacted by the Proposal is not considered to be important for the long term survival of the species in the Locality;
- The Proposal will not have an adverse effect on critical habitat (directly or indirectly); and
- The Proposal is not inconsistent with a recovery plan for the species.

Leucopogon exolasius

Leucopogon exolasius is an erect shrub to 1 m high listed as a Vulnerable species on both the TSC and EPBC Acts.

Leucopogon exolasius was not recorded within the Study Area during the field surveys. The species is considered to have potential habitat in the Study Area in gullies within Sandstone Gully Peppermint Forest, Nepean Sandstone Gully Forest and Sandstone Riparian Scrub.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Little is known of the life cycle of *Leucopogon exolasius*. The species flowers from August through to October and the fruit is a drupe (Benson and McDougall 1995) and therefore, probably dispersed by fruit eating birds. It has an alluvial distribution and, being an Epacridaceae, is likely to require fire for germination (DEC 2005).

Impacts associated with the Proposal involve the potential changes in localised hydrological regimes associated with subsidence, potentially resulting in change in vegetation type within a localised area. MSEC (2007) states that some fracturing is likely within the smaller gullies and creek line habitats, but that it is unlikely to be extreme due to their shallow nature. In addition, Wongawilli Creek and Sandy Creek will not be directly mined beneath.

Leucopogon exolasius was not recorded within the Study Area during the field surveys and therefore a viable population within the Study Area is considered unlikely to be present. It is unlikely that the lifecycle of the species would be disrupted such that a viable population would be placed at risk of extinction because impacts to potential habitats for this species are likely to be minimal (i.e. little to no water drainage from creek/drainage lines) (MSEC 2007).

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

N/A

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

N/A

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**
ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Leucopogon exolasius was not recorded within the Study Area despite current and previous targeted surveys. Locally this species has been recorded from the Woronora River where it occurs within the rocky, bare riparian zone where alluvial soils were almost absent (M. Richardson, Biosis Research Pty. Ltd., pers. comm.). The species is considered to have potential habitat in the Study Area in gullies within Sandstone Gully Peppermint Forest, Nepean Sandstone Gully Forest and Sandstone Riparian Scrub.

There are no previous recordings of the species in the Locality or within 10 km of the Study Area. Potential habitat for *Leucopogon exolasius* in the Locality, includes:

- Approximately 6,821.8 ha in good condition in the Locality; and
- Approximately 1,306.3 ha in good condition within the Study Area.

The creekline habitats that provide potential habitat for *Leucopogon exolasius* may be impacted by subsidence as they are reliant on impeded waterbodies (drainage lines). These potential habitats cover an area of approximately 1,306.3 ha within the Study Area. The habitat within the Study Area equates to approximately 19.1 % of the local distribution (5 km) of similar habitats in similar condition.

The Proposal will not result in any areas of habitat fragmentation. Given that large scale alteration of the habitats in the Study Area are considered unlikely, the Proposal is not likely to result in the isolation of populations of this species within the Study Area.

Despite the potential impacts of the Proposal, all potential habitats are likely to be well conserved in the Study Area and are likely to remain in good condition. Given the condition and size of potential habitat in the Locality, and the fact that no individuals have been recorded in the Study Area, potential impacts resulting from the Proposal are not likely to have a significant impact on the long term survival of the species in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Under the TSC Act, the Director-General of DECC maintains a Register of Critical Habitat. To date, no critical habitat has been declared for *Leucopogon exolasius*.

The Proposal will not have an adverse effect on critical habitat (directly or indirectly).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

To date, no recovery plan or threat abatement plan has been prepared for this species. DECC has listed seven priority actions to help recover this species. The priority action considered relevant to the Proposal is:

- Undertake surveys of known sites and potential habitat, particularly on Department of Defence land and along the Georges River – potential habitat for the species within the Study Area has been identified and mapped (Figure 10). The species has not been recorded in the Study Area despite targeted surveys within potential habitat.

On the basis that *Leucopogon exolasius* has not been previously recorded in the Study Area, the Proposal is not considered likely to interfere with the priority actions to assist in recovery of the species.

Whether the action proposed constitutes or is part of a Key Threatening Process or is likely to result in the operation of, or increase the impact of, a Key Threatening Process.

KTPs listed on the TSC Act that are relevant to the Proposal and may impact on potential habitat for *Leucopogon exolasius* include:

- Alteration of habitat following subsidence due to longwall mining (NSW Scientific Committee 2005a);

- Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands (NSW Scientific Committee 2002a); and

- Human-caused Climate Change (NSW Scientific Committee 2000b).

Leucopogon exolasius has been specifically listed in the final determination for the KTP ‘Alteration of habitat following subsidence due to longwall mining’ as a species ‘known to occur in areas affected by subsidence due to longwall mining’ and its habitat is considered ‘likely to be altered by subsidence and mining-associated activities’(NSW Scientific Committee 2005a).

The Proposal has the potential to increase the affects of these KTPs in relation to *Leucopogon exolasius* in the Study Area.

Conclusion

The Proposal will have the following impacts on *Leucopogon exolasius*:

- Up to 1,306.3 ha of potential habitat will be potentially impacted by the Proposal; and

- Increase in the impact of some KTPs.

The Proposal is **not** considered likely to result in a significant impact on a local population of *Leucopogon exolasius*, as:

- It is unlikely individuals will be removed by the Proposal and, as a result, an impact on the lifecycle of the species or fragmentation of a population is not likely within the Locality;

- The habitat to be impacted by the Proposal is not considered to be important for the long term survival of the species in the Locality;

- The Proposal will not have an adverse effect on critical habitat (directly or indirectly); and

- The Proposal is not inconsistent with a recovery plan for the species.

Pultenaea aristata

Pultenaea aristata is a small shrub, up to 1 m tall, and is listed as Vulnerable on both the TSC and EPBC Acts. Based on the DEC (DEC 2005,) threatened species profile, *P. aristata* occurs in either dry sclerophyll woodland or wet heath on sandstone.

During current and previous surveys of the Study Area, *P. aristata* was recorded within the Upland Swamps. The species is also considered to have limited potential habitat in areas of impeded drainage lines within Exposed Sandstone Scribbly Gum Woodland (ESSW) and Sandstone Gully Peppermint Forest (SGPF) within the Study Area.

Up to 159.4 ha of known and potential habitat (based on Upland Swamps only) for *Pultenaea aristata* may be impacted as part of the Proposal. *Pultenaea aristata* is commonly recorded as a dominant shrub in Upland Swamps within the Study Area, with hundreds and sometimes thousands of individuals recorded at each location.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Direct impacts associated with the Proposal involve the potential changes in localised hydrological regimes associated with subsidence, potentially resulting in a long term change in vegetation type within a localised area. MSEC (2007) predicts that some fracturing is likely within gullies and creek line habitats, but that it is unlikely to be extreme due to the reasonably shallow nature of the gullies. The report also states that some fracturing of the bedrock beneath the swamps and smaller creeks is possible although the probability of any major damage occurring is low. *Pultenaea aristata* is probably killed by fire (as other *Pultenaea* species are) (DEC 2005,). As with many *Pultenaea* species, recruitment is known to occur following fire (McDougal 1996) and based on anecdotal observation of populations within the Locality; the species sometimes germinates on mass following fire. The Proposal is unlikely to interfere with fire regimes within the Study Area.

Pollination and dispersal are considered important stages of the lifecycle of *Pultenaea aristata*. Based on the ecology of the species, pollinators and dispersers for the species are likely to be insects and ants. It is not anticipated that the potential impacts of subsidence are likely to significantly impact the movements, shelter or foraging opportunities of these invertebrate vectors.

Given the large proportion of the *Pultenaea aristata* population occurring in the Locality, but outside the Study Area, potential impacts resulting from the Proposal are not considered likely to impact on the lifecycle of the species such that the viable local population would be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

N/A

In the case of a critically endangered or endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

N/A

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**
ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Pultenaea aristata is known to occur in both dry sclerophyll woodlands and wet heath on sandstone (DEC 2005,), although records within the Study Area are from Upland Swamps only. The species was most abundant within vegetation mapped by NPWS (2003) as the Upland Swamp, Banksia Thicket sub-community. This habitat type is common across in the Study Area (Figure 10). Limited potential habitat is also likely to occur within other Upland Swamp communities and within areas of impeded drainage.

The plants recorded within the Study Area are likely to be part of a larger local population of the species estimated to support thousands of individuals extending from within the south-west of the Study Area to just outside the Study Area in the south. This is likely to be a conservative underestimate of the abundance of the species in the Locality, as it was recorded as the dominant shrub in some swamps.

Habitat and populations of *Pultenaea aristata* in the Locality include:

- Two populations, supporting an estimate of 27,550 plants per hectare in the south-west of the Study Area;

- At least seven populations recorded within the locality, some of which include *P. aristata* as a dominant species within the plant community;
- Approximately 159.4 ha of known and potential habitat in good condition within the Study Area; and
- Approximately 993.6 ha of known and potential habitat (Upland Swamps), within the Locality (NPWS 2003).

The area of habitat that may be impacted as a result of subsidence is restricted to plant communities that are reliant on impeded waterbodies (drainage lines) including Upland Swamps and creek lines. The area of known and potential habitat within the Study Area equates to approximately 16% of the local distribution (5 km) of similar habitats in similar condition.

The Proposal will not result in any areas of habitat fragmentation. On the basis that *P. aristata* can occur in both wet and dry plant communities, it is considered unlikely that the Proposal would result in the isolation of populations of this species within the Study Area.

Despite the potential impacts of the Proposal, all potential habitats are likely to be well conserved in the Study Area and are likely to remain in good condition. Given the condition and size of potential habitat in the Locality, potential impacts resulting from the Proposal are not likely to have a significant impact on the long term survival of the species in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Under the TSC Act, the Director-General of DECC maintains a Register of Critical Habitat. To date, no critical habitat has been declared for *Pultenaea aristata*.

The Proposal will not have an adverse effect on critical habitat (directly or indirectly).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

To date, no recovery plan or threat abatement plan has been prepared for this species. DEC (2005,) has listed two priority actions to help recover this species, these are:

- Review fire management requirements – the requirements of threatened species known to occur in the Study Area should be considered by the

SCA in any proposed fire regime. This is particularly important for *Pultenaea aristata* as it is thought to be killed by fire; and

- Confirm location details of existing records – potential habitat for the species in the Study Area has been identified and mapped (Figure 5).

The Proposal is not inconsistent with the two listed priority actions.

Whether the action proposed constitutes or is part of a Key Threatening Process or is likely to result in the operation of, or increase the impact of, a Key Threatening Process.

KTPs listed on the TSC Act relevant to the Proposal include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a);
- ‘Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands’(NSW Scientific Committee 2002a); and
- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b).

Pultenaea aristata has been specifically listed in the final determination for the KTP ‘Alteration of habitat following subsidence due to longwall mining’ as a species ‘known to occur in areas affected by subsidence due to longwall mining’ and its habitat is considered ‘likely to be altered by subsidence and mining-associated activities’ (NSW Scientific Committee 2005a).

The Proposal has the potential to increase the affects of these KTPs in relation to *Pultenaea aristata* in the Study Area.

Conclusion

The Proposal may have the following potential impacts on *Pultenaea aristata*:

- Up to 159.4 ha of potential habitat (based on Upland Swamps only) for *Pultenaea aristata* may be modified due to subsidence related impacts over the long term; and
- An increase in the impacts of two KTPs on known and potential habitat of the species.

The Proposal is **not** considered likely to result in a significant impact on a local population of *Pultenaea aristata*, as:

- No individuals will be removed by the Proposal;
- Impacts on the lifecycle of the species resulting from fragmentation or

isolation of a population are not likely to occur within the Locality;

- The habitat to be impacted by the Proposal is not considered to be important for the long term survival of the species in the Locality;
- The Proposal will not have an adverse effect on critical habitat (directly or indirectly); and
- The Proposal is not inconsistent with a recovery plan for the species.

9.2 Assessments of Significance: Affected Animal Species

9.2.1 Summary of impacts on fauna

The impacts predicted from subsidence as they relate to fauna are summarised below to limit the repetitious discussion of these impacts throughout the Seven Part Tests. The possible mechanisms and physical effects of subsidence may have a direct impact on known and potential habitat for threatened animal species, such as waterways, Upland Swamps, riparian vegetation, rock overhangs, crevices and, in some instances, ridgetop environments. However, it is unlikely that impacts from subsidence would impact on other habitats or habitat components outside waterways, swamps, ridgelines and rocky outcrops/cliffs. For example, subsidence is unlikely to impact on woodland and forest habitats not wholly dependant on ground water or on specific habitat components such as tree hollows, although surface cracking may result in a small area of vegetation being impacted immediately around the cracking and a small number of animals may perish if they should fall down the cracks. Therefore, potential impacts from the Proposal are mostly restricted to animal species that are reliant on habitat provided by or reliant on waterways, Upland Swamps, ridgetops or rocky outcrops/cliffs. Impacts outside these areas (i.e. from cracking) are likely to have negligible impacts on threatened species and/or their habitat.

The Proposed longwall layout and set backs around the creek lines, Wongawilli and Sandy Creek means that impacts will be reduced in these areas. However, other creeks and tributaries of the main creek lines, ridgelines and Upland Swamps will be directly mined beneath and subjected to the full range of predicted subsidence-related movements.

It should be noted that the subsidence predictions for the Study Area are based on upper bound prediction curves and it is unlikely that the upper limit of subsidence impacts predicted by MSEC (2007) will be realised. However, a conservative assessment of impacts on ecological values requires that the upper limit subsidence parameters for each impact type be considered for species impact assessments. It is likely that subsidence will result in cracking and changes to hydrology or water quality in only a small proportion of the drainage lines and Upland Swamps within the Study Area. For example, MSEC (2007) predict that less than 7 to 10% of clifflines located directly above the longwalls would be impacted (i.e. cracking and rock falls would take place). However, because the exact severity and location of subsidence impacts cannot be precisely predicted on the lands surface, the species assessments assume that these impacts may directly affect threatened species populations present in the Study Area, even though this is unlikely for all populations over the entire Study Area. Additionally, because the species assessments are at the local population level and, for frogs species and the Giant Dragonfly, these local populations may be contained within individual drainage lines or swamps, impacts to a single drainage line or swamp may impact on the whole local population.

The types, severity and extent of predicted impacts possible from subsidence within DA3 are as follows (MSEC 2007):

- Modified Ponding, Flooding and Scouring: It is unlikely that there would be any significant increases in the levels of ponding, flooding, or scouring of the creek banks within Wongawilli and Sandy Creek as the longwalls are set back from these watercourses. However, it is possible, that there could be some localised increased level of ponding or flooding where the maximum predicted tilts coincide with existing pools, steps or cascades along the creeks. Within otherwater courses (including tributaries of Sandy and Wongawilli Creeks) that will be mined beneath, there may be minor increases in pool size (ponding/flooding) in some areas and increased scouring in other areas, although it is likely that any impacts would be short lived;

- Fracturing and Surface Flow Diversions: Minor, isolated fracturing within the main creeks may occur but it is not expected to result in significant fracturing or surface flow water diversions for these larger watercourses. Fracturing of bedrock and therefore re-direction of surface flows is possible in the smaller creeks and tributaries that would be directly mined beneath. This fracturing may lead to draining of some pools over some sections of the longwall(s). Water quality impacts are likely to be reduced (diluted) in periods of high flow, but there is likely to be some change in water quality during low flow periods;

- Water Quality and Groundwater: Water quality may be impacted through erosion and loss of soil materials into watercourses, via physico-chemical effects and through the induction of upland ferruginous springs. This can impact amphibious fauna and riparian vegetation. However, changes to water quality are considered highly unlikely to lead to significant impacts to fauna or riparian vegetation (Ecoengineers 2007);

- Cliff and Rock Falls: Impacts on rocky areas and cliff lines directly above the proposed longwalls, including rock falls are not expected to impact more than 7 – 10 % of the entire length of any ridge line. No large scale cliff collapses or slope failure is predicted as these effects have not been observed before in the Southern Coalfield. Smaller rock outcrops are expected to experience very minor or no impacts. Although rock falls may alter or remove roosting or sheltering habitat (overhangs, caves, crevices) for a number of species, it may also create new habitat for these species, and therefore, from an overall habitat availability perspective the impacts are likely to be less than the MSEC (2007) predictions might suggest;

- Upland Swamps: It is possible that any changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. Generally, however, the surfaces of the swamps are free draining, and it is not anticipated that significant changes in ponding would occur as a result of differential subsidence or tilt. Significant changes to vegetation within swamps are not predicted and have not previously been observed within monitored swamps that have been mined beneath (Biosis Research 2007e, d, c). Although bedrock fracturing is likely to occur, especially where the swamp is situated within a deeply incised valley, it is unlikely that drainage of the swamps would occur as any cracking would not connect with the mine or other deep storage. While the gradients of these swamps are relatively low it is not expected that they would be susceptible to scour under high rates of runoff unless significant prior fire damage had occurred. Extensive water quality monitoring within swamps and immediately downstream of them in the region over almost five years of study has also failed to detect any geochemical effects from mining subsidence beneath swamps (Ecoengineers 2007). Although changes to water flow and water quality in Upland Swamps from subsidence are possible, these impacts are considered unlikely, and therefore, changes to vegetation even less likely. As discussed in Section 3.2.1 subsidence has the potential to to reduce catchment areas for swamps and as a result it is possible that minor changes in water level may occur (Cardno Forbes Rigby 2007a). On this basis, a reduction in available habitat for species dependant on the moisture within Upland Swamps could occur. Based on an assessment of the potential for catchment area changes by Cardno Forbes Rigby (2007a) is unlikely that the majority of swamps in DA3 will be impacted by mining induced catchment change;

- Surface Bedrock Fracturing and Soil Cracking: Surface bedrock and soil cracking are likely to occur due to systematic subsidence movements where tensile strains are greatest. Surface cracking tends to increase as the depth of cover decreases and only minor fracturing would be expected where the depths of cover are greater than 300 m and the terrain is relatively flat. In the case of DA3A, MSEC (2007) predict that fractures at the surface could be as wide as 50 mm in relatively flat areas. It is also likely that large surface cracks would occur above the proposed longwalls as a result of downhill movements adjacent to the ridgelines and along the steep slopes, similar to that observed in Dendrobium Area 1 (up to 400mm wide). However, the terrain in DA3A is flatter than that in Area 1, and it is therefore predicted that the maximum crack widths above the proposed longwalls would be less than that observed in Area 1 (MSEC 2007). Impacts to vegetation from surface cracking have been limited to a few individual trees becoming unstable and falling over where large cracks have been observed. Individual animals may perish if they should fall into a subsidence-created crack, although there is no data to support or quantify this impact. The impacts from the possible loss of vegetation and fauna from surface cracking are considered to be negligible; and

- Surface Gas Emissions: Gas emissions may result when fracturing or dilation of strata occurs due to subsidence. Gas emissions, under a very small number of certain environmental conditions, may result in vegetation dieback. This phenomenon has previously been observed only once in the Southern Coalfields within the Cataract River where small patches of vegetation were impacted. Any such impacts are short lived and, in the case of the riparian vegetation within the Cataract River, regeneration occurred almost immediately following the initial dieback and at the cessation of three years monitoring, substantial regeneration had taken place (Fyfe 2000). It is considered unlikely that gas emissions would result in vegetation dieback within DA3.

9.2.2 Assessments of significance

A number of Affected animal species are considered unlikely to be significantly impacted by the Proposal. Those species whose known and/or potential habitat is considered likely to experience only negligible impacts are considered in Table 16.

Table 16: Seven Part Test criteria as applied to Affected animal species with potential habitat in the Study Area that are likely to experience only negligible impacts.

Scientific Name	Common Name	TSC [1]	Seven Part Test Questions							
			1	2	3	4	5	6	7	Significant Impact
Callocephalon fimbriatum	Gang-gang Cockatoo	V	No - loss of feed trees in riparian vegetation is possible, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of moderate importance.	No	Yes	Subsidence and climate change.	No
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	No - loss of feed trees in riparian vegetation is possible, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of moderate importance.	No	Yes	Subsidence and climate change.	No
Dasyornis brachypterus	Eastern Bristlebird	E	No – limited habitat may be impacted, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of low importance.	No	Yes	Subsidence and climate change.	No
Ixobrychus flavicollis	Black Bittern	V	No – limited habitat may be impacted, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of low importance.	No	Yes	Subsidence, climate change and Alteration to the natural flow regimes.	No
Ninox connivens	Barking Owl	V	No - food source (gliders) may be impacted from loss of habitat, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of moderate importance.	No	Yes	Subsidence and climate change.	No
Ninox strenua	Powerful Owl	V	No - food source (gliders) may be impacted from loss of habitat, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of moderate importance.	No	Yes	Subsidence and climate change.	No
Pezoporus wallicus wallicus	Eastern Ground Parrot	V	No – limited habitat may be impacted, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of low importance.	No	Yes	Subsidence and climate change.	No
Tyto capensis	Grass Owl	V	No – limited habitat may be impacted, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of low importance.	No	Yes	Subsidence and climate change.	No

Scientific Name	Common Name	TSC [1]	Seven Part Test Questions							
			1	2	3	4	5	6	7	Significant Impact
Tyto novaehollandiae	Masked Owl	V	No - food source (gliders) may be impacted from loss of habitat, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of moderate importance.	No	Yes	Subsidence and climate change.	No
Tyto tenebricosa	Sooty Owl	V	No - food source (gliders) may be impacted from loss of habitat, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of moderate importance.	No	Yes	Subsidence and climate change.	No
Petaurus norfolcensis	Squirrel Glider	V	No – food source (banksias) may be impacted around Upland Swamps, but highly unlikely.	NA	NA	i. small extent removed, if any; ii. no fragmentation; iii. habitat of moderate importance.	No	Yes	Subsidence and climate change.	No

Key 1: V = Vulnerable, E = Endangered under the schedules of the TSC Act.

Seven Part Tests for the remaining Affected animal species are detailed below.

Unless otherwise stated the information contained in the following Assessments of Significance has been derived from the NSW Governments Bionet database and DECC’s Threatened Species profiles and/or Environmental Impact Assessment Guidelines for each species.

Littlejohn’s Tree Frog *Litoria littlejohni*

Littlejohn’s Tree Frog is listed as Vulnerable on Schedule 2 of the TSC Act and as Vulnerable on the EPBC Act.

Littlejohn’s Tree Frog appears to be restricted to sandstone woodland and heath communities from 100 to 950 metres above sea level (White and Ehmann 1997). It is not associated with any specific plant communities and appears to breed in wet forest margins (NPWS 2002c). A variety of breeding habitats have been described, including temporary pools, deep permanent pools in slow creeks and slow, rock-lined rivers and dams (White and Ehmann 1997). It forages in the tree canopy and on the ground (NPWS 2002c). Where the species occurs when it is not breeding is virtually unknown, although it has been observed sheltering under rocks on high exposed ridges during summer (NSW Scientific Committee 2000a).

Biosis Research has recorded a large population and other smaller populations of this species within the Study Area (within DA3A, DA3B and DA3C).

Approximately 30 individuals were recorded during the current surveys over eight different sites (Donald's Castle Creek, Creek LA4, Native Dog Creek, Banksia Creek, Sandy Creek, Creek LC7 and Upland Swamp's 7 and 15b) occurring within Sandstone Gully Peppermint Forest, Upland Swamp Sedgeland Heath Complex, Upland Swamp Fringing Eucalypt Woodland and Exposed Sandstone Scribbly Gum Woodland. The species is regularly encountered by Biosis Research during monitoring and targeted surveys and is possibly the largest population ever recorded. Lemckert (2004) states he was only able to obtain 75 records in total of the species from NSW and Victoria. However, the most recent targeted surveys (winter 2007) conducted by Biosis Research recorded 77 individuals and did not cover all known locations within the Study Area. Higher numbers of the species have been recorded during previous surveys (e.g. fauna monitoring) within the Study Area. The largest population recorded within the Study Area occurs within the Sandy Creek Catchment located entirely within DA3A (within Sandstone Gully Peppermint Forest, Tall Open Peppermint-Blue Gum Forest, Upland Swamp Sedgeland Heath Complex, Upland Swamp Banksia Thicket and Exposed Sandstone Scribbly Gum Woodland plant communities). Biosis Research has also recorded the species at five locations outside the Sandy Creek Catchment, within the Study Area. Other plant communities that may provide potential habitat include Upland Swamp Tea-tree Thicket, Rock Plate Heath-Mallee, Nepean Sandstone Gully Forest and Moist Gully Gum Forest.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Littlejohn's Tree Frog occurs along permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops. Breeding is triggered by heavy rain and can occur from late winter to autumn, but is most likely to occur in spring when conditions are favourable (DEC 2005z). Biosis Research has recorded the species breeding in late winter (amplexus observed), and eggs, tadpoles and/or metamorphs have been observed in all seasons. Males call from low vegetation close to slow flowing pools (DEC 2005z). Biosis Research has recorded the species calling in all seasons. Eggs are laid in loose gelatinous masses attached to small submerged twigs (DEC 2005z). Eggs and tadpoles are mostly found in slow flowing pools that receive extended exposure to sunlight, but will also use temporary isolated pools (DEC 2005z).

Littlejohn's Tree Frog was recorded within the Study Area during the current and previous Biosis Research surveys. The species is probably moderately common within areas of suitable habitat in the Study Area, which appears to support a large viable population and other smaller populations of the rare species. Populations within the Study Area have been determined by the species' presence within the different catchments and include the Sandy Creek Catchment population (the largest), Donald's Castle Creek, Lake Avon, Native Dog Creek and Lake Cordeaux Catchments populations. Known and potential habitat for this species occurs in the Study Area within woodland, forest and Upland Swamp plant communities which contain suitable foraging, sheltering and breeding resources (e.g. slow flowing creeks and rocky streams with deep pools).

The area of known and potential habitat for Littlejohn's Tree Frog that may be impacted as a result of subsidence includes creek lines, riparian vegetation, rock outcrops and Upland Swamps (see Section 9.2.1 summary of impacts). These habitats provide foraging, sheltering and breeding resources for Littlejohn's Tree Frog. Wongawilli and Sandy Creeks will not be mined beneath, so potential impacts will be minimised in these areas. However, other creeks and tributaries of Wongawilli and Sandy Creeks, rocky ridges and Upland Swamps will be directly mined beneath and are expected to be subjected to the full range of predicted systematic subsidence and valley related movements (MSEC 2007). Whilst subsidence impacts are possible for each watercourse, ridge line and Upland Swamp occurring in the Study Area (particularly those directly above the longwalls), it is unlikely that all would be impacted by the Proposal.

Direct impacts to Littlejohn's Tree Frog (individuals and populations) are possible and it is most likely these impacts would also effect breeding habitat. A number of breeding pools have been recorded within the Study Area (all within DA3A) in creek lines occurring within woodland/forest and/or adjacent to Upland Swamps (e.g. Waratah Creek, Banksia Creek, Cascade Creek and Upland Swamp 15a). Egg masses, tadpoles, metamorphs and calling adults have been observed at these sites. All of these sites are planned to be mined beneath, either wholly or partially. The loss of surface flow and deep pools from creek lines, changes to water flow regimes and water quality, and hydrological changes to Upland Swamps are likely to impact on the life cycle of the species. Any draining of a breeding pool containing the eggs, tadpoles or metamorphs of Littlejohn's Tree Frog would likely result in the loss of an entire generation of recruits for that pool within that creek line or local population.

In addition to disturbance of breeding habitat, subsidence may impact on non-breeding sheltering sites such as ridge lines and rocky outcrops. Rockfalls and overhang collapse (predicted to be less than 7 to 10 per cent of the total length of cliffline to be mined directly beneath (MSEC 2007) may lead to the loss of individuals. Fracturing of the sandstone may result in cracks forming on the ridge lines. These cracks may vary in size and depth and can become potential fauna traps.

Indirect impacts are also possible on Littlejohn's Tree Frog. For example, fracturing of a creek line directly above a longwall, particularly where there is exposed bedrock (which is the case for many creek lines within the Study Area), can lead to the loss of surface water into the dilated strata beneath. This loss of water above a longwall can lead to loss of water and reduced water quality downstream of the fracture, even where the creek line does not occur directly above a longwall. This effect has been observed to a maximum of approximately 800m downstream (Ecoengineers 2007) from where large creeks were mined under directly by a number of longwalls (Native Dog and Wongawilli Creeks by Elouera Colliery). In the case of Dendrobium Area 3 Wongawilli and Sandy Creeks will not be mined under directly and these downstream effects are likely to be much less.

There is also some possibility for Littlejohn's Tree Frog to be indirectly impacted by the Proposal due to Chytrid Fungus. Whilst the infection or spread of the disease is unlikely to be exacerbated by the Proposal, if the fungus is present in frog populations within the Study Area (the disease is known to occur in Dendrobium Area 1 adjacent to the Study Area), these populations may be rendered more susceptible to other threatening processes (NSW Scientific Committee 2003a) such as loss and degradation of habitat (e.g. loss of breeding pools, changes to natural flow regimes, reduced water quality).

Whilst Wongawilli and Sandy Creek within the Study Area are less likely to be significantly impacted by the Proposal, minor and isolated impacts (fracturing and loss of surface water) are still expected (MSEC 2007). Littlejohn's Tree Frog has been recorded at Sandy Creek, which possibly provides a movement corridor for the species. The species has been recorded in higher numbers (including breeding sites) within the tributaries of the main creek lines and Upland Swamps, which are expected to be subjected to the full range of predicted systematic subsidence and valley related movements (MSEC 2007). The species requires specific breeding conditions and has been recorded in significant numbers within the Study Area. The loss of known breeding habitat and possible population recruitments by predicted subsidence events (should such events occur where the species is present) is likely to cause disruption to the life cycle of one or more local populations within the Study Area to the extent that they may be placed at risk of extinction in these locations.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an

Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, no population of Littlejohn's Tree Frog is listed as an Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Known and potential habitat for Littlejohn's Tree Frog occurs in Sandstone Gully Peppermint Forest, Upland Swamp Sedgeland Heath Complex, Upland Swamp Fringing Eucalypt Woodland, Exposed Sandstone Scribbly Gum Woodland, Tall Open Peppermint-Blue Gum Forest, Upland Swamp Banksia Thicket, Upland Swamp Tea-tree Thicket, Rock Plate Heath-Mallee, Nepean Sandstone Gully Forest and Moist Gully Gum Forest plant communities within the Study Area where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of these plant communities, is considered potential habitat for the species.

- The Study Area contains approximately 3,243 ha of woodland, forest and Upland Swamp habitat for this species;
- Specifically, habitats including permanent rocky streams with thick fringing

vegetation, deep pools, Upland Swamps and rocky outcrops are likely to be important for the species within the Study Area;

- Subsidence has the potential to alter a proportion of these habitat features within the Study Area though it is highly unlikely that all of this habitat within the Study Area would be impacted;
- These habitats are widely distributed within the Locality (approximately 20,305 ha). The known and/or potential habitat for Littlejohn's Tree Frog in the Study Area represents 15.9 per cent of potential habitat within the Locality; and
- Section 9.2.1 of the SIS details the "predicted" impacts of subsidence on these habitat types.

While the Proposal is unlikely to fragment or isolate woodland or forest habitat in the Study Area from the surrounding area, hydrological changes to Upland Swamps or the loss of/alteration to surface flow at creek lines may isolate and reduce the number of breeding sites for Littlejohn's Tree Frog. The loss of surface water may also restrict movement of the species between areas of potential habitat. The mechanisms of dispersal for Littlejohn's Tree Frog are unknown. The species is presumably able to move through at least small areas of riparian and gully forest as it has been recorded away from creek lines outside its breeding season. The loss of these connective habitats may fragment known and potential breeding habitat for the species.

The habitat within the Study Area is of good quality for Littlejohn's Tree Frog and previous surveys conducted by Biosis Research within the Locality indicate that the habitat outside the area to be impacted (by the current Proposal) is of similar quality. While woodland and forest plant communities that could provide potential habitat for the species are continuous throughout the Locality, Upland Swamps and suitable creek lines occur more infrequently. Littlejohn's Tree Frog is considered to be an "extremely rare resident" within the Greater Southern Sydney Region whose "known breeding sites should be treated as being of very high conservation value" (DEC 2005Ž). The species has been recorded in sufficient numbers in the Study Area to suggest the populations are important populations of the species in the region, and across the species known range. The habitat within the Study Area is considered essential to the long-term survival of the species in the Locality as it supports a very large and important population.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for Littlejohn's Tree Frog (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is currently no recovery plan for Littlejohn's Tree Frog. However, the DECC has prepared 13 Priority Actions to help recover this species. Those relevant to the Proposal include:

- Develop management strategies where possible that protect existing water flow and quality or restore natural water flows and water quality – subsidence has the potential to impact on water flow and water quality of known habitat for Littlejohn's Tree Frog;
- Develop strategies for providing supplementary breeding habitat at selected locations throughout the species range – subsidence has the potential to impact known and potential breeding sites within the Study Area;
- Retain riparian native vegetation – subsidence has the potential to impact riparian vegetation by gas emissions and water loss, although, such impacts are predicted to be unlikely and/or insignificant;
- Investigate methods of ameliorating or attenuating Chytrid action – appropriate gear and vehicle washdown procedures should be followed at all times, and
- Undertake survey in some of the less surveyed parts of the species distribution.

There is currently no NSW threat abatement plan for Littlejohn's Tree Frog, but the species is considered in the Commonwealth threat abatement plan 'Infection of amphibians with Chytrid Fungus resulting in chytridiomycosis'. The plan states that there have been no reports of Chytrid Fungus in Littlejohn's Tree Frog, but that also no surveys have been performed to test for the pathogen in this species (DEH 2006). Therefore, Littlejohn's Tree Frog should be considered susceptible to infection by Chytrid Fungus. The aim of the threat abatement plan is to reduce the impacts of the KTP 'Infection of frogs by amphibian Chytrid causing the disease chytridiomycosis' (NSW Scientific Committee 2003a) to maximise the chances of the long-term survival of affected species, particularly listed threatened species.

The current Proposal is unlikely to exacerbate the infection or spread of Chytrid Fungus however, if the fungus is present in frog populations within the

Study Area (the disease is known to occur in Dendrobium Area 1 adjacent to the Study Area), these populations may be rendered more susceptible to other threatening processes such as loss and degradation of habitat (NSW Scientific Committee 2003a).

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for Littlejohn's Tree Frog include:

- 'Alteration of habitat following subsidence due to longwall mining'(NSW Scientific Committee 2005a) – known and potential habitat for Littlejohn's Tree Frog occurs within forest, woodland and Upland Swamp habitat where permanent slow-flowing creeks, deep pools and fringing vegetation are present; all of which are known and/or may be vulnerable to the effects of subsidence;

- 'Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands' (NSW Scientific Committee 2002a) – Littlejohn's Tree Frog requires permanent slow-flowing creeks with deep pools and fringing vegetation for breeding within the Study Area. Loss of water or changes to flow patterns could impact on the species; and

- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Littlejohn's Tree Frog.

Conclusion

A large number of observations of Littlejohn's Tree Frog have been made within the Study Area during the current and previous surveys. Known and potential habitat for this species occurs within creek lines, ridge lines and Upland Swamps surrounded by woodland and/or forest communities. The Proposal has the potential to impact Littlejohn's Tree Frog through alteration of known and potential foraging, sheltering and breeding habitat, including hydrological changes to Upland Swamps, loss of pool water or surface flow from creeks and rockfalls. The disturbance to, loss of, fragmentation and isolation of known breeding sites by subsidence-related events (such as creek bed fractures, loss of surface water and pools, changes to water flows in creek lines and hydrological changes to Upland Swamps) and impacts on sheltering sites (such as rockfalls) is likely to impact on the reproductive and dispersal viability of Littlejohn's Tree Frog in these local areas.

The Proposal will result in the operation of three KTPs which have the potential to impact foraging, sheltering and breeding habitat for Littlejohn's Tree Frog. While good quality habitat occurs throughout the Locality and it is unlikely that the habitat in the Study Area would be isolated or fragmented from the surrounding area in a broad sense (i.e. vegetation would not be cleared), the loss of known breeding sites may reduce the immediate reproductive ability of the species in the local areas of impact. Specific climatic breeding requirements and conditions for reproduction suggest a low and intermittent recruitment rate for Littlejohn's Tree Frog. The populations in the Study Area should be considered important populations and known breeding sites should be treated as a high conservation priority. Furthermore, the DEC (2005Ž) made the recommendation that "Longwall mining under the Woronora Plateau must not result in the draining of Upland Swamps which appear to be of importance to Littlejohn's Tree Frog". However, it should be noted that the draining of monitored Upland Swamps as a result of recent mining has not been observed and is not predicted for the Proposal. The numbers recorded in the Study Area possibly constitute the largest known population of Littlejohn's Tree Frog recorded to date. Given all of the above and the scattered nature of the known breeding populations outside the Locality; it is considered **likely** that the Proposal will result in a significant impact to one or more local populations of Littlejohn's Tree Frog.

Giant Burrowing Frog	*Heleioporus australiacus*

The Giant Burrowing Frog is listed as Vulnerable on Schedule 2 of the TSC Act and Vulnerable on the EPBC Act.

The Giant Burrowing Frog prefers hanging swamps on sandstone shelves adjacent to perennial non-flooding creeks (Daly 1996a, Rescei 1997). It can also occur within shale outcrops within sandstone formations. In the southern part of its range the Giant Burrowing Frog can occur in wet and dry forests, montane sclerophyll woodland and montane riparian woodland (Daly 1996a). Individuals can be found around sandy creek banks or foraging along ridge-tops during or directly after heavy rain. Their diet includes ground-dwelling invertebrates such as ants, beetles and spiders. Males often call from burrows located in sandy banks next to water (Barker *et al.* 1995).

Two individuals of the Giant Burrowing Frog were recorded during the current surveys; one along Donald's Castle Creek where Sandstone Gully Peppermint Forest and Upland Swamp Sedgeland Heath Complex occur (on the border of DA3B and DA3C); and one on a ridge line of Exposed Sandstone Scribbly Gum Woodland within the Donald's Castle Creek Catchment (in DA3C). Biosis

Research has also recorded the species during monitoring surveys along two creek lines (Banksia Creek and SC10C) within Upland Swamp habitat in DA3A. Other plant communities that may provide potential habitat include Upland Swamp Banksia Thicket, Upland Swamp Fringing Eucalypt Woodland, Upland Swamp Tea-tree Thicket, Rock Plate Heath-Mallee, Tall Open Peppermint-Blue Gum Forest, Nepean Sandstone Gully Forest and Moist Gully Gum Forest.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Giant Burrowing Frog generally lives in heath or forest and will travel several hundred metres to creeks to breed (DEC 2005r). They burrow into deep litter or loose soil, emerging to feed or breed after rain. The species breeds from August to March and the eggs are laid in a white foam-mass under vegetation in creeks or in yabby holes (DEC 2005r).

The Giant Burrowing Frog has been recorded within the Study Area during the current and previous Biosis Research surveys. Multiple records also occur within 10 km of the Study Area (including the Locality). The species is possibly moderately common within areas of suitable habitat in the Study Area and Locality. However, the species' cryptic behaviour makes it difficult to estimate abundance. Populations within the Study Area have been determined by the species' presence within the different catchments and include the Sandy Creek Catchment and Donald's Castle Creek Catchment populations. Known and potential habitat for this species occurs in the Study Area within woodland, forest and Upland Swamp plant communities which contain suitable foraging, sheltering and breeding resources (e.g. creeks, drainage ponds, and ridge top structures containing water).

The area of known and potential habitat for the Giant Burrowing Frog that may be impacted as a result of subsidence includes creek lines, rock outcrops and Upland Swamps (see Section 9.2.1 summary of impacts). These habitats provide foraging, sheltering and breeding resources for the Giant Burrowing Frog. Wongawilli and Sandy Creeks will not be mined beneath, so potential impacts will be minimised in these areas. However, other creeks and tributaries, rocky ridges and Upland Swamps will be directly mined beneath and are expected to be subjected to the full range of predicted systematic subsidence and valley related movements (MSEC 2007). Whilst subsidence impacts are possible for each watercourse, ridge line and Upland Swamp occurring in the Study Area (particularly those directly above the longwalls), it is unlikely that all would be impacted by the Proposal.

Direct impacts on the Giant Burrowing Frog (individuals and populations) are possible and it is likely this impact would be to breeding and sheltering habitat. The species has been recorded within the Study Area in creek lines occurring within forest/woodland and/or adjacent to Upland Swamps (e.g. Banksia Creek, SC10C Creek, Donald's Castle Creek and Upland Swamps 15a and 15b), and on a ridge line within the Donald's Castle Creek Catchment. All of these sites are to be mined beneath either wholly or partially. The loss of surface flow and deep pools from creek lines, changes to water flow regimes and water quality, and any hydrological changes to Upland Swamps are likely to impact on the life cycle of the species. The draining of a breeding pool containing the eggs, tadpoles or metamorphs of the Giant Burrowing Frog would likely result in the loss of an generation of recruits for that creek line pool or local population.

In addition to disturbance of breeding habitat, subsidence may impact on non-breeding sheltering sites such as ridge lines and rocky outcrops. Rockfalls and overhang collapse (predicted to be less than 7 to 10 per cent of the total length of cliff line to be mined directly beneath (MSEC 2007) may lead to the loss of individuals. Fracturing of the sandstone may result in cracks forming on the ridge lines. These cracks may vary in size and depth and can become potential fauna traps.

Indirect impacts are also possible on the Giant Burrowing Frog. For example, fracturing of a creek line directly above a longwall, particularly where there is exposed bedrock (which is the case for many creek lines within the Study Area), can lead to the loss of surface water into the dilated strata beneath. This loss of water above a longwall can lead to loss of water and reduced water quality downstream of the fracture, even where the creek line does not occur directly above a longwall. This effect has been observed to a maximum of approximately 800m downstream (Ecoengineers 2007) from where large creeks were mined under directly by a number of longwalls (Native Dog and Wongawilli Creeks by Elouera Colliery). In the case of Wongawilli and Sandy Creeks would not be mined under directly and these downstream effects are likely to be much less.

There is also some possibility for the Giant Burrowing Frog to be indirectly impacted by the Proposal due to Chytrid Fungus. Whilst the infection or spread of the disease is unlikely to be exacerbated by the Proposal, if the fungus is present in frog populations within the Study Area (the disease is known to occur in Dendrobium Area 1 adjacent to the Study Area), these populations may be rendered more susceptible to other threatening processes (NSW Scientific Committee 2003a) such as loss and degradation of habitat (e.g. loss of breeding pools, changes to natural flow regimes, reduced water quality).

Whilst the extent of Wongawilli and Sandy Creek within the Study Area are less likely to be significantly impacted by the Proposal, minor and isolated impacts (fracturing and loss of surface water) are still expected (MSEC 2007). The Giant

Burrowing Frog has been recorded at a main creek line, Donald's Castle Creek which possibly provides a movement corridor for the species. The species has also been recorded within the tributaries of Sandy Creek which are expected to be subjected to the full range of predicted systematic subsidence and valley related movements (MSEC 2007). The species requires specific breeding conditions (e.g. only breeds after heavy rain) and has been recorded within the Study Area. The loss of breeding habitat and possible population recruitments by predicted subsidence events (should such events occur where the species is present) is likely to cause disruption to the life cycle of one or more local populations within the Study Area to the extent that at that location they may be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, no population of the Giant Burrowing Frog is listed as an Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Known and potential habitat for the Giant Burrowing Frog occurs in Sandstone Gully Peppermint Forest, Upland Swamp Sedgeland Heath Complex, Upland Swamp Fringing Eucalypt Woodland, Exposed Sandstone Scribbly Gum Woodland, Tall Open Peppermint-Blue Gum Forest, Upland Swamp Banksia Thicket, Upland Swamp Tea-tree Thicket, Rock Plate Heath-Mallee, Nepean Sandstone Gully Forest and Moist Gully Gum Forest plant communities within the Study Area where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of these plant communities, is considered potential habitat for the species.

- The Study Area contains approximately 3,243 ha of woodland, forest and Upland Swamp habitat for this species;
- Specifically, habitats including streams with sandy banks, deep pools, Upland Swamps and rocky outcrops are likely to be important for the species within the Study Area;
- Subsidence has the potential to alter a proportion of these habitat features within the Study Area though it is highly unlikely that all of this habitat within the Study Area would be impacted;
- These habitats are widely distributed within the Locality (approximately 20,305 ha). The known and/or potential habitat for the Giant Burrowing Frog in the Study Area represents 15.9 per cent of potential habitat within the Locality; and
- Section 9.2.1 of the SIS details the “predicted” impacts of subsidence on these habitat types.

The Giant Burrowing Frog generally lives in heath or forest and will travel several hundred metres to creeks to breed (DEC 2005r). While the Proposal is unlikely to fragment or isolate woodland or forest habitat in the Study Area from the surrounding area, any hydrological changes to Upland Swamps or the loss of/alteration to surface flow at creek lines may isolate and reduce the number of breeding sites and hence require larger travelling distances for the Giant Burrowing Frog.

The habitat within the Study Area is of good quality for the Giant Burrowing Frog and previous surveys conducted by Biosis Research within the Locality indicate that the habitat outside the area to be impacted (by the current Proposal) is of similar quality. While woodland and forest plant communities that could provide potential habitat for the species are continuous throughout the Locality, Upland Swamps and suitable creek lines occur more infrequently. The Giant Burrowing Frog is considered to be an "uncommon resident" within the Greater Southern Sydney Region, with the catchment lands of the Woronora Plateau and Royal NP considered to be "of extreme importance to the overall survival of the Giant Burrowing Frog" and the protection of Upland Swamps is considered "paramount to the survival of this frog in the region" (DEC 2005Ž). The species is cryptic and difficult to detect, however, it has been recorded within the Study Area. Whilst the species has only been record in low numbers, this is quite possibly due to its cryptic nature and restricted access to the Metropolitan Special Area during wet weather (when the species is most active). The habitat within the Study Area is of very high importance to the long-term survival of the species in the Locality as it supports known populations of the Giant Burrowing Frog.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Giant Burrowing Frog (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is currently no recovery plan for the Giant Burrowing Frog. However, the DECC has prepared 24 Priority Actions to help recover this species. Those relevant to the Proposal include:

- Develop best practice management strategies that buffer and protect important breeding sites from changes to water flow, flow regimes and water quality changes – subsidence has the potential to impact on water flow and water quality of breeding sites for the Giant Burrowing Frog; and
- Investigate methods of ameliorating or attenuating Chytrid action –

appropriate gear and vehicle washdown procedures should be followed at all times.

There is currently no NSW threat abatement plan for the Giant Burrowing Frog, but the species is considered in the Commonwealth threat abatement plan ‘Infection of amphibians with Chytrid Fungus resulting in chytridiomycosis’. The plan states that archived specimens of Giant Burrowing Frog have tested positive for Chytrid Fungus (DEH 2006). The aim of the threat abatement plan is to reduce the impacts of the KTP ‘Infection of frogs by amphibian Chytrid causing the disease chytridiomycosis’ to maximise the chances of the long-term survival of affected species, particularly listed threatened species.

The current Proposal is unlikely to exacerbate the infection or spread of Chytrid Fungus however, if the fungus is present in frog populations within the Study Area (the disease is known to occur in Dendrobium Area 1 adjacent to the Study Area), these populations may be rendered more susceptible to other threatening processes such as loss and degradation of habitat (NSW Scientific Committee 2003a).

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Giant Burrowing Frog include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – known and potential habitat for the Giant Burrowing Frog occurs within creek lines with sandy soils, ridge lines and Upland Swamps; all of which are known and/or may be be vulnerable to the effects of subsidence;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – Giant Burrowing Frogs require first or second order creeks and ponded drainage lines for breeding. Loss of water or changes to flow patterns could impact on the species; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Giant Burrowing Frog.

Conclusion

The Giant Burrowing Frog has been previously recorded both within the Study Area and the Locality, including two records made during the current surveys in the Study Area. Known and potential habitat for this species occurs within creek lines, ridge lines and Upland Swamps surrounded by woodland and/or forest communities. The Proposal has the potential to impact the Giant Burrowing Frog through alteration of known and potential foraging, sheltering and breeding habitat, including any hydrological changes to Upland Swamps, draining of creeks and rockfalls. The disturbance to, loss of, fragmentation and isolation of breeding (creek lines and Upland Swamps) and sheltering (rocky ridge lines and burrows within sandy banks) sites by subsidence-related events is likely to impact on the reproductive and dispersal viability of the Giant Burrowing Frog.

The Proposal will result in the operation of three KTPs which have the potential to impact foraging, sheltering and breeding habitat for the Giant Burrowing Frog. While good quality habitat occurs throughout the Locality and it is unlikely that the habitat in the Study Area would be isolated or fragmented from the surrounding area in a broad sense (i.e. vegetation would not be cleared), the loss of breeding sites may reduce the immediate reproductive ability of the species. Specific climatic breeding requirements (e.g. heavy rain) and conditions (e.g. deep pools) for reproduction suggest a low and intermittent recruitment rate for the Giant Burrowing Frog. The populations in the Study Area should be considered important populations and breeding sites (particularly Upland Swamps) should be treated as a high conservation priority. The DEC made the recommendation that "Longwall mining under the Woronora Plateau must not result in the draining or disturbance of swamps" (DEC 2005Ž) in relation to the Giant Burrowing Frog. The draining of Upland Swamps has not been observed in swamps monitored during recent mining and is not predicted for the Proposal, although, hydrological changes may occur. Given all of the above and the localised nature of the known breeding populations outside the Locality; it is considered **likely** that the Proposal will result in a significant impact to one or more local populations of the Giant Burrowing Frog.

Stuttering Frog	***Mixophyes balbus***

The Stuttering Frog is listed as Endangered on Schedule 1 of the TSC Act and as Vulnerable on the EPBC Act.

The Stuttering Frog is usually associated with mountain streams, wet mountain forests and rainforests (Barker *et al.* 1995). It rarely wanders very far from the banks of permanent forest streams, although it will forage on nearby forest floors. They feed on insects and smaller frogs (DEC 2005‹). They forage amongst understorey and leaf litter within 500 metres of breeding habitat, sheltering amongst ground litter, ground logs or burrows (DEC 2005‹).

The Stuttering Frog has not been recorded within the Study Area or within a 10 km radius of the Study Area. The closest records occur approximately 18 km south-west of the Study Area and were recorded in the year 2000 (Bionet). Potential habitat is considered to be within Coachwood Warm Temperate Rainforest in the Study Area. This habitat type contains suitable foraging habitat and forest streams which provide potential breeding habitat for the Stuttering Frog.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Stuttering Frog breeds in streams during summer after heavy rain (DEC 2005‹). Eggs are deposited in leaf litter on the banks of streams to be washed into the water during heavy rains (Barker *et al.* 1995) or on rock shelves or shallow riffles in small, flowing streams (DEC 2005‹). As the tadpoles grow they move to deep permanent pools and take approximately 12 months to metamorphose (DEC 2005‹). Outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor (DEC 2005‹).

The Stuttering Frog has not been recorded within the Study Area or Locality. The Stuttering Frog is considered to be an “extremely rare resident” within the Greater Southern Sydney Region (DEC 2005Ž). Potential habitat for this species occurs within the rainforest habitat of the Study Area, which essentially occurs in two areas: a section of Wongawilli Creek (in DA3B) and Sandy Creek (in DA3A) and their associated tributaries. The area of potential habitat for the Stuttering Frog that may be impacted as a result of subsidence includes creek lines and riparian vegetation (see Section 9.2.1 summary of impacts). These habitats provide foraging, sheltering and breeding resources for the Stuttering Frog. Wongawilli and Sandy Creek will not be mined beneath, so potential impacts will be minimised in these areas. However, other creeks and tributaries of Wongawilly and Sandy Creeks will be directly mined beneath and are expected to be subjected to the full range of predicted systematic subsidence and valley related movements (MSEC 2007). Whilst subsidence impacts are possible for each watercourse occurring in the Study Area (particularly those directly above the longwalls), it is unlikely that all would be impacted by the Proposal.

Direct impacts on the Stuttering Frog (if present) are possible and are most likely to be a result of impact to breeding habitat. Potential breeding habitat (permanent, flowing, rocky streams with deep pools and deep leaf litter on the forest floor) may be impacted by the Proposal by an increase in localised ponding, flooding, scouring of the banks, creek bed fracturing and loss of surface water and pools (MSEC 2007). As Wongawilli and Sandy Creeks (where potential breeding habitat for the Stuttering Frog occurs) will not be directly mined beneath, such impacts are predicted to be minor and isolated. However, the potential habitat for the stuttering Frog is very limited within the Study Area and if the species is present, any impacts are likely to have a significant impact on the life cycle of the species. The draining of a breeding pool containing the eggs, tadpoles or metamorphs of the Stuttering Frog would likely result in the loss of an entire generation of recruits for the local population.

Indirect impacts are also possible on the Stuttering Frog. For example, fracturing of a creek line directly above a longwall, particularly where there is exposed bedrock (which is the case for many creek lines within the Study Area), can lead to the loss of surface water into the dilated strata beneath. This loss of water above a longwall can lead to loss of water and reduced water quality downstream of the fracture, even where the creek line does not occur directly above a longwall. This effect has been observed to a maximum of approximately 800m downstream (Ecoengineers 2007) from where large creeks were mined under directly by a number of longwalls (Native Dog and Wongawilli Creeks by Elouera Colliery). In the case of Dendrobium Area 3 Wongawilli and Sandy Creek will not be mined beneath directly and these downstream effects are likely to be much less.

There is also some possibility for the Stuttering Frog to be indirectly impacted by the Proposal due to Chytrid Fungus. Whilst the infection or spread of the disease is unlikely to be exacerbated by the Proposal, if the fungus is present in frog populations within the Study Area (the disease is known to occur in Dendrobium Area 1 adjacent to the Study Area), these populations may be rendered more susceptible to other threatening processes (NSW Scientific Committee 2003a) such as loss and degradation of habitat (e.g. loss of breeding pools, changes to natural flow regimes, reduced water quality).

The Stuttering Frog appears to be localised and restricted to the immediate vicinity (within 500 m) of its breeding habitat (DEC 2005‹), hence recruitment and re-colonisation of areas of vacant habitat is thought to be low. The Stuttering Frog follows an opportunistic reproductive strategy reliant on rainfall and deep permanent pools for tadpole development. Their restricted mobility and limited potential habitat within the Study Area combined with a low rate of recruitment suggests any impact to this species' life cycle is likely to have a significant effect on a local population, if present. It is likely that the Proposal would place a viable local population of the Stuttering Frog, if present, at risk of local extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, no population of the Stuttering Frog is listed as an Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- **i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
- **ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

- **i. the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**
- **ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- **iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

The Stuttering Frog has not been recorded in the Study Area however, potential habitat for this species occurs within the Coachwood Warm Temperate Rainforest community where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of this plant community, is considered potential habitat for the species.

- The Study Area contains approximately 15.6 ha of rainforest habitat for this species;
- Specifically, habitats including permanent flowing streams, rock shelves and shallow riffles, deep pools, and dense leaf litter are likely to be important for the species within the Study Area;
- Subsidence has the potential to alter a proportion of these habitat features within the Study Area though it is highly unlikely that all of this habitat within the Study Area would be impacted;
- Rainforest habitat is distributed within the Locality (approximately 778 ha). The potential habitat for the Stuttering Frog in the Study Area represents 2 per cent of potential habitat within the Locality; and
- Section 9.2.1 of the SIS details the “predicted” impacts of subsidence on these habitat types.

While it is unlikely that the rainforest plant community would be isolated or fragmented from the surrounding forest/woodland, the Stuttering Frog is relatively localised, specific to rainforest habitat and is not likely to travel across large areas for dispersal. Thus fragmentation even on a small scale (e.g. through the drying of a stream) coupled with the lack of adjoining rainforest habitat in the Study Area, is likely to impact on the movement and viability of this species at the local area.

The habitat within the Study Area is of good quality for the Stuttering Frog although it is limited. Previous surveys conducted by Biosis Research within the Locality (e.g. Dendrobium Area 1 fauna monitoring sites) indicate that the habitat outside the area to be impacted (by the current Proposal) is of similar quality. However, having said that, Biosis Research has not recorded any Stuttering Frogs in or near the Study Area during any previous surveys (e.g. long-term monitoring). While rainforest that could provide potential habitat for the species occurs in the Locality, suitable rainforest streams and deep pools may be limited. Given the restricted mobility of the species, low rate of recruitment and specific breeding and foraging requirements, and that the Stuttering Frog is considered to be an “extremely rare resident” within the Greater Southern Sydney Region (DEC 2005Ž), if the Stuttering Frog is present in the Study Area, it could indicate highly important habitat for the species’ persistence in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Stuttering Frog (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is currently no recovery plan for the Stuttering Frog. However, the DECC suggests a number of recovery strategies to help recover this species. Those relevant to the Proposal include:

- Maintain natural stream channel morphology and flows – subsidence has the potential to impact on water flow and water quality of potential habitat for the Stuttering Frog;
- Retain riparian native vegetation – subsidence has limited potential to impact riparian vegetation by gas emissions and water loss, although, such impacts are predicted to be unlikely and/or insignificant; and
- Investigate methods of ameliorating or attenuating Chytrid action – appropriate gear and vehicle washdown procedures should be followed at all times.

There is currently no NSW threat abatement plan for the Stuttering Frog, but the species is considered in the Commonwealth threat abatement plan ‘Infection of amphibians with Chytrid Fungus resulting in chytridiomycosis’. The plan states that Chytrid Fungus is endemic in Stuttering Frog populations in NSW (DEH 2006). The aim of the threat abatement plan is to reduce the impacts of the KTP ‘Infection of frogs by amphibian Chytrid causing the disease chytridiomycosis’ (NSW Scientific Committee 2003a) to maximise the chances of the long-term survival of affected species, particularly listed threatened species.

The current Proposal is unlikely to exacerbate the infection or spread of Chytrid Fungus however, if the fungus is present in frog populations within the Study Area (the disease is known to occur in Dendrobium Area 1 adjacent to the Study Area), these populations may be rendered more susceptible to other threatening processes such as loss and degradation of habitat (NSW Scientific Committee 2003a).

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Stuttering Frog include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – potential habitat for the Stuttering Frog occurs within rainforest creek lines in the Study Area. Creek lines are known to be vulnerable to the effects of subsidence;
- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Stuttering Frog requires permanent, flowing streams with deep pools for breeding. Loss of water or changes to flow patterns could impact on the species; and
- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Stuttering Frog.

Conclusion

The Stuttering Frog has not been recorded within the Study Area or Locality. Potential habitat for this species occurs within Coachwood Warm Temperate Rainforest in the Study Area particularly within 500 metres of forest streams. The Proposal has the potential to impact the Stuttering Frog through alteration of potential foraging, sheltering and breeding habitat, including the draining of streams and pools and alteration to water flow (should such impacts occur where the species is present). The disturbance to, loss of, fragmentation and isolation of breeding and sheltering sites by subsidence-related events (such as creek bed fractures, loss of surface water and pools and changes to water flows in creeks) is likely to impact on the local reproductive and dispersal viability of the Stuttering Frog, if present.

The Proposal will result in the operation of three KTPs which have the potential to impact foraging, sheltering and breeding habitat for the Stuttering Frog. While good quality rainforest habitat occurs within the Locality and it is unlikely that the habitat in the Study Area would be isolated or fragmented from the surrounding area in a broad sense (i.e. vegetation would not be cleared), the loss of breeding sites and connection between areas of potential habitat may reduce the immediate reproductive ability of the species. Specific climatic breeding requirements (e.g. heavy rain) and conditions (e.g. deep pools) for reproduction suggest a low and intermittent recruitment rate for the Stuttering Frog. Locally, the Stuttering Frog is close to extinction and if present within the Study Area, any populations of the species should be considered “critical to the survival of the species across its range” (DEC 2005Ž). Given all of the above and the lack of current known breeding populations within and outside the Locality; it is considered **likely** that the Proposal will result in a significant impact to one or more local populations of the Stuttering Frog, if present.

Red-crowned Toadlet	***Pseudophryne australis***

The Red-crowned Toadlet is listed as Vulnerable on Schedule 2 of the TSC Act.

The Red-crowned Toadlet occurs on wetter ridge tops and upper slopes of sandstone formations on which the predominant vegetation is dry open forests and heaths. This species typically breeds within small ephemeral creeks that feed into larger semi-perennial streams. These creeks are characterised after rain by a series of shallow pools lined with dense grasses, ferns and low shrubs (Thumm and Mahony 1996, Thumm and Mahoney 1997). The Red-crowned Toadlet disperses outside the breeding period to shelter under rocks and logs on sandstone ridges and to forage amongst leaf-litter (DEC 2005„).

Approximately 25 observations of the Red-crowned Toadlet were recorded during the current surveys across five different sites occurring within Sandstone Gully Peppermint Forest, Tall Open Peppermint-Blue Gum Forest and Upland Swamp Sedgeland Heath Complex. The sites where the species was recorded include LC8, WC21, SC10C, Upland Swamp 10 and an unnamed drainage line near Upland Swamp 15b. These sites occur within DA3A, DA3B and DA3C. Biosis Research has also recorded the species during monitoring surveys along drainage line SC10C and a second, unnamed drainage line (both Sandstone Gully Peppermint Forest) adjacent to Upland Swamp 15b (Upland Swamp Sedgeland Heath Complex) within the Study Area, as well as within the Locality (on ridge lines). Other plant communities that may provide potential habitat include Exposed Scribbly Gum Woodland, Upland Swamp Banksia Thicket, Upland Swamp Fringing Eucalypt Woodland, Upland Swamp Tea-tree Thicket, Rock Plate Heath-Mallee, Moist Gully Gum Forest and Nepean Sandstone Gully Forest. These habitat types contain finer scale features such as ephemeral streams and soak areas hence possible breeding habitat for the Red-crowned Toadlet.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Red-crowned Toadlet forms breeding congregations in dense vegetation and debris beside ephemeral creeks and gutters. Eggs are laid in moist leaf litter, from where they are washed by heavy rain; a large proportion of the development of the tadpoles takes place in the egg (DEC 2005„). Individuals disperse outside the breeding period, when they are found under rocks and logs on sandstone ridges and foraging amongst leaf-litter.

The Red-crowned Toadlet was recorded within the Study Area during the current surveys and has been previously recorded within the Locality by Biosis Research. Potential habitat for this species occurs within the woodland, forest and Upland Swamp habitats particularly on ridges and in ephemeral drainage lines.

The area of known and potential habitat for the Red-crowned Toadlet that may be impacted as a result of subsidence includes creek lines, riparian vegetation, rocky ridges and slopes, and Upland Swamps (see Section 9.2.1 summary of impacts). These habitats provide foraging, sheltering and breeding resources for the Red-crowned Toadlet. Wongawilli and Sandy Creek will not be mined beneath, so potential impacts will be minimised in these areas. However, other creeks and tributaries of Wongawilli and Sandy Creeks, rocky ridges and Upland Swamps will be directly mined beneath and are expected to be subjected to the full range of predicted systematic subsidence and valley related movements (MSEC 2007). Whilst subsidence impacts are possible for each watercourse, ridge line and Upland Swamp occurring in the Study Area (particularly those directly above the longwalls), it is unlikely that all would be impacted by the Proposal.

Direct impacts on the Red-crowned Toadlet (individuals and populations) are possible and are likely to impact breeding, sheltering and foraging habitat. The species has been recorded within the Study Area in creek lines and Upland Swamps occurring within forest/woodland usually with a rocky ridge or slope nearby (e.g. LC8, WC21, SC10C, Upland Swamp 10 and an unnamed drainage line near Upland Swamp 15b). All of these sites are to be mined beneath either wholly or partially. Changes to water flow regimes and water quality, any hydrological changes to Upland Swamps, rockfalls, and to a lesser extent, loss of surface flow (as the species is generally accustomed to ephemeral waterways) is likely to impact on the life cycle of the species. The draining of an ephemeral creek or drainage line containing the eggs, tadpoles or metamorphs of the Red-crowned Toadlet would likely result in the loss of an entire generation of recruits for that creek line or local population.

In addition to the above disturbances, fracturing of the sandstone may result in cracks forming on the ridge lines. These cracks may vary in size and depth and can become potential fauna traps.

Indirect impacts are also possible on the Red-crowned Toadlet. For example, fracturing of a creek line directly above a longwall, particularly where there is exposed bedrock (which is the case for many creek lines within the Study Area), can lead to the loss of surface water into the dilated strata beneath. This loss of water above a longwall can lead to loss of water and reduced water quality downstream of the fracture, even where the creek line does not occur directly above a longwall. This effect has been observed to a maximum of approximately 800m downstream (Ecoengineers 2007) from where large creeks were mined under directly by a number of longwalls (Native Dog and Wongawilli Creeks by Elouera Colliery). In the case of Dendrobium Area 3 these major creeklines would not be mined under directly and these downstream effects are likely to be much less.

There is also some possibility for the Red-crowned Toadlet to be indirectly impacted by the Proposal due to Chytrid Fungus. Whilst the infection or spread of the disease is unlikely to be exacerbated by the Proposal, if the fungus is present in frog populations within the Study Area (the disease is known to occur in Dendrobium Area 1 adjacent to the Study Area), these populations may be rendered more susceptible to other threatening processes (NSW Scientific Committee 2003a) such as loss and degradation of habitat (e.g. loss of breeding pools, changes to natural flow regimes, reduced water quality).

Whilst the extent of Wongawilli and Sandy Creek within the Study Area are less likely to be significantly impacted by the Proposal, minor and isolated impacts (fracturing and loss of surface water) are still expected (MSEC 2007). The Red-crowned Toadlet has not been recorded at any of the main creek lines however, the species has been recorded within the tributaries of these and other creek lines and Upland Swamps, which are expected to be subjected to the full range of predicted systematic subsidence and valley related movements (MSEC 2007). The species follows an opportunistic reproductive strategy and requires specific breeding conditions for egg laying and tadpole development. Red-crowned Toadlets are considered to be localised and restricted to the immediate vicinity of their breeding habitat, hence recruitment and re-colonisation of areas of vacant habitat is thought to be low (DEC 2005*f*). The Red-crowned Toadlet has been recorded in reasonable numbers within the Study Area. The loss of known breeding habitat and possible population recruitments by predicted subsidence events (should such events occur where the species is present) is likely to cause disruption to the life cycle of one or more local populations within the Study Area to the extent that they may be placed at risk of local extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, no population of the Red-crowned Toadlet is listed as Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Known and potential habitat for the Red-crowned Toadlet occurs in Sandstone Gully Peppermint Forest, Tall Open Peppermint-Blue Gum Forest, Upland Swamp Sedgeland Heath Complex, Exposed Sandstone Scribbly Gum Woodland, Upland Swamp Banksia Thicket, Upland Swamp Fringing Eucalypt Woodland, Upland Swamp Tea-tree Thicket, Rock Plate Heath-Mallee, Nepean

Sandstone Gully Forest and Moist Gully Gum Forest plant communities within the Study Area where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of these communities, is considered potential habitat for the species.

- The Study Area contains approximately 3,243 ha of woodland, forest and Upland Swamp habitat for this species;
- Specifically, habitats including ephemeral drainage lines and soaks, Upland Swamps and rocky ridges and slopes are likely to be important for the species within the Study Area;
- Subsidence has the potential to alter a proportion of these habitat features within the Study Area though it is highly unlikely that all of this habitat within the Study Area would be impacted;
- These habitats are widely distributed within the Locality (approximately 20,305 ha). The known and/or potential habitat for Littlejohn's Tree Frog in the Study Area represents 15.9 per cent of potential habitat within the Locality; and
- Section 9.2.1 of the SIS details the "predicted" impacts of subsidence on these habitat types.

While the Proposal is unlikely to fragment or isolate woodland or forest habitat in the Study Area from the surrounding area, the Red-crowned Toadlet is relatively localised and is not likely to travel across large areas for dispersal. Thus fragmentation even on a small scale through any hydrological changes to Upland Swamps, draining of a creek line, or the loss of or disturbance to suitable adjacent habitat, is likely to impact on the movement and viability of this species.

The habitat within the Study Area is of good quality for the Red-crowned Toadlet and previous surveys conducted by Biosis Research within the Locality indicate that the habitat outside the area to be impacted (by the current Proposal) is of similar quality. While woodland and forest plant communities that could provide potential habitat for the species are continuous throughout the Locality, Upland Swamps and suitable ephemeral creek lines and soaks may occur more infrequently. The Red-crowned Toadlet is considered to be a "locally common resident" within the Greater Southern Sydney Region (DEC 2005Ž). The catchment lands of the Woronora Plateau, where the Locality is situated, have been identified as being of "extreme importance to the overall survival of the Red-crowned Toadlet" and it is considered that "any future declines from this stronghold will jeopardise the survival of the species as a whole" (DEC 2005Ž). Therefore, given the above and the species' restricted mobility, low rate of recruitment, specific breeding requirements and known occurrence within the

Study Area, the habitat within the Study Area is considered to be of very high importance to the long-term survival of the species in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Red-crowned Toadlet (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is currently no recovery plan or threat abatement plan for the Red-crowned Toadlet. However, the DECC has prepared 14 Priority Actions to help recover this species. Those relevant to the Proposal are outlined below.

- Retain and protect habitat and buffers around habitat, particularly vegetation on upper slopes and ridges – subsidence may impact on potential habitat such as Upland Swamps and rocky slopes;
- Develop best practice management strategies that buffer and protect important headwater/ridge top breeding sites from changes to water flow, flow regimes and water quality changes – subsidence has the potential to impact on water flow and water quality of breeding sites for the Red-crowned Toadlet; and
- Investigate methods of ameliorating or attenuating Chytrid action – appropriate gear and vehicle washdown procedures should be followed at all times.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Red-crowned Toadlet include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – known and potential habitat for the Red-crowned Toadlet occurs within Upland Swamps, ephemeral creek lines and rocky slopes; all of which are known and/or may be vulnerable to the effects of subsidence;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – Red-crowned Toadlets prefer ephemeral creeks and drainage lines for breeding. Loss of water or changes to flow patterns could impact on the species; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Red-crowned Toadlet.

Conclusion

The Red-crowned Toadlet was recorded approximately 25 times within the Study Area during the current surveys and the species has also been previously recorded within the Locality. Potential habitat for this species occurs within the woodland, forest and Upland Swamp habitats particularly on ridges and in ephemeral drainage lines. The Proposal has the potential to impact the Red-crowned Toadlet through alteration of known and potential foraging, sheltering and breeding habitat, including the draining of creeks and ephemeral drainage lines, any hydrological changes to Upland Swamps and rockfalls. The disturbance to, loss of, fragmentation and isolation of breeding (ephemeral creek and drainage lines and Upland Swamps) and sheltering (rocky ridge lines and slopes) sites by subsidence-related events Upland Swamp is likely to impact on the reproductive and dispersal viability of the Red-crowned Toadlet.

The Proposal will result in the operation of three KTPs which have the potential to impact foraging, sheltering and breeding habitat for the Red-crowned Toadlet. While good quality habitat occurs throughout the Locality and it is unlikely that the habitat in the Study Area would be isolated or fragmented from the surrounding area in a broad sense (i.e. vegetation would not be cleared), the Red-crowned Toadlet is relatively localised and is not likely to travel across large areas for dispersal. In addition, their specific breeding requirements, dependence on ephemeral feeder channels for development and restricted mobility indicate changes to known or potential habitat would have a detrimental impact on the life cycle of the species. Given all of the above and the importance of the species’ “stronghold” (DEC 2005Ž) within the Study Area and Locality, it is considered **likely** the Proposal would have a significant impact on one or more local populations of the Red-crowned Toadlet.

Eastern Pygmy-possum	*Cercartetus nanus*

The Eastern Pygmy-possum is listed as Vulnerable on Schedule 2 of the TSC Act.

The Eastern Pygmy-possum is found in a range of habitats from rainforest through sclerophyll forest and woodland to heath. In most areas woodlands and heath appear to be preferred habitat. They forage along escarpments and gullies within woodlands, heath and forests containing Banksias or other Proteaceous or Myrtaceous shrubs, feeding largely on nectar and pollen. Insects and soft fruits are eaten when flowers are less available. Although the Eastern Pygmy-possum is broadly widespread, within its range the species appears to be patchily distributed and its overall abundance is low.

Eastern Pygmy-possums will often nest and shelter in tree hollows, rotten stumps, holes in the ground, abandoned bird-nests, Common Ringtail Possum (*Pseudocheirus peregrinus*) dreys, or thickets of vegetation (e.g. grass-tree skirts) and they can also construct their own nest (Turner and Ward 1995). Because of its small size, the species is able to utilise a range of hollow sizes including very small hollows (Gibbons and Lindenmayer 1997). The species appears to be mainly solitary, each individual using several nests, with males having non-exclusive home-ranges of about 0.68 hectares and females about 0.35 hectares (DECC Threatened Species Unit). Young can be born whenever food sources are readily available, with most births occurring between late spring and early autumn.

The Eastern Pygmy-possum has been previously recorded by Biosis Research on four separate occasions: twice along a creek line and twice within Upland Swamp habitat. Further potential habitat in the Study Area occurs within woodland, gully forest, rainforest and heath-mallee habitats, particularly where Banksia species are present. There are also records of the Eastern Pygmy-possum within the Locality (DECC Atlas of NSW Wildlife).

Potential habitat for the Eastern Pygmy-possum occurs within the Study Area in the ridgetop woodland (Exposed Sandstone Scribbly Gum Woodland), gully forest (Sandstone Gully Peppermint Forest, Coachwood Warm Temperate Rainforest, Moist Gully Gum Forest, Tall Open Peppermint-Blue Gum Forest, Nepean Sandstone Gully Forest), heath-mallee (Rock Plate Heath-Mallee), and Upland Swamp (Upland Swamp Banksia Thicket, Upland Swamp Sedgeland Heath Complex, Upland Swamp Fringing Eucalypt Woodland and Upland Swamp Tea-tree Thicket) habitat types. These habitats contain escarpment edge forest, heath and woodland including Proteaceous or Myrtaceous shrubs, which provide foraging habitat for Eastern Pygmy-possums, as well as hollow-bearing trees which the species may use for nesting.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Eastern Pygmy-possum has been previously recorded by Biosis Research in the Study Area.

The Eastern Pygmy-possum utilises a variety of microhabitats for nest construction. Breeding generally takes place from spring to autumn but can occur year round if food resources, especially Banksias, are available (Menkhorst 1995). Similarly, time for development to sexual maturity has been shown to be dependent on food availability (Menkhorst 1995).

The area of known and potential habitat for the Eastern Pygmy-possum that may be impacted as a result of subsidence includes Upland Swamps and riparian vegetation. These habitats provide foraging and breeding resources for the Eastern Pygmy-possum. Although changes to water flow and water quality in Upland Swamps from subsidence are possible, these impacts are considered unlikely, and therefore, changes to vegetation even less likely. Some vegetation immediately surrounding any cracking may die, but the impacts from the loss of this vegetation are considered to be negligible. Gas emissions have the potential to impact riparian vegetation, however, MSEC (2007) consider it unlikely that gas emissions will be a significant issue for Dendrobium Area 3. See summary of impacts (Section 9.2.1 of the SIS) for more details.

The above impacts resulting from subsidence events may lead to a possible reduction in known and/or potential foraging habitat (e.g. Banksias within the riparian and Upland Swamp habitat). Given the extent of potential foraging habitat within the Locality (21,317 ha) and expected low impact on native vegetation from subsidence events associated with the Proposal, it is unlikely that foraging resource would be significantly impacted for this species.

It is unlikely that potential breeding resources (e.g. tree hollows) within the Study Area would be significantly impacted for the Eastern Pygmy-possum. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to result in a significant loss of hollow-bearing trees from the Study Area.

Given the above, the Proposal is not considered likely to impact on the life cycle of the Eastern Pygmy-possum such that a viable local population would be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, no population of the Eastern Pygmy-possum is listed as an Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

The Eastern Pygmy-possum has been previously recorded by Biosis Research on four occasions: twice along a creek line within Sandstone Gully Peppermint Forest and twice within Upland Swamp habitat.

Known and potential habitat for the Eastern Pygmy Possum including Upland

Swamps Banksia Thicket and Upland Swamps Sedgeland Heath Complex are likely to be important for the species within the study area, and further potential habitat occurs within Exposed Sandstone Scribbly Gum Woodland, Upland Swamps Fringing Eucalypt Woodland, Upland Swamps: Tea-tree Thicket, Coachwood Warm Temperate Rainforest, Rock Plate Heath-Mallee, Transitional Shale Stringybark Forest, Moist Gully Gum Forest, Tall Open Peppermint-Blue Gum Forest and Nepean Sandstone Gully Forest plant communities where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of these plant communities, is considered potential habitat for the species.

- The Study Area Contains approximately 3,270 ha of known and/or potential habitat for this species, located within Upland Swamps, ridge lines, creek lines and rainforest;
- Specifically, habitats containing Banksia species are likely to be important for this species;
- Subsidence has the potential to alter a proportion of these habitat features (i.e. Banksia trees) within the study area though it is highly unlikely that all of this habitat within the study area would be impacted;
- These habitats are widely distributed within the Locality (approximately 21,317 ha). The potential habitat for the Eastern Pygmy-possum in the Study Area represents 15.3 per cent of potential habitat within the Locality; and
- Section 9.2.1 of the SIS details the “predicted” impacts of subsidence on these habitat types.

Upland Swamps occur within the Study Area within small stands where appropriate soil, geological and hydrological conditions prevail. Subsidence is unlikely to result in further fragmentation or isolation of Upland Swamp habitats within the Study Area. However, small-scale changes in Upland Swamp vegetation may occur and act as barriers to the Eastern Pygmy-possum. The Eastern Pygmy-possum has a small home range and is unlikely to traverse across long distances due to predation risk. The effects of longwall mining are unlikely to cause significant long-term isolation or fragmentation of the habitat, but may force Eastern Pygmy-possums to make high-risk journeys between patches of high quality habitat. Although this may impact on individuals, it is unlikely to affect entire populations. The woodland and forest habitat types are continuous into the greater Locality and are of similar quality to the habitat within the Study Area; they also will not be fragmented or isolated on a large scale by the Proposal.

The Eastern Pygmy-possum habitat within the Study Area is considered to be in good condition, with finer scale habitat features including Proteaceous and Myrtaceous shrubs, hollow-bearing trees and vegetation thickets that provide shelter and foraging habitat. These habitat features are widely distributed within the Locality and the Proposal is unlikely to affect nesting sites for this species. Genetic exchange within and between populations could be disrupted in some cases, but in most should continue to occur. As the species is considered to be an uncommon resident within the Greater Southern Sydney Region (DEC 2005Ž), yet is known to occur in the Study Area, the habitat is likely to be of high importance to the long-term survival of a local population or populations of the Eastern Pygmy-possum in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Eastern Pygmy-possum (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is currently no threat abatement plan or recovery plan for the Eastern Pygmy-possum. However, the DECC has listed seven Priority Actions to help recover the species. Those relevant to the Proposal include:

- Encourage and support land managers to undertake management actions that benefit the species – the Study Area is zoned 7a Special Environmental Protection (Water Catchment) which enables the long-term protection of habitat and habitat connectivity for this species. Grazing and wood collection are not permitted in this area.

- Conduct field surveys using "Elliott" traps in trees and on the ground and pitfall traps to further delineate distribution and key populations. Avoid periods of cold weather. Areas identified for development should receive high priority – trapping has been undertaken for this species in the Study Area; and

- Protect habitat in development areas and retain linkages across the broader landscape – subsidence has the potential to fragment and isolate areas of known and potential habitat on a small scale, however linkages for fauna movement and genetic exchange will remain in the Study Area.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and/or potential habitat for the Eastern Pygmy-possum include:

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2005a) – subsidence due to longwall mining has the potential to alter the natural flow regimes of watercourses, which could alter riparian vegetation in the Study Area, however, significant changes to vegetation within the swamps are not predicted. The draining of pools within creek lines as a result of subsidence within the Study Area may impact on the species by reducing the amount of potential habitat available to the Eastern Pygmy-possum in the Study Area;

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2002a) – the Eastern Pygmy-possum is often found in Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting is hydrological changes. It is possible that any changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not predicted; and

- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Eastern Pygmy Possum.

Conclusion

The Eastern Pygmy-possum has been recorded within the Study Area and the Locality. Known and potential habitat for the Eastern Pygmy-possum occurs in the woodland, gully forest, rainforest, heath-mallee and Upland Swamp habitats of the Study Area, particularly where Banksia species are present.

Potential impacts of the proposal involve possible alteration to foraging resources within the riparian (gully forest) and Upland Swamp habitats. Given the extent of potential foraging habitat (approximately 21,317 ha) and expected low impact on native vegetation from subsidence events associated with the Proposal, it is unlikely that foraging resource would be significantly impacted for this species.

The Proposal will result in the operation of three KTPs, which have the potential to result in a reduction in food resources for the species. Eastern Pygmy-possums inhabit small home ranges, suggesting they may have difficulty relocating if impacts occur. The Proposal may impact individual Eastern Pygmy-possums by reducing the availability of known and potential habitat for the species and forcing it into high-risk searches for new home ranges. However, this scenario is unlikely to affect an entire population of the species, as impacts on potential or known habitat are expected to be localised. Furthermore, it is unlikely that potential breeding resources (e.g. tree hollows) within the Study Area would be significantly impacted. Based on this information, it is **unlikely** that the Proposal will have a significant impact on any local populations of Eastern Pygmy-possum.

Spotted-tailed Quoll	***Dasyurus maculatus***

The Spotted-tailed Quoll is listed as Vulnerable on Schedule 2 of the TSC Act and as Endangered on the EPBC Act.

Habitat of the Spotted-tailed Quoll includes wet and dry sclerophyll forests, rainforests, woodland, coastal heathland and riparian forest. The Spotted-tailed Quoll consumes a variety of prey, including gliders, possums, small wallabies, rats, birds, bandicoots, rabbits and insects, and will also feed on carrion. Spotted-tailed Quolls are primarily solitary, nocturnal and terrestrial however, they have been seen active by day and are agile climbers. They are a highly mobile species; females occupy home ranges up to 750 ha and males significantly greater up to 3,500 ha (DECC Threatened Species Unit); (Claridge *et al.* 2005). Male home ranges tend to overlap considerably with those of other individuals, while females tend not to overlap with those of other females (Claridge *et al.* 2005). Home range overlap appears to be related to habitat quality, with higher overlap occurring in higher quality environments (Claridge *et al.* 2005). Individuals require large areas of relatively intact vegetation through which to forage, and usually traverse their ranges along densely vegetated creek lines. Den and sheltering resources utilised by the Spotted-tailed Quoll include tree hollows, hollow logs, caves, rock crevices and boulder piles, rocky cliff faces or other animal burrows (NPWS 1999h). Quolls often use multiple den sites within their home range.

Potential foraging habitat and den sites for the Spotted-tailed Quoll occur within the Study Area in woodland and gully forest habitats (within Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Coachwood Warm Temperate Rainforest, Rock Plate Heath-Mallee, Tall Open Peppermint-Blue Gum Forest, Moist Gully Gum Forest and Nepean Sandstone Gully Forest plant communities) and within Upland Swamps (Upland Swamp Banksia Thicket, Upland Swamp Fringing Eucalypt Woodland, Upland Swamp Sedgeland Heath Complex and Upland Swamp Tea-tree Thicket).

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Spotted-tailed Quoll has not been recorded within the Study Area, but has been recorded within the Locality approximately 5 km south-west of the Study Area. Potential habitat for this species occurs within the Study Area in woodland, gully forest and Upland Swamp habitats where hollow logs, rock crevices, caves, an abundance of food, and areas of intact vegetation occurs.

Potential foraging habitat for this species exists within Upland Swamps. Although changes to water flow and water quality in Upland Swamps from subsidence are possible, these impacts are considered unlikely, and therefore, changes to vegetation even less likely. Some vegetation immediately surrounding any cracking may die, but the impacts from the loss of this vegetation are considered to be negligible. Gas emissions have the potential to impact riparian vegetation, however, MSEC (2007) consider it unlikely that gas emissions will be a significant issue for Dendrobium Area 3. See summary of impacts (Section 9.2.1 of the SIS) for more details.

Although rock falls may destroy sheltering habitat (overhangs, caves, crevices) for the Spotted-tailed Quoll, these may also create new habitat for this species.

The Spotted-tailed Quoll is very mobile with a large home range (750-3,500 ha) and the ability to exploit a wide range of habitats including alternate resources for denning, such as hollow logs, caves and boulder piles. Although some individuals may be impacted by the Proposal, subsidence-related events on potential habitat are expected to be minimal for this species. It is therefore considered unlikely that a viable local population would be placed at risk of extinction as a result of the Proposal.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule

1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, no population of the Spotted-tailed Quoll is listed as an Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Known and potential habitat for Spotted-tailed Quoll occurs in Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Coachwood Warm Temperate Rainforest, Rock Plate Heath-Mallee, Tall Open Peppermint-Blue Gum Forest, Moist Gully Gum Forest, Nepean Sandstone Gully Forest and Upland Swamp plant communities within the Study Area where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of these plant communities, is considered potential habitat for the species.

- The Study Area Contains approximately 3,259 ha of potential habitat for the Spotted-tailed Quoll, located within Upland Swamps, ridge lines, creek lines and rainforest;
- Specifically, habitats where suitable den sites and foraging resources are

present are likely to be important for the species within the Study Area;

- Subsidence has the potential to alter a proportion of these habitat features within the study area though it is highly unlikely that all of this habitat within the study area would be impacted;
- Spotted-tailed Quoll habitats are widely distributed within the Locality (approximately 21,083 ha). The potential habitat for the Spotted-tailed Quoll in the Study Area represents 15.5 per cent of potential habitat within the Locality; and
- Section 9.2.1 of the SIS details the “predicted” impacts of subsidence on these habitat types.

Potential habitats for the Spotted-tailed Quoll within the Study Area are of similar quality and continuous with habitat in the greater Locality. Spotted-tailed Quolls are very mobile with a large home range and are unlikely to face exceptional danger if forced to relocate. Rock falls are unlikely to cause significant isolation or fragmentation of the potential habitat. Upland SwampSwamps, which provide potential foraging habitat for the Spotted-tailed Quoll, occur in the Study Area within small stands where appropriate soil, geological and hydrological conditions prevail. Subsidence is unlikely to result in further fragmentation or isolation of Upland Swamp habitats within the Study Area.

The Spotted-tailed Quoll has not been recorded in the Study Area, but one record occurs within the Locality, to the south-west of the Study Area. It appears to be present in low numbers in the Locality. Connectivity will be retained within the Study Area and the Locality, and would allow dispersal of individuals and genetic exchange within and between populations. Impacts from subsidence are highly unlikely to disrupt dispersal and genetic exchange. The potential habitat in the Study Area is not considered to be vital to the survival of a local population of this species, if one is present, and impacts on this habitat are unlikely to be significant.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Spotted-tailed Quoll (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is currently no recovery plan for the Spotted-tailed Quoll. However, the DECC has developed a list of 32 Priority Actions and recovery strategies to help recover this species in NSW. Those actions relevant to the Proposal include:

- Retain and protect large, forested areas with hollow logs and rocky outcrops, particularly areas with thick understorey or dense vegetation along drainage lines – subsidence has the potential to impact rocky outcrops, drainage lines and riparian vegetation, however any impacts are likely to be insignificant, and forested areas will be retained throughout the Study Area;

- Habitat requirements of Spotted-tailed Quolls are to be adequately conserved within environmental planning instruments and through other legislative protection mechanisms, including property vegetation plans; and – habitat for the Spotted-tailed Quoll is protected within the Catchment area and adjacent national parks; and

- Identify sites across the NSW range and within different habitat types at which long-term population monitoring can be undertaken – no population of Spotted-tailed Quoll is known to occur within the Study Area, however if the species were detected monitoring could be undertaken.

The Red Fox (*Vulpes vulpes*) has been recorded in the Study Area. The Spotted-tailed Quoll is listed as a species of medium priority in the NSW threat abatement plan 'Predation by the Red Fox' (NPWS 2001f). The plan aims to reduce predation on native animals by the Red Fox and focuses on fox control at a number of priority sites. The Study Area is not a priority site.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Spotted-tailed Quoll include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – the Spotted-tailed Quoll often dens in caves, rock crevices, overhangs and boulder piles which may collapse as a result of subsidence (such impacts are predicted to occur over a small percentage of the Study Area and to be localised);

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Spotted-tailed Quoll may forage at water sources such as rivers and streams, however these are generally unlikely to be significantly impacted by the Proposal; and
- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Spotted-tailed Quoll.

Conclusion

The Spotted-tailed Quoll has not been recorded within the Study Area, but the species has been documented within the Locality and within the 10 km search area. Potential habitat within the Study Area occurs within woodland, gully forest and Upland Swamps. These habitats provide potential den sites and foraging resources for the Spotted-tailed Quoll.

The Proposal will result in the operation of three KTPs which may lead to impacts on potential foraging habitat (e.g. Upland Swamps and creek lines) and potential sheltering and breeding habitat (e.g. rocky outcrops and overhangs) for the Spotted-tailed Quoll. Although some individuals may be impacted by the Proposal (due to possible collapse of suitable rock sheltering habitats), given the predicted impacts of rock falls and changes in vegetation are expected to be small; and the extent of potential habitat within the Locality (21,083 ha), it is **unlikely** that the Proposal would have a significant impact on the Spotted-tailed Quoll.

Brush-tailed Rock-wallaby	***Petrogale penicillata***

The Brush-tailed Rock-wallaby is listed as Endangered on Schedule 1 of the TSC Act and as Vulnerable under the EPBC Act.

Potential habitat of the Brush-tailed Rock-wallaby includes rocky outcrops, cliffs and ridgelines in forest and woodlands. They are thought to prefer north facing habitats with numerous caves and hollows (DEC 2005l). These wallabies tend to live in small family groups of 2-5 adults and one or two juveniles within a home range ranging from 6 to 30 ha around a ridge line (DEC 2005l). Home ranges are generally rectangular, spanning 400 to 900 metres along a rocky ridgeline (DEC 2005l). Little is known of the dispersal of the Brush-tailed Rock-wallaby but work so far indicates high site fidelity, low migration and re-colonisation rates (DEC 2005l).

The Brush-tailed Rock-wallaby is nocturnal to crepuscular, sheltering in rocky habitats during daytime hours and foraging in surrounding habitat at night up to 2 km away. Young may also be left in rocky refuges while the mother is foraging (DEC 2005l). The dietary requirements of the Brush-tailed Rock-wallaby include a wide variety of grasses and shrubs and it is thought to be an adaptable forager (DEC 2005l).

Potential habitat within the Study Area is considered to be woodland, forest (within Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Coachwood Warm Temperate Rainforest, Rock Plate Heath-Mallee, Tall Open Peppermint-Blue Gum Forest, Moist Gully Gum Forest and Nepean Sandstone Gully Forest) and Upland Swamp (Upland Swamp Banksia Thicket, Upland Swamp Fringing Eucalypt Woodland, Upland Swamp Sedgeland Heath Complex and Upland Swamp Tea-tree Thicket) vegetation within 200 m of rocky areas.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Brush-tailed Rock-wallaby has been previously recorded within a 10 km radius of the Study Area (DECC Atlas of NSW), but not within it. Brush-tailed Rock-wallabies are dependant upon large, rocky outcrops and cliffs with good surrounding vegetation. Potential sheltering/breeding and foraging habitat occurs within woodland, forest and Upland Swamp vegetation types within 200 m of rocky areas (DEC 2005e). These rocky sheltering areas are assumed to provide protection from predators as well as providing improved microclimate for daytime sheltering for this nocturnal species. As such it is likely that appropriate shelters play a part in successful recruitment of young Brush-tailed Rock-wallabies. Additionally, mothers have been recorded leaving joeys in rocky shelter areas whilst foraging.

Brush-tailed Rock-wallabies rely on caves and overhangs for shelter and breeding. Rock falls may destroy sheltering habitat (overhangs, caves, crevices) for the Brush-tailed Rock-wallaby, but may also create new habitat for this species.

Potential foraging habitat for this species exists within Upland Swamps. Although changes to water flow and water quality in Upland Swamps from subsidence are possible, these impacts are considered unlikely, and therefore, changes to vegetation even less likely. Some vegetation immediately surrounding any cracking may die, but the impacts from the loss of this vegetation are considered to be negligible. See summary of impacts (Section 9.2.1 of the SIS) for more details.

The collapse of rock ledges within the Study Area could impact a local population of the Brush-tailed Rock-wallaby through mortality of sheltering individuals crushed during rock falls (though the likelihood of this occurrence is very low), or by reduction of available habitat within the Study Area. As populations are restricted to a small home range surrounding a particular rocky outcrop, and these shelter sites are important for recruitment and population survival, the collapse of this habitat feature, coupled with the species' low recorded rates of migration and re-colonisation, could have an adverse effect on the life cycle of a population of the Brush-tailed Rock-wallaby inhabiting the Study Area. However, rock falls and cliff collapses are likely to create alternative sheltering sites. As such, it is unlikely that a local population of the Brush-tailed Rock-wallaby would be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

There is one Endangered Population of the Brush-tailed Rock-wallaby listed under the Act. The endangered population is within the Warrumbungle National Park and neighbouring properties. This population is not represented within the Study Area or Locality.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

Known and potential habitat for Brush-tailed Rock-wallaby occurs in Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Coachwood Warm Temperate Rainforest, Rock Plate Heath-Mallee, Tall Open Peppermint-Blue Gum Forest, Moist Gully Gum Forest, Nepean Sandstone Gully Forest and Upland Swamp plant communities where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of these plant communities, is considered potential habitat for the species.

- The Study Area Contains approximately 3,259 ha of potential habitat for this species, located within Upland Swamps, ridge lines, creek lines and rainforest, of which only a small portion has the potential to be impacted;

- Specifically, habitats including rocky areas adjacent to woodland are likely to be important for the species within the Study Area;

- Subsidence has the potential to alter a proportion of these habitat features within the study area though it is highly unlikely that all of this habitat within the study area would be impacted;

- These habitats are widely distributed within the Locality (approximately 21,083 ha). The potential habitat for the Brush-tailed Rock-wallaby in the Study Area represents 15.5 per cent of potential habitat within the Locality; and

- Section 9.2.1 of the SIS details the “predicted” impacts of subsidence on these habitat types.

Limited studies suggest that Brush-tailed Rock-wallaby colonies do not generally move from their rocky outcrop territory and surrounding foraging area. However rocky outcrops are naturally isolated from the surrounding areas of rocky habitat within the Study Area (e.g. rocky ridgelines separated by gullies). Rock falls are unlikely to cause significant isolation or fragmentation of the potential habitat. Upland Swamps, which provide potential foraging habitat for the Brush-tailed Rock-wallaby, occur in the Study Area within small stands where appropriate soil, geological and hydrological conditions prevail. Subsidence is unlikely to result in further fragmentation or isolation of Upland Swamp habitats within the Study Area.

The vegetation communities of the Study Area contain sunny, north-facing, rocky outcrops considered to be good quality potential habitat for the Brush-tailed Rock-wallaby. There are also a variety of rocky outcrops with western, eastern or southern aspects or with greater shade which constitute lower quality habitat for the Brush-tailed Rock-wallaby, but the species has still been recorded utilising such outcrops (DEC 2005l). The Locality contains similar vegetation communities and geology and as such it is likely that these habitat features would be well represented within the Locality. Given that the Brush-tailed Rock-wallaby has not been recorded within 10 km of the Study Area for more than 40 years, and that the species is unlikely to migrate long distances to re-colonise, the potential habitat in the Study Area is unlikely to be of high importance to the species. However, if this cryptic species (shelters during the day; active at night) is found to be present within the Study Area, the potential habitat is likely to be of importance to the long-term survival of this highly endangered species within the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director General maintains a register of critical habitat. To date, no critical habitat has been declared for the Brush-tailed Rock-wallaby (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

A draft NSW recovery plan has been prepared for the recovery of the Brush-tailed Rock-wallaby in NSW. The specific objectives of this recovery plan are:

- To increase recruitment at priority sites;
- To decrease the rate of decline in range and abundance;
- To prevent the decline of the species to a level at which it would be at risk of becoming extinct in the wild; and

- To increase knowledge to enable more effective management of the species.

It is noted within the draft NSW recovery plan that the protection of all Brush-tailed Rock-wallaby sites is beyond the constraints of the plan, and therefore it is not an objective of this recovery plan that all populations of Brush-tailed Rock-wallaby will necessarily be conserved. Potential habitat for the Brush-tailed Rock-wallaby occurs in parts of the Study Area but no individuals have been recorded. Potential habitat will remain throughout the Study Area. As no significant impact is likely on this species as a result of the Proposal, the action is not inconsistent with the recovery plan.

The DECC has also prepared a list of recovery strategies as well as 32 Priority Actions and recovery strategies to assist in the species' recovery in NSW. Strategies relevant to the Proposal is outlined below.

- Retain rocky habitat and adjacent open forest or grassland areas – rocky habitat will be retained in the Study Area; and

- Conduct field research on Brush-tailed Rock-wallaby ecology to improve our understanding of how individuals, colonies and populations respond to threatening processes – no population was detected during surveys in the Study Area.

The Brush-tailed Rock-wallaby is listed as a species of high priority in the NSW threat abatement plan 'Predation by the Red Fox' (NPWS 2001f). The Red Fox has been recorded in the Study Area. The plan aims to reduce predation on native animals by the Red Fox and focuses on fox control at a number of priority sites. The Study Area is not a priority site, however one exists nearby. A population of Brush-tailed Rock-wallaby persists on the Bullio portions of Nattai National Park occupying rock outcropping in an area that adjoins private property. This site has been included as a DECC monitoring site as part of the threat abatement plan for predation by the Red Fox (NPWS 2001f).

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs are listed under Schedule 3 of the TSC Act. Two KTPs relevant to the Proposal that may impact on potential habitat for the Brush-tailed Rock-wallaby are outlined below.

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – the Brush-tailed Rock-wallaby is found in habitats such as gullies and on rocky outcrops that are known to be impacted by subsidence. If the species is present, rockfalls, the collapse of caves, steep slopes, rock crevices and overhangs may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding habitat, however additional habitat may be created by these events. Some potential foraging resources may also be impacted (e.g. Upland Swamps); and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Brush-tailed Rock-wallaby.

Conclusion

The Brush-tailed Rock-wallaby has not been recorded within the Study Area, but the species has been documented within the 10 km search area. Potential sheltering/breeding and foraging habitat occurs within woodland, forest and Upland Swamp vegetation types within 200 m of rocky areas.

The Proposal will result in the operation of two KTPs which may lead to impacts on potential foraging habitat (e.g. Upland Swamps) and potential sheltering and breeding habitat (e.g. rocky outcrops and overhangs) for the Brush-tailed Rock-wallaby. Although some individuals may be impacted by the Proposal (due to possible collapse of suitable rock sheltering habitats), given the predicted impacts of rockfalls and changes in vegetation types are expected to be minimal, it is **unlikely** that the Proposal would have a significant impact on the Brush-tailed Rock-wallaby.

Southern Brown Bandicoot (eastern)	***Isoodon obesulus obesulus***

The Southern Brown Bandicoot is listed as Endangered on Schedule 1 of the TSC Act and as Endangered on the EPBC Act.

Southern Brown Bandicoots are generally only found in heath or open forest with a heathy understorey on sandy or friable soils (DEC 2005ˆ). A mosaic of post fire vegetation is an important component of habitat for this species (Maxwell *et al.* 1996). They nest during the day in a shallow depression in the ground covered by leaf litter, grass or other plant material (DEC 2005ˆ). Mating occurs any time of the year, usually following heavy rain. Two or three litters of 2-4 young may be produced annually. They have a short gestation period of 11-12 days and young become independent around 60 days after being born (DEC 2005ˆ). They feed on a variety of ground-dwelling invertebrates and the fruit-bodies of hypogeous (underground-fruiting) fungi. Males have a home range of approximately 5-20 hectares whilst females forage over smaller areas of about 2-3 hectares (DEC 2005ˆ).

A single record of the Southern Brown Bandicoot exists within the Study Area from 1997 and occurs within Exposed Sandstone Scribbly Gum Woodland (DECC Atlas of NSW Wildlife). Further potential habitat for the Southern Brown Bandicoot within the Study Area is considered to be within forest and woodland (within Sandstone Gully Peppermint Forest, Transitional Shale Stringybark Forest, Nepean Sandstone Gully Forest), heath-mallee (Rock Plate Heath-Mallee) and Upland Swamp (Upland Swamp Banksia Thicket, Upland Swamp Fringing Eucalypt Woodland, Upland Swamp Sedgeland Heath Complex and Upland Swamp Tea-tree thicket) habitats where there is a heathy understorey on sandy soil.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Southern Brown Bandicoot can occur in a range of habitats and usually nest in plant material, but may also utilise rabbit burrows, rock ledges or crevices. Mating occurs any time of the year. Southern Brown Bandicoots have small home ranges relative to the size of the Subject Site. Fungal material is part of their diet (Broughton and Dickman 1991). Fungal sporocarps are typically distributed as discrete clusters often in association with host tree roots (Claridge *et al.* 1993).

A single record exists within the Study Area recorded in woodland habitat. No Southern Brown Bandicoots were recorded within the Study Area during the current surveys. Potential habitat for this species occurs in woodlands, forest, heath-mallee and Upland Swamp habitats within the Study Area.

Foraging resources could be impacted by subsidence, but impacts are unlikely to be significant. Changes to water flow and water quality in Upland Swamps from subsidence are possible, however these impacts are considered unlikely, and therefore, changes to vegetation even less likely. Gas emissions have the potential to impact riparian vegetation however MSEC (2007) consider it unlikely that gas emissions will be a significant issue for Dendrobium Area 3. See summary of impacts (Section 9.2.1 of the SIS) for more details.

Fracturing of the sandstone may result in cracks forming on the ridge lines. These cracks may vary in size and depth and can become potential fauna traps, hence it is possible that individual Southern Brown Bandicoots may be impacted. There is a limited possibility of individual trees (which could be hosts to the fungal sporocarps which make up part of this species diet) becoming dislodged and hence dying due to surface cracks, although large-scale tree death due to subsidence has not been previously observed.

The collapse of rock ledges, rock crevices and burrows may cause death or injury to individuals though this is unlikely. Furthermore, such events may reduce the availability of potential breeding habitat, however additional habitat may be created.

Southern Brown Bandicoots inhabit relatively small home ranges but these home ranges are relatively flexible with individuals able to shift their home range depending on resource availability (Broughton and Dickman 1991). They are not solely dependent on rocky areas for refuge and will also nest amongst soil litter and plant material. Southern Brown Bandicoot would be able to use resources in the forest and woodlands adjacent to impacted areas. While there is the potential for some individuals to be affected by the Proposal, impacts on the long-term viability of the local population are unlikely to be significant.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

The Southern Brown Bandicoot is listed as an Endangered species on Schedule 1 of the TSC Act and therefore no population of the species is listed as an Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Known and potential habitat for Southern Brown Bandicoot occurs in Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Rock Plate Heath-Mallee, Transitional Shale Stringybark Forest, Nepean Sandstone Gully Forest and Upland Swamp plant communities within the Study Area where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of these plant communities, is considered potential habitat for the species.

- The Study Area contains approximately 3,206 ha of potential habitat for the Southern Brown Bandicoot in Upland Swamps, ridge lines, and creek lines;
- Specifically, habitats where there is a heathy understorey on sandy soil are likely to be important for the species within the Study Area;
- Subsidence has the potential to alter a proportion of these habitat features within the study area though it is highly unlikely that all of this habitat within the study area would be impacted;
- These habitats are widely distributed within the Locality (approximately 18,327 ha). The potential habitat for the Southern Brown Bandicoot in the Study Area represents 17.5 per cent of potential habitat within the Locality; and
- Section 9.2.1 of the SIS details the “predicted” impacts of subsidence on these habitat types.

Upland Swamps occur within the Study Area within small stands where appropriate soil, geological and hydrological conditions prevail. Subsidence is unlikely to result in further fragmentation or isolation of Upland Swamp habitats within the Study Area. Furthermore, the woodland and forest habitat types are continuous into the greater Locality and are of similar quality to the habitat within the Study Area; they also will not be fragmented or isolated by the

Proposal.

Known and potential habitat for the Southern Brown Bandicoot within the Study Area is considered to be in good condition, containing mixed Eucalypts and understorey heath. While subsidence could impact on some individuals, genetic exchange should not be disrupted within a wider population, however, the current distribution and population size of the Southern Brown Bandicoot is poorly understood and therefore, any populations are to be treated as being of the highest conservation priority (DEC 2005Ž). While the Southern Brown Bandicoot may be able to utilise a range of habitat types, and suitable habitat within the Study Area is continuous with habitat of a similar quality within the Locality, known and potential habitat within the Study Area should be considered of high importance to the long-term survival of the Southern Brown Bandicoot, if a population is present.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Southern Brown Bandicoot (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

A recovery plan has been prepared for the Southern Brown Bandicoot. The overall objective of the recovery plan is to improve the conservation status of the Southern Brown Bandicoot and maximise the opportunity for viability of this species in the wild in NSW (DEC 2006c). One specific objective of the recovery plan is to:

- Clarify the status of the species by better defining its distribution and relative abundance by continued survey in National Parks and other tenures – one recommendation is for targeted survey using hair traps and cage traps within the southern Avon Catchment (DEC 2005Ž) which is adjacent to (and partly within) the Study Area. This species was surveyed for in the Study Area.

The DECC has also identified 17 Priority Actions and recovery strategies to assist in the species' recovery in NSW. Relevant actions to the Proposal are outlined below.

- Survey on National Parks and other tenures – surveys were conduct for this species in the Study Area; and

- Protect all known and potential habitat and include linkages across the broader landscape – the majority of known and potential habitat in the Study Area is unlikely to be impacted by subsidence and connectivity will remain within and between the Study Area and the wider Locality.

The Southern Brown Bandicoot is listed as a species of high priority in the NSW threat abatement plan ‘Predation by the Red Fox’ (NPWS 2001f). The Red Fox has been recorded in the Study Area. The plan aims to reduce predation on native animals by the Red Fox.

Whether the action proposed is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Southern Brown Bandicoot include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Southern Brown Bandicoot has been previously recorded within the Study Area and is found in habitats such as forests, woodlands and Upland Swamps. This habitat may be impacted by subsidence (e.g. surface cracks and hydrological changes). A change in forest structure has been recognised as a threat to the species (DEC 2005ˆ). Significant changes to vegetation within the Study Area are not predicted. The collapse of rock ledges, rock crevices and burrows may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Furthermore, such events may reduce the availability of potential breeding and roosting habitat;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – potential habitat for the Southern Brown Bandicoot exists along water sources such as rivers and streams. Upland Swamp habitat has the potential to be impacted by the Proposal by subsidence movements, resulting in hydrological changes. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. However, significant changes to vegetation within the swamps are not predicted; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Southern Brown Bandicoot.

Conclusion

The Proposal has the potential to impact the Southern Brown Bandicoot through alteration of Upland Swamps, riparian habitats and rocky outcrops resulting in the possible loss of foraging, sheltering and breeding habitat.

The Proposal will result in the operation of three KTPs which have the potential to impact known and potential resources for the Southern Brown Bandicoot. However, the Proposal is unlikely to result in fragmentation or isolation of potential habitat for the species and good quality potential habitat for the Southern Brown Bandicoot is continuous within the Locality. Southern Brown Bandicoots may use Upland Swamps, riparian habitats and rocky outcrops, but they will not be solely reliant on these habitats and will be able to use the surrounding forest and woodland habitats that will be less impacted by the Proposal. In addition, possible impacts on known and/or potential habitat of the Southern Brown Bandicoot are predicted to be minimal. It is therefore considered **unlikely** the Proposal would have a significant impact on the long-term survival of the Southern Brown Bandicoot.

Long-nosed Potoroo	***Potorous tridactylus***

The Long-nosed Potoroo is listed as Vulnerable on Schedule 2 of the TSC Act and as Vulnerable on the EPBC Act.

The Long-nosed Potoroo inhabits coastal heath and wet and dry sclerophyll forests. It generally occurs in areas with rainfall greater than 760 mm (DEC 2005{). 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 (DEC 2005{). A sandy loam soil is also a common feature (DEC 2005{). The fruit-bodies of hypogeous (underground-fruiting) fungi are a large component of the diet of the Long-nosed Potoroo. They also dig to eat roots, tubers, insects and their larvae and other soft-bodied animals in the soil (DEC 2005{). Individuals are mainly solitary, non-territorial and have home range sizes ranging between 2-5 ha (DEC 2005{).

Potential habitat within the Study Area is likely to occur in woodlands, forest, rainforest, heath-mallee and Upland Swamp habitats (within the Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Transitional Shale Stringybark Forest, Nepean Sandstone Gully Forest, Coachwood Warm Temperate Rainforest, Rock Plate Heath-Mallee and Upland

Swamp plant communities) where there is a dense, heathy understorey on sandy soil, with occasional open areas.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Long-nosed Potoroo requires dense understorey in heaths and forests for breeding. Adults mature at one year of age and breeding peaks typically occur in late winter to early summer. A single young is born per litter and adults are capable of two reproductive bouts per annum. Long-nosed Potoroos have small home ranges (2-5 ha) relative to the size of the Subject Site; however they are generally solitary and not strictly territorial.

No Long-nosed Potoroos have been recorded within the Study Area or within a further 10 km radius of the Study Area. However potential habitat for this species occurs in the woodlands, forest, rainforest, heath-mallee and Upland Swamp habitats within the Study Area.

Any changes to vegetation could impact this species. Changes to water flow and water quality in Upland Swamps from subsidence are possible, however these impacts are considered unlikely, and therefore, changes to vegetation even less likely. Some vegetation immediately surrounding any cracking may die, but the impacts from the loss of this vegetation are considered to be negligible. Gas emissions have the potential to impact riparian vegetation, however, MSEC (2007) consider it unlikely that gas emissions will be a significant issue for the whole of Dendrobium Area 3. See summary of impacts (Section 9.2.1 of the SIS) for more details.

Fracturing of the sandstone may result in cracks forming on the ridge lines. These cracks may vary in size and depth and can become potential fauna traps, hence it is possible that individual Long-nosed Potoroos may be impacted. There is a limited possibility of individual trees (which could be hosts to the fungal sporocarps which make up the largest component of this species diet) becoming dislodged and hence dying due to surface cracks, although large-scale tree death due to subsidence has not been previously observed.

The above impacts may result in the possible reduction of potential foraging and breeding habitat for the Long-nosed Potoroo. While the Long-nosed Potoroo requires some open areas for foraging, they also rely on a dense understorey of ferns, heath and shrubs which may be affected by these subsidence impacts.

Long-nosed Potoroos inhabit small home ranges, they are solitary and not strictly territorial suggesting individuals may have the potential to shift their home range depending on resources. The habitat within the Study Area is continuous with greater areas of suitable habitat within the Locality providing potential for potoroos to relocate. Any changes in vegetation due to the Proposal are not likely to be immediate and the Long-nosed Potoroo would be able to use resources in the forest and woodlands adjacent to impacted areas. Furthermore, possible impacts on potential habitat of the Long-nosed Potoroo are predicted to be minimal. This suggests that a viable local population of the Long-nosed Potoroo, if present within the Study Area, would be unlikely to be placed at risk of extinction as a result of the Proposal.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

The Cobaki Lakes and Tweed Heads West population of the Long-nosed Potoroo in the Tweed LGA is listed as an Endangered Population. This population is not represented within the Study Area or Locality.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Known and potential habitat for Long-nosed Potoroo occurs in Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Coachwood Warm Temperate Rainforest, Rock Plate Heath-Mallee, Transitional Shale Stringybark Forest, Nepean Sandstone Gully Forest and Upland Swamp plant communities where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of these plant communities, is considered potential habitat for the species.

- The Study Area Contains approximately 3,222 ha of potential habitat for the Long-nosed Potoroo species, located within Upland Swamps, ridge lines, creek lines and rainforest;

- Specifically, habitats including those where there is a dense, heathy understorey on sandy soil, with occasional open areas are likely to be important for the species within the Study Area;

- Subsidence has the potential to alter a proportion of these habitat features within the study area though it is highly unlikely that all of this habitat within the study area would be impacted;

- These habitats are widely distributed within the Locality (approximately 19,105 ha). The potential habitat for the Long-nosed Potoroo in the Study Area represents 16.9 per cent of potential habitat within the Locality; and

- Section 9.2.1 of the SIS details the “predicted” impacts of subsidence on these habitat types.

Upland Swamps occur within the Study Area within small stands where appropriate soil, geological and hydrological conditions prevail. Subsidence is unlikely to result in further fragmentation or isolation of Upland Swamp habitats within the Study Area. The effects of longwall mining are unlikely to cause significant long-term isolation or fragmentation of the habitat. The woodland and forest habitat types are continuous into the greater Locality and are of similar quality to the habitat within the Study Area; they also will not be fragmented or isolated on a large scale by the Proposal.

Potential habitat for the Long-nosed Potoroo within the Study Area is considered to be in good condition, containing mixed Eucalypts and understorey shrubs, heath and fern. Connectivity will remain within and between the Study Area and the Locality, allowing for genetic exchange of any populations (if present). Given the range of habitat types that the Long-nosed Potoroo may utilise and that habitats within the Study Area are continuous with habitat of a similar quality within the Locality, potential habitat within the Study Area is likely to be only of moderate importance to the long-term survival of the species in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Long-nosed Potoroo (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

To date, no recovery or threat abatement plans have been prepared for the Long-nosed Potoroo. The DECC has identified 19 Priority Actions and recovery strategies to assist in the species' recovery in NSW. Those relevant to the Proposal are outlined below.

- Using survey methods such as hair-tubing, trapping, scat analysis and the abundance of diggings, estimate the population sizes and relative densities of populations – surveys were conducted for this species in the Study Area;

- Protect and maintain habitat, especially dense understorey. Provide linkages across the broader landscape –impacts from subsidence are not likely to significantly alter habitat for this species. Broad linkages will remain throughout the Study Area ; and

- Habitat Rehabilitation/Restoration and/or Regeneration: Increase habitat via revegetation work and/or establishing corridors to link multiple patches of suitable habitat to expand the effective area of habitat – this is not necessary in the Study Area as it is currently vegetated and impacts from subsidence are unlikely to be so significant that habitat rehabilitation is required.

Whether the action proposed is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Long-nosed Potoroo include:

- 'Alteration of habitat following subsidence due to longwall mining' (NSW Scientific Committee 2005a) – the Long-nosed Potoroo is found in habitats such as sclerophyll forests, woodlands and Upland Swamps. Subsidence due to longwall mining has the potential to drain Upland Swamps which are important habitat for the species (NSW Scientific Committee 2005b). However, it is not predicted that the Upland Swamps within the Study Area would drain as a result of the Proposal;

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – potential habitat for the Long-nosed Potoroo exists at water sources such as creeks, drainage lines and Upland Swamps. Upland Swamp habitat has the potential to be impacted by the Proposal, however, significant changes to vegetation within the swamps are not anticipated. The draining of creek lines as a result of subsidence within the Study Area may impact on the species, if present; and

- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Long-nosed Potoroo.

Conclusion

The Proposal has the potential to impact the Long-nosed Potoroo through any alteration of Upland Swamp, watercourses and riparian habitats, resulting in the loss of potential foraging, nesting and breeding habitat. These habitats are widely distributed within the Locality. The potential habitat for the Long-nosed Potoroo in the Study Area represents 16.9 per cent of potential habitat within the Locality.

The Proposal will result in the operation of three KTPs which may impact potential resources for the Long-nosed Potoroo. However, the Proposal is unlikely to result in fragmentation or isolation of potential habitat for the species and good quality potential habitat for the Long-nosed Potoroo is continuous within the Locality. Long-nosed Potoroos may use Upland Swamps and riparian habitats but they will not be solely reliant on these habitats and will be able to use the surrounding forest and woodland habitats that will be less impacted by the Proposal. Despite the potential impacts of the Proposal, all potential habitats are likely to be well conserved in the Study Area and are likely to remain in good condition. Given this; the extent of potential habitat in the Locality; and that possible impacts on potential habitat of the Long-nosed Potoroo are predicted to be minimal, it is considered **unlikely** the Proposal would have a significant impact on the long-term survival of the Long-nosed Potoroo.

Microchiropteran Bats – Cave-roosting Species

Known and/or potential habitat for seven threatened cave-roosting bat species occurs within the Study Area: the Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*, Little Bentwing-bat *Miniopterus australis*, Eastern Cave Bat *Vespadelus troughtoni*, Large-eared Pied Bat *Chalinolobus dwyeri*, Eastern False Pipistrelle *Falsistrellus tasmaniensis*, Golden-tipped Bat *Kerivoula papuensis* and the Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris*. These Bat species have been grouped together based on the impact on breeding/ roosting habitat. The Southern (Large-footed) Myotis *Myotis macropus* is also known to roost in caves, but is assessed separately as it has other limiting habitat requirements that may be impacted by subsidence.

All seven species are listed as Vulnerable on Schedule 2 of the TSC Act. The Large-eared Pied Bat is also listed as Vulnerable on the EPBC Act.

The Eastern Bentwing-bat, Little Bentwing-bat, Eastern Cave Bat and Large-eared Pied Bat can be considered cave-dependant as they utilise caves almost exclusively for roosting requirements, including for maternity roosts. The remaining three species use caves or similar structures for roosting some of the time, but will also utilise other structures, such as tree hollows. Although no large caves are known to occur in the Study Area, for the purpose of this assessment, all rocky overhangs, rocky crevices and small caves are considered potential cave-roosting habitat.

The Large-eared Pied Bat, Little Bentwing-bat, Eastern Bentwing-bat and the Yellow-bellied Sheathtail-bat occur over a broad variety of habitats, with the Large-eared Pied Bat and Little Bentwing-bat generally found in timbered areas (forest and woodland), while the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat can be found in a broad range of vegetation types (from rainforest to grassland to desert) (Churchill 1998). The Eastern False Pipistrelle inhabits sclerophyll forests between the Great Dividing Range and the coast. The Eastern Cave Bat is said to prefer tropical mixed woodland and wet sclerophyll forest close to the coast, but extends into drier forest inland (Churchill 1998), while the

Golden-tipped Bat occurs mainly in rainforest and wet sclerophyll forests.

Foraging behaviour and flight capability varies between the species. The Large-eared Pied Bat has a relatively slow flight and forages within the canopy (Churchill 1998) and the Yellow-bellied Sheathtail-bat and Eastern Bentwing-bat are fast, high fliers, foraging above the canopy (Churchill 1998). The Eastern False Pipistrelle and Little Bentwing-bat are fast and manoeuvrable, foraging within the canopy. The Golden-tipped Bat has a slow but manoeuvrable flight that allows it to pluck its main prey item, spiders, from their webs. Foraging behaviour of the Eastern Cave Bat is so far unknown. The Eastern Bentwing-bat is wide-ranging, dispersing within a 300 km range of their maternity sites (DEC 2005m). Little is known about the dispersal of the other bat species dealt with here.

All of the records from the current survey are based on Anabat survey techniques, which vary in their certainty of call identification. Two species, the Eastern Bentwing-bat and the Large-eared Pied Bat were recorded with *definite* certainty, the Eastern False Pipistrelle, Little Bentwing-bat and Yellow-bellied Sheathtail-bat were recorded with *probable* certainty and the Eastern Cave Bat and Golden-tipped Bat were recorded with *possible* certainty. Known and/or potential habitat in the Study Area for these species may occur in woodland and/or forest (within the Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Coachwood Warm Temperate Rainforest, Rock Plate Heath-Mallee, Transitional Shale Stringybark Forest, Tall Open Peppermint-Blue Gum Forest, Moist Gully Gum Forest and Nepean Sandstone Gully Forest) and Upland Swamp plant communities.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

All bat roost sites are important for day to day survival (day and night time resting, predator protection, social contact and breeding), but roosts used for winter, cold weather hibernation and breeding (maternity sites) are most significant (DEC 2004a).

Impacts associated with subsidence events may involve fracturing of bedrock resulting in possible collapse of rocky overhangs, rocky crevices and small caves and possible changes to vegetation. This may result in the loss, disruption or modification of potential foraging, roosting and breeding habitat for the seven bat species. However as discussed in Section 9.2.1 of the SIS the predicted impacts are not expected to be more than 7 – 10 % of the entire length of any ridge line that is mined beneath. Furthermore cliff lines and overhangs that will not be directly mined beneath are unlikely to exhibit any significant impacts (MSEC

2007).

It is unlikely that potential foraging resources within the Study Area would be significantly impacted for the seven Bat species. The possible mechanisms and physical effects of subsidence are highly unlikely to result in a significant loss of woodland and forest habitats not wholly dependant on ground water from the Study Area.

Given roosting and breeding habitat features are widely distributed throughout the Study Area (3,269 ha) and Locality (22,633 ha), and the mobility of all seven bat species, it is unlikely that potential impacts of subsidence would have a significant impact on these habitat features. Although some individuals may be impacted by the Proposal (due to possible collapse of rock overhangs) it is unlikely that the Proposal would place a viable local population of the Eastern Bentwing-bat, Eastern Cave Bat, Eastern False Pipistrelle, Golden-tipped Bat, Large-eared Pied Bat, Little Bentwing-bat or Yellow-bellied Sheathtail-bat at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in NSW in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, there are no Endangered Populations of the Eastern Bentwing-bat, Eastern Cave Bat, Eastern False Pipistrelle, Golden-tipped Bat, Large-eared Pied Bat, Little Bentwing-bat or the Yellow-bellied Sheathtail-bat listed under the Act.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

The Study Area contains approximately 3,269 ha of known and/or potential habitat for the seven Bat species within the forest and woodland habitats. Specifically, habitats that provide suitable breeding and roosting resources are likely to be important for these species within the Study Area. Subsidence has the potential to alter a proportion of these habitat features (e.g. rock overhangs) within the Study Area, though it is highly unlikely that all of this habitat would be impacted. Section 9.2.1 of the SIS details the "predicted" impacts of subsidence on these habitat types. The potential habitat for the seven Bat species in the Study Area represents 14.4 per cent of potential habitat within the Locality.

Potential habitats for the seven Bat species within the Study Area are of similar quality and continuous with habitat in the greater Locality. Given the mobility of these Bat species it is unlikely that the Proposal would result in the fragmentation or isolation of potential habitat for these species.

The forest and woodland habitat within the Study Area is considered to be of good quality, containing watercourses, varying densities of vegetation, and good canopy for foraging as well as hollow-bearing trees, rock crevices and rocky overhangs for roosting. These habitat features are widely distributed within the

Locality (approximately 22,633 ha) and the Proposal is unlikely to affect foraging resources for these species. Given the mobility of these Bat species it is unlikely they would be entirely dependant on the habitat features within the Study Area. As such the Study Area is only likely to be of moderate importance to the long-term survival of the Eastern Bentwing-bat, Eastern Cave Bat, Eastern False Pipistrelle, Golden-tipped Bat, Large-eared Pied Bat, Little Bentwing-bat or Yellow-bellied Sheathtail-bat. In addition cave-dependent microchiropteran bats are more likely to utilise larger caves than those present in the Study Area, and the Golden-tipped Bat, Yellow-bellied Sheathtail Bat and Eastern False Pipistrelle may also roost in tree hollows and/or amongst dense vegetation in the Study Area.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Eastern Bentwing-bat, Eastern Cave Bat, Eastern False Pipistrelle, Golden-tipped Bat, Large-eared Pied Bat, Little Bentwing-bat or Yellow-bellied Sheathtail-bat.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

To date, there is no recovery plan or threat abatement plan for the Eastern Bentwing-bat, Eastern Cave Bat, Eastern False Pipistrelle, Golden-tipped Bat, Large-eared Pied Bat, Little Bentwing-bat or Yellow-bellied Sheathtail-bat.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and/or potential habitat for the cave-roosting bats include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Eastern Cave Bat, Large-eared Pied Bat, Eastern Bentwing-bat and the Little Bentwing-bat all roost primarily in rock caves or mine shafts. The Eastern Cave Bat prefers well lit roosts and sometimes roosts under rock overhangs. The Yellow-bellied Sheathtail-bat often roosts in crevices and cracks. Subsidence due to longwall mining may cause cave-ins or collapses that alter or remove potential breeding and roosting habitat. The Proposal is unlikely to significantly impact on non-cave roosting resources (e.g. hollow-bearing trees);

- 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' (NSW Scientific Committee 2002a) – these bat species all forage along watercourses, although they also forage in woodland and forest habitats. The possible mechanisms of subsidence and physical effects of subsidence are highly unlikely to result in a significant loss of woodland and forest habitats; and

- 'Human-caused Climate Change' (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for these Bat species. In particular, global warming may cause a range extension or distribution shift for the Eastern Cave Bat and Little Bentwing-bat, for which the Study Area occurs at the southern limits of known distribution for these species.

Conclusion

Known and potential habitat for the Eastern Bentwing-bat, Eastern Cave Bat, Eastern False Pipistrelle, Golden-tipped Bat, Large-eared Pied Bat, Little Bentwing-bat and Yellow-bellied Sheathtail-bat occurs within the woodland, forest and Upland Swamp habitat within the Study Area. Impacts associated with subsidence events may result in the loss, disruption or modification of potential foraging, roosting and breeding habitat for the seven Bat species. Given the minor nature of subsidence impacts (Section 9.2.1 of the SIS); large extent of potential habitat within the Study Area and Locality; and mobility of all seven Bat species it is **unlikely** that the Proposal would have a significant impact on a local population of the Eastern Bentwing-bat, Eastern Cave Bat, Eastern False Pipistrelle, Golden-tipped Bat, Large-eared Pied Bat, Little Bentwing-bat or the Yellow-bellied Sheathtail-bat.

Southern Myotis	***Myotis macropus***

The Southern Myotis is listed as Vulnerable on Schedule 2 of the TSC Act. The Southern Myotis is the southern subspecies of the Large-footed Myotis *Myotis adversus* (currently being separated into three divisions).

The Southern Myotis is known to roost in caves, but it has been considered separately from cave-dependent bats in this assessment because it is also able to roost in tree hollows under bridges and in mines (Richards 1995, Churchill 1998) and it has a particular requirement for foraging along waterways, a habitat feature that is more likely to be impacted by subsidence than general forest and woodland habitats. For the purpose of this assessment, all rock crevices, overhangs and small caves are considered as potential roosting resources.

The Southern Myotis occurs in a broad range of habitat types including swamps, rainforest and woodland within close proximity to water sources. They have been caught in mangroves, paperbark swamps, riverine monsoon forest, rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland (Churchill 1998). Southern Myotis forage over streams and pools, catching insects (e.g. water-boatmen, mayflies and water striders) and small fish by raking their feet across the water surface. They are also aerial foragers, including prey such as moths, beetles, crickets, cockroaches and flies.

The Southern Myotis was recorded in the Study Area as *definite*, *probable* (80 % certainty) and *possible* identifications along Wongawilli Creek (Section DA3C) during Anabat analysis. The species was also recorded as *probable* (80 % certainty) and *possible* identifications along Sandy Creek (Section DA3A) in the Study Area. The DECC holds another five records of the species from 1999 within the 10 km search area (two within the Study Area and two within the Locality). One of these records also occurs along Wongawilli Creek in the Study Area.

Potential habitat in the Study Area also occurs in the forest and woodland habitats (within the Sandstone Gully Peppermint Forest, Exposed Sandstone Scribbly Gum Woodland, Tall Open Peppermint-Blue Gum Forest, Moist Gully Forest and Nepean Sandstone Gully Forest plant communities).

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Southern Myotis generally roosts in groups of 10-15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage (DEC 2005x). They will often choose caves that overhang pools even when the caves are rather open (Churchill 1998). In NSW, females have one young each year, usually in November or December (DEC 2005x). They may form small breeding groups with a single male and one to twelve females (Churchill 1998). Other males may roost alone or in small all-male clusters (Churchill 1998). Known and potential habitat for this species occurs in woodland and forest within the Study Area.

Potential impacts from the Proposal are mostly restricted to habitats such as streams, creeks, ridgetops and rocky outcrops/cliffs. The main impacts of subsidence on the Southern Myotis are likely to involve the potential loss of foraging and breeding resources. Subsidence impacts may alter potential foraging sites through fracturing of bedrock and therefore re-direction of surface flows, hence, possible reduction of prey species such as fish. Such impacts are likely to occur within the smaller creeks that would be directly mined beneath. However, these events are expected to be isolated and of a minor nature, and unlikely to result in any significant surface water flow diversions (MSEC 2007). In addition, larger creeks such as Sandy and Wongawilli Creeks will not be mined beneath are not expected to result in any significant impacts (MSEC 2007).

The possible collapse of rocky overhangs, rocky crevices and small caves due to subsidence impacts, may result in the loss, disruption or modification of potential roost and breeding habitat for the Southern Myotis. However, as discussed in Section 9.2.1 of the SIS, the predicted impacts are not expected to be more than 7 – 10 % of the entire length of any ridge line that is mined beneath. Furthermore cliff lines and overhangs that will not be directly mined beneath are unlikely to exhibit any significant impacts (MSEC 2007).

Given foraging, roosting and breeding habitat features are widely distributed throughout the Locality (19,230 ha), that the species is also known to use foraging and breeding resources less likely to be impacted by subsidence (e.g. flying insects and tree-hollows within woodland/forest), and the mobility of this species, it is unlikely that potential impacts of subsidence would have a significant impact on foraging, breeding or roosting habitats. Although some individuals may be impacted by the Proposal (due to possible collapse of rock overhangs) it is unlikely that the Proposal would place a viable local population of the Southern Myotis at risk of extinction

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in NSW in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, no population of Southern Myotis is listed as an Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

The Study Area contains approximately 3,079 ha of known and/or potential habitat for the Southern Myotis within the forest and woodland habitats. Specifically, habitats with watercourses for foraging and suitable breeding and roosting resources are likely to be important for these species within the Study Area. Subsidence has the potential to alter a proportion of these habitat features (i.e. rock overhangs) within the Study Area, though it is highly unlikely that all of this habitat would be impacted. Section 9.2.1 of the SIS details the “predicted” impacts of subsidence on these habitat types. The potential habitat for the Southern Myotis in the Study Area represents 16 per cent of potential habitat within the Locality.

Potential habitats for the Southern Myotis within the Study Area are of similar quality and continuous with habitat in the greater Locality. Additionally, the Southern Myotis is highly mobile. Therefore, it is unlikely that the Proposal would isolate or fragment areas of known or potential habitat for this species.

The habitat within the Study Area is considered to be of good quality, containing watercourses, varying densities of vegetation, and good canopy for foraging as well as hollow-bearing trees, rock crevices and rocky overhangs for roosting.

These habitat features are widely distributed within the Locality. Given the mobility of this bat species it is unlikely to be entirely dependant on the habitat features within the Study Area. As such the Study Area is only likely to be of moderate importance to the long-term survival of the Southern Myotis.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been for the Southern Myotis (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

To date, there is no recovery plan or threat abatement plan for the Southern Myotis.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on known and potential habitat for the Southern Myotis include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Southern Myotis may roost in caves and rock overhangs which may collapse as a result of subsidence (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). It is also possible that foraging habitat for this species would be reduced by the effects of subsidence (e.g. loss of surface flow in creeks);

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Southern Myotis forages almost exclusively at water sources such as rivers and streams. The possibility of watercourses being altered or the flow being reduced could result in a reduction of foraging habitat and important prey species for the Southern Myotis; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for the Southern Myotis.

Conclusion

The Proposal has the potential to impact the Southern Myotis through alteration of forest and woodland habitat along watercourses and ridge lines, resulting in loss of potential foraging habitat, prey species and roosting habitat. Subsidence is highly unlikely to affect the full extent of potential habitat in the Study Area and impacts are only expected to be minor, occurring at some of the creeks, drainage lines and ridge lines that are mined beneath.

The Proposal would result in the operation of three KTPs, which could result in loss of foraging, roosting and breeding habitat, reduction in water insect prey species and the death of roosting individuals. However, potential foraging and roosting habitat is abundant throughout the Locality thus; it is **unlikely** that the Proposal would have a significant impact on a local population of the Southern Myotis.

Greater Broad-nosed Bat	***Scoteanax rueppellii***

The Greater Broad-nosed Bat is listed as Vulnerable on Schedule 2 of the TSC Act.

The Greater Broad-nosed Bat prefers moist gullies in mature coastal forests and rainforests, between the Great Dividing Range and the coast. The species roosts in hollow tree trunks and branches (Churchill 1998) and has also been found in buildings. The Greater Broad-nosed Bat is a slow flyer with low manoeuvrability and tends to forage along gaps and edges of forests and bushland patches, in moist gullies of mature coastal forest or in rainforest (Churchill 1998). The Greater Broad-nosed bat feeds on a range of insects including moths and beetles.

The Greater Broad-nosed Bat was detected on a number of occasions throughout the Study Area with varying levels of confidence. The highest level recorded was 80 per cent *probable* in Sandstone Gully Peppermint Forest creek lines followed by 70 per cent *probable* in Upland Swamp Fringing Eucalypt Woodland. Further potential habitat occurs within forest and woodland habitat (Coachwood Warm Temperate Rainforest, Tall Open Peppermint-Blue Gum Forest, Moist Gully Forest and Nepean Sandstone Gully Forest) and Upland Swamps (Upland Swamp Sedgeland Heath Complex, Upland Swamp Banksia Thicket and Upland Swamp Tea-tree Thicket). It has been previously recorded at multiple sites within 10 km of the Study including within the Locality.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Little is known of the reproductive cycle of the Greater Broad-nosed Bat. A single young is born in January and prior to birth, females congregate at maternity sites located in suitable trees, where they appear to exclude males during the birth and raising of the young.

Potential habitat for this species occurs within forest, woodland and Upland Swamps in the Study Area where there is suitable trees with hollows and decorticating bark suitable for roosting, and foraging habitat. Subsidence impacts associated with the Proposal may result in changes to water flow, water quality and vegetation. However, as discussed in Section 9.2.1 of the SIS these impacts are considered unlikely, and therefore, changes to vegetation even less likely. Some vegetation immediately surrounding any cracking may die, but the impacts from the loss of this vegetation are considered to be negligible. In addition larger creeks such as Sandy and Wongawilli Creeks will not be mined beneath and are not expected to result in any significant impacts (MSEC 2007).

The Proposal is highly unlikely to impact potential breeding habitat (i.e. tree hollows) for the Greater Broad-nosed Bat. The possible mechanisms and physical effects of subsidence are highly unlikely to result in a significant loss of hollow-bearing trees from the Study Area. There is a limited possibility of some trees becoming dislodged and hence dying due to surface cracks, although large-scale tree death due to subsidence has not been previously observed.

Subsidence impacts are likely to impact foraging habitat only for the Greater Broad-nosed Bat and are highly unlikely to impact on breeding habitat (i.e. tree hollows). It is therefore unlikely that the Proposal would have a significant impact on the life cycle of a viable local population of the Greater Broad-nosed Bat such that it was placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in NSW in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, no population of the Greater Broad-nosed Bat is listed as an Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.**

Known and potential habitat for the Greater Broad-nosed Bat in the Study Area is considered to be within forest and woodland and Upland Swamp habitats. Specifically, habitats along creek and river corridors and those that contain suitable trees with hollows and decorticating bark suitable for roosting are likely to be important for the Greater Broad-nosed Bat. The Study Area contains approximately 1,521 ha of woodland, forest and Upland Swamp habitat for this species. Subsidence has the potential to alter a proportion of these habitat features within the Study Area (Section 9.2.1 of the SIS) though it is highly unlikely that all of this habitat would be impacted. These habitat types are widely distributed throughout the Locality (10,764 ha). Potential habitat for the Greater Broad-nosed Bat within the Study Area represents 14.1 per cent of the available habitat within the Locality.

Given the mobility of the Greater Broad-nosed Bat and continuous habitat within the Locality, it is unlikely that the Proposal would isolate or fragment areas of known or potential habitat for this species.

The habitat within the Study Area is considered to be of good quality, containing watercourses, varying densities of vegetation and good canopy for foraging, as well as hollow-bearing trees for roosting. This habitat is continuous with habitat of a similar quality within the Locality and it is likely the Greater Broad-nosed Bat would utilise habitat outside the Study Area. Therefore, habitat that might be removed or modified by the Proposal is only likely to be of moderate importance to the long-term survival of the species in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Greater Broad-nosed Bat.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

To date, there is no recovery plan or threat abatement plan for the Greater Broad-nosed Bat.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Greater Broad-nosed Bat include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – the Greater Broad-nosed Bat is known to favour creeks and rivers as foraging sites. Subsidence can impact the flow of surface water in creeks and rivers, which may alter the amount of available habitat in the Study Area for this species;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – the Greater Broad-nosed Bat is known to favour creeks and rivers as foraging sites. Subsidence can affect the flow of natural water sources; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Greater Broad-nosed Bat.

Conclusion

The Greater Broad-nosed Bat was detected on a number of occasions throughout the Study Area with varying levels of confidence. The Proposal has the potential to impact this species through any alteration of forest, woodland and Upland Swamp habitat, particularly along watercourses and in gullies, resulting in loss of potential foraging habitat. The Proposal is highly unlikely to impact on roosting and breeding habitat (i.e. tree hollows).

The Proposal would result in the operation of three KTPs that could result in loss of foraging and roosting habitat. Given the species' mobility; extent of suitable habitat within the Locality and the unlikely impact on possible roosting habitat, it is **unlikely** that the Proposal would have a significant impact on a local population of the Greater Broad-nosed Bat.

Broad-headed snake	*Hoplocephalus bungaroides*

The Broad-headed Snake is listed as Endangered on Schedule 1 of the TSC Act and as Vulnerable on the EPBC Act.

The Broad-headed Snake mainly occurs in association with communities occurring on Triassic sandstone within the Sydney Basin and is typically found among exposed sandstone outcrops with west or north-westerly aspects with vegetation types ranging from woodland to heath. Within these habitats it generally uses rock crevices and exfoliating rock during the cooler months and tree hollows during summer (Webb and Shine 1998). Suitable rock crevices are important in order to maintain thermoregulatory functions such as maximising temperatures for evening feeding periods (Webb and Shine 1998). While little is known of the Broad-headed Snake's arboreal habits during the warmer months, trees which are known to regularly co-occur with known Broad-headed Snake sites include *Corymbia gummifera*, *Eucalyptus sieberi*, and *Eucalyptus piperita* which occur commonly in the Study Area. The Broad-headed Snake has restricted mobility, with recorded home ranges averaging 3.3 hectares in males and non-gravid females, and 0.05 hectares in gravid females (Webb and Shine 1997). Males and non-gravid females have been recorded moving up to 780 m during summer (Webb and Shine 1997). Home ranges of adult Broad-headed Snakes have virtually no overlap suggesting the maximum population density within a certain area may be limited (Webb and Shine 1997).

Potential habitat within the Study Area occurs within woodland and open forest Habitat (Exposed Sandstone Scribbly Gum Woodland, Rock Plate Heath-Mallee, Sandstone Gully Peppermint Forest and Nepean Sandstone Gully Forest plant communities). These habitats contain exposed sandstone outcrops where Broad-headed Snakes spend winter months as well as hollow-bearing trees of the species which regularly occur at known Broad-headed snake summer sites.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Broad-headed Snake has been recorded within the woodland and open forest habitats within the Locality on several occasions, including one record just outside the Study Area in Dendrobium Area 2 on a ridge line.

The Broad-headed Snake could potentially be impacted by subsidence due to the proposed longwall mining. The main impacts of subsidence on the woodland and open forest habitats are likely to include possible impacts on rocky outcrops, overhangs and cliffs. Although rock falls may destroy sheltering habitat (overhangs, caves, crevices), these may also create new habitat for this species. In addition to disturbance of rocky outcrops and cliffs, fracturing of the sandstone may result in cracks forming on the ridge lines, hence it is possible that individual Broad-headed Snakes may be impacted.

It is possible that the impacts of subsidence on the Broad-headed Snake may result in the loss of individuals and/or modification of potential habitat. However, the woodland and open forest habitats including exposed sandstone outcrops are widely represented within the Study Area and Locality. Given the predicted impacts of rockfalls and cliff disturbance is expected to be small and the extent of potential habitat within the Study Area and Locality, it is unlikely that a viable local population of the Broad-headed Snake would be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, no population of the Broad-headed Snake is listed as an Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality**

Known and potential habitat for Broad-headed Snake occurs in Sandstone Gully Peppermint Forest, Exposed Sandstone Scribbly Gum Woodland, Rock Plate Heath-Mallee and Nepean Sandstone Gully plant communities within the Study Area where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of these plant communities, is considered potential habitat for the species.

- The Study Area Contains approximately 3,036 ha of known and/or potential habitat for the Broad-headed Snake, located within ridge lines and creek lines;
- Specifically, habitats including particularly exposed sandstone outcrops within the woodland and open forest are likely to be important for the species within the Study Area;
- Subsidence has the potential to alter a proportion of these habitat features within the study area though it is highly unlikely that all of this habitat within the study area would be impacted;
- These habitats are widely distributed within the Locality (approximately

17,100 ha). The potential habitat for the broad-headed Snake in the Study Area represents 17.8 per cent of potential habitat within the Locality; and

- Section 9.2.1 of the SIS details the “predicted” impacts of subsidence on these habitat types.

The Proposal will not result in any large-scale habitat fragmentation. The Proposal may alter the habitats in localised portions of the Study Area over the long-term. Given that large-scale alteration of the habitats in the Study Area is considered unlikely, the Proposal is not likely to result in the isolation or fragmentation of Broad-headed Snake habitat within the Study Area.

The habitat within the Study Area is of good quality for the Broad-headed Snake and previous surveys conducted by Biosis Research within the Locality indicate that the habitat outside the area to be impacted (by the current Proposal) is of similar quality. While woodland and forest plant communities that could provide potential habitat for the species are continuous throughout the Locality, suitable rocky outcrops and crevices that occur close to hollow-bearing trees may occur more infrequently. Any impacts are unlikely to disrupt the potential for genetic exchange within and between populations of this species in the Study Area (if present) and the Locality. The Broad-headed Snake is considered to be an extremely rare resident within the Greater Southern Sydney Region for which longwall mining can alter habitat (DEC 2005Ž). The species has been recorded within the Locality including just outside the Study Area in Dendrobium Area 2 and is likely to occur within the Study Area. The habitat within the Study Area is considered likely to be of importance to the long-term survival of a local population of this species in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Broad-headed Snake (DEC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is currently no Commonwealth or NSW recovery plan or threat abatement plan for the Broad-headed Snake. However, the DECC has prepared 22 Priority Actions and recovery actions to help recover this species. Those relevant to the Proposal are outlined below.

- Retain woodland adjacent to sandstone escarpments, particularly large hollow-bearing trees – woodland and forest will be retained adjacent to escarpments, as will hollow-bearing trees;

- Undertake artificial or replacement rock initiatives to replace or supplement lost habitat – while subsidence has the potential to impact potential habitat of the Broad-headed Snake, rock falls may provide alternate or additional habitat areas, and thus no artificial habitat would be required; and

- Retain sandstone rock in bushland on escarpment areas – subsidence has the potential to alter the current state of sandstone rock (e.g. rockfalls) however, would not remove any sandstone rock from the Study Area.

Whether the action proposed is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

KTPs listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Broad-headed Snake include:

- ‘Alteration of habitat following subsidence due to longwall mining’(NSW Scientific Committee 2005a) - The Broad-headed Snake has been specifically listed in the final determination for this KTP as a species ‘known to occur in areas affected by subsidence due to longwall mining’ and its habitat is considered ‘likely to be altered by subsidence and mining-associated activities’ as it is typically found among exposed sandstone outcrops and shelters within rock crevices, which can be impacted by subsidence (NSW Scientific Committee 2005a). The Proposal is likely to result in the operation of this KTP in relation to the Broad-headed Snake winter habitat in the Study Area. However, impacts to rocky outcrops, crevices and overhangs are predicted to occur over a small percentage of the Study Area and to be localised. The operation of this KTP is unlikely to impact the Broad-headed Snake summer habitat (i.e. tree hollows) within the Study Area; and
- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Broad-headed Snake.

Conclusion

The Broad-headed Snake has not been recorded within the Study Area however, the species has been recorded within the Locality including just outside the Study Area in Dendrobium Area 2. Potential habitat within the Study Area occurs within woodland and open forest habitat (Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Rock Plate Heath-Mallee and Nepean Sandstone Gully Forest plant communities). These habitats contain exposed sandstone outcrops where Broad-headed Snakes spend winter months as well as hollow-bearing trees during summer.

The Proposal will result in the operation of two KTPs which has the potential to impact foraging, sheltering and breeding habitat for the Broad-headed Snake. The Proposal is likely to cause fracturing of sandstone resulting in cracking and possible fauna entrapment areas, disturbance to rocky outcrops and overhangs and disturbance to rocky cliffs. Although individual Broad-headed Snakes and potential habitat may be impacted by the Proposal, the predicted occurrence of rockfalls and cliff instabilities is expected to be small (between seven and 10 %). Furthermore, given the extent of potential habitat within the Study Area (3,036 ha) and Locality (17,100 ha) it is unlikely that the Proposal would result in an impact on the life cycle of the species or fragmentation of a population within the Locality. Given all of the above, it is considered **unlikely** that the Proposal would result in a significant impact on the Broad-headed Snake.

Rosenberg's Goanna	***Varanus rosenbergi***

Rosenberg's Goanna is listed as Vulnerable on Schedule 1 of the TSC Act.

Rosenberg's Goanna is a Hawkesbury/Narrabeen sandstone outcrop specialist (Wellington and Wells 1990). Within these areas, the Rosenberg's Goanna typically inhabits heath, open forest and woodland where it is active diurnally and shelters nocturnally in hollow logs, fallen dead timber, burrows (which it digs) or other species burrows (e.g. rabbit), rock crevices and sandstone outcrops (Aitkens 1999). This species is a generalist forager and scavenger, and as such its diet consists mainly of insects and smaller reptiles but it will scavenge on mammals killed on roads where available (King and Green 1993). Termite mounds are a critical habitat component as they are required for nesting (DEC 2005†). The female Rosenberg's Goanna digs a chamber underneath a termite mound where she lays a clutch of up to 14 eggs (which take approximately eight months to hatch). Little published data about home range and mobility of the Rosenberg's Goanna exists and it is considered that individuals require large areas of habitat (DEC 2005†). Based on studies conducted on Kangaroo Island, the Rosenberg's Goanna has a relatively small home range, averaging 19.44 hectares (King and Green 1993). However, radio-tracking of individuals in the

Goobang Dam area, NSW has recorded individuals roaming distances in the order of 4-5 km over a couple of days (W. Smith, former employee of National Parks & Wildlife Service, Queanbeyan, pers. comm.). They are generally slow moving and on the tablelands likely only to be seen on the hottest days (DEC 2005†).

Rosenberg's Goanna was not recorded during the current surveys however it has been previously recorded by Biosis Research on a few occasions within Exposed Sandstone Scribbly Gum Woodland in the Study Area. The species has also been previously recorded by Biosis Research within the Locality. Further potential habitat within the Study Area occurs within Sandstone Gully Peppermint Forest, Rock Plate Heath-Mallee, Transitional Shale Stringybark Forest, Tall Open Peppermint-Blue Gum Forest, Moist Gully Gum Forest, Nepean Sandstone Gully Forest and Upland Swamp plant communities where suitable microhabitat features (described above) occur.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Rosenberg's Goanna is dependent upon the distribution of termite mounds in which it nests. The species shelters amongst surface rock, outcropping rock or fallen dead timber (DEC 2005†).

Rosenberg's Goanna was not recorded during the current surveys however it has been previously recorded multiple times both within the Study Area and Locality. Known and potential habitat for this species occurs within the woodland, forest, heath-mallee and Upland Swamp plant communities of the Study Area where hollow logs, fallen dead timber, burrows, rock crevices, sandstone outcrops and termite mounds occur.

Potential foraging habitat for this species exists within Upland Swamps, which could be impacted by changes to water flow and water quality, cracking and gas emissions, however impacts on vegetation are likely to be neglibible. As Rosenberg's Goanna is unlikely to be reliant on specific riparian vegetation or water flow regimes, impacts from subsidence on these features are unlikely to cause significant disruption to Rosenberg's Goanna's foraging and/or breeding abilities in the Study Area.

Direct impacts on Rosenberg's Goanna are possible through the collapse of rock crevices, rock overhangs and burrows as a result of subsidence, and may cause death or injury to individuals. Although rock falls may destroy sheltering habitat (overhangs, caves, crevices), these may also create new habitat for this species. Loss of sheltering sites could affect the life cycle of a local population as individuals are believed to return to the same sheltering sites regularly (W.

Smith, pers. comm.).

Impacts to nesting resources (termite mounds), alternate shelter sites (hollow logs and fallen wood) and the general woodland/forest habitat this species uses for foraging is expected to be negligible. Therefore, it is considered unlikely the Proposal would place a viable local population of Rosenberg's Goanna at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, no population of Rosenberg's Goanna is listed as an Endangered Population.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality**

Known and potential habitat for Rosenberg's Goanna occurs in Exposed Sandstone Scribbly Gum Woodland, Sandstone Gully Peppermint Forest, Rock Plate Heath-Mallee, Transitional Shale Stringybark Forest, Tall Open Peppermint-Blue Gum Forest, Moist Gully Gum Forest, Nepean Sandstone Gully Forest and Upland Swamp plant communities within the Study Area where suitable breeding, foraging and sheltering resources occur. Only where such resources occur, and not the entire extent of these plant communities, is considered potential habitat for the species.

- The Study Area Contains approximately 3,700 ha of known and/or potential habitat for this species, located within Upland Swamps, ridge lines, creek lines and rainforest;
- Specifically, habitats where hollow logs, fallen dead timber, burrows, rock crevices, sandstone outcrops and termite mounds occur are likely to be important for the species within the Study Area;
- Subsidence has the potential to alter a proportion of these habitat features within the study area though it is highly unlikely that all of this habitat within the study area would be impacted;
- These habitats are widely distributed within the Locality (approximately 20,539 ha). The potential habitat for the broad-headed Snake in the Study Area represents 15.8 per cent of potential habitat within the Locality; and
- Section 9.2.1 of the SIS details the "predicted" impacts of subsidence on these habitat types.

The woodland and forest habitat types are continuous in the greater Locality and of similar quality to the habitat within the Study Area. The Proposal is unlikely to cause significant long-term isolation or fragmentation of potential habitat for the Rosenberg's Goanna within the Study Area. The Proposal may result in some small-scale fragmentation of Upland Swamps and creek lines (e.g. loss of water and/or riparian vegetation) however, such impacts are unlikely to create a movement barrier to the Rosenberg's Goanna.

Rosenberg's Goanna has been recorded within the Study Area. The known and potential habitat within the Study Area and Locality is considered to be in good condition, containing suitable foraging, sheltering and nesting resources. As the habitat within the Study Area is continuous with habitat of a similar quality within the Locality, there is potential for Rosenberg's Goanna to use surrounding habitat as well as providing for continued genetic exchange. Given that Rosenberg's Goanna is considered to be an "uncommon resident" within the Greater Southern Sydney Region (DEC 2005Ž); that it is present within the Study Area; that there is a high number of suitable resources occurring within the Study Area; and, the connectivity between areas of good habitat, the Study Area provides important habitat for the long-term survival of the species in the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for Rosenberg's Goanna (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is currently no recovery plan or threat abatement plan for Rosenberg's Goanna. However, the DECC has prepared 9 Priority Actions to help recover this species; one that is relevant to the Proposal is:

- Retain and protect heath, woodland and forest remnants within the known distribution of the species – subsidence has the potential to impact some known and potential habitat for this species within the Study Area, but habitat for this species is protected within the Study Area.

Whether the action proposed is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

KTPs are listed under Schedule 3 of the TSC Act. Two KTPs relevant to the Proposal that may impact on known and potential habitat for the Rosenberg's Goanna are outlined below.

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – known and potential habitat for Rosenberg’s Goanna occurs within Upland Swamps, creek lines and ridge lines. The collapse of rock crevices, overhangs and burrows may cause death or injury to individuals (such impacts are predicted to occur over a small percentage of the Study Area and to be localised). Any impacts on potential foraging resources are likely to be negligible for this species; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of known and/or potential habitat for Rosenberg’s Goanna.

Conclusion

The Proposal has the potential to impact the Rosenberg’s Goanna through any alteration of Upland Swamp, forest and woodland habitat, resulting in loss of potential foraging resources, sheltering and breeding habitat. The Rosenberg’s Goanna has been previously recorded within the Study Area and Locality and the Proposal has the potential to modify approximately 3,253 hectares of known and/or potential habitat for this species. This represents 15.8 per cent of the suitable habitat for this species within the Locality (20,539 ha). However, given the nature of subsidence, it is likely that only a proportion of this area may be impacted (e.g. creek lines, rock outcrops and Upland Swamps).

The Proposal would result in the operation of two KTPs which have the potential to result in loss of foraging, sheltering, and breeding habitat for a local population. However, the Proposal is unlikely to result in fragmentation or isolation of potential habitat for the species and good quality potential habitat for the Rosenberg’s Goanna is continuous within the Locality. The Rosenberg’s Goanna may use the Upland Swamps within the Study Area, but it would not be solely reliant on the habitat features contained within and would be able to use the surrounding woodland/forest habitats that are unlikely to be impacted by the Proposal. Termite mounds required by the species for nesting are unlikely to be impacted. While some sheltering resources may be destroyed via collapse of rock crevices, rock overhangs or burrows, other shelter resources less likely to be impacted such as hollow logs and fallen timber will still be available to be utilised. It is therefore considered **unlikely** the Proposal would have a significant impact on the long-term survival of the Rosenberg’s Goanna.

Giant Dragonfly	*Petalura gigantea*

The Giant Dragonfly is listed as Endangered on Schedule 1 of the TSC Act.

Potential habitat for the Giant Dragonfly includes wetland and swamp vegetation containing areas with sufficiently moist organic/peaty soil for breeding and larval development (DEC 2005s) (NSW Scientific Committee 2004). The adults are short-lived (living only during one summer season) and spend most of the time settled on vegetation. The larval stage is unusually long (up to 10 years or more) and larvae live in a burrow they dig under the swamp (NSW Scientific Committee 2004, DECC 2005). The species is an obligate carnivore, feeding on other invertebrates in both larval and adult life stages (DECC 2005). Nothing is known about the species larval behaviour, other than they are burrow dwelling; although they may leave their burrows to hunt during suitable weather or times of day, or may wait inside their burrow entrances to ambush prey (Ian Baird, pers. comm.). The adult Giant Dragonfly forages aerially within swamps, along swamp margins and in adjacent areas for their flying insect prey (DECC 2005).

The dispersal ability of the adult Giant Dragonfly is also unknown, although individuals, including females, have been observed as far away as 500 metres from a swamp on dry ridgetops or in other non-breeding habitats (Ian Baird, pers. comm.). It has been suggested that they may be poor fliers (or dispersers) (NSW Scientific Committee 2004), however, this suggestion is based upon a single observation of them not being recorded in a swamp with apparently suitable habitat within several kilometres of the known population at Wingecarribee Swamp (Ian Baird, pers. comm.).

Potential habitat for this species occurs in the Study Area within Upland Swamp vegetation types. A record of the Giant Dragonfly in the Locality has recently been confirmed, yet specific location information is not yet available.

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Giant Dragonfly has not been recorded in the Study Area, but a record of the species in the Locality has recently been confirmed. This species is difficult to detect as the adult stage is very short-lived and the long-lived larval stage is highly cryptic.

The Giant Dragonfly has previously been recorded by experienced odonate observers in Upland Swamps at similar elevations nearby to the Study Area at Uloola Swamp near Waterfall in 1969-70, in the early 1990's, and in December 1999. The nearest records for the species to the south are for the extant population at Wingecarribee Swamp and for sightings 'near Robertson' in 1969-

70 (Ian Baird, pers. comm.). The Wingecarribee Swamp population lies approximately 18 km south-west of the Study Area. The life cycle of the Giant Dragonfly begins in its swamp breeding habitats where eggs are deposited in soft, moist/wet organic or peaty substrate (often in micro-topographic depressions) amongst swamp vegetation, including directly into *Sphagnum*, cracks in peat, under decaying plant litter and into small holes and cavities within the substrate and amongst exposed plant roots (Ian Baird, pers. comm.).

The unusually long larval stage is believed to extend up to 10 years or more, with the larvae excavating deep burrows in moist organic/peaty soil at the original oviposition site, where they spend their entire larval stage until adulthood (Ian Baird, pers. comm.). The larvae are generally thought to spend the day within their burrows and emerge to forage at night or during suitable conditions, for terrestrial insect prey (NSW Scientific Committee 2004). Within the Study Area, such breeding/larval development habitat could consist of groundwater-fed creeks or soaks within the Upland Swamps. The adult Giant Dragonfly hatches in summer and lives only during this season (NSW Scientific Committee 2004).

It is predicted that the 159 hectares of potential Upland Swamp habitat is unlikely to be significantly impacted by the proposal. It is also the case that adult Giant Dragonflies will use adjacent vegetation communities for foraging and can at times be found perching in adjoining Banksia Thickets, Mallee-Heath and Fringing Eucalypt Woodland (Ian Baird, pers. comm.). These Upland Swamp plant communities are often closely associated with the more likely Upland Swamp breeding habitats for the species, such as Tea-tree Thickets, Cyperoid Heath and perhaps wetter seepage patches within Restioid Heath (Ian Baird, pers. comm.). It should be noted that not all Upland Swamps within the Study Area are likely to contain suitable microhabitat requirements for breeding for the Giant Dragonfly.

Upland Swamps within the Study Area are believed to retain moisture partly due to impeded drainage groundwater captured by shale strata and released into the swamp. Significant changes to vegetation within the Upland Swamps of the Study Area are not predicted (MSEC 2007). Seepage creeklets, soaks and other groundwater-fed areas also exist within the Upland Swamps of the Study Area and may be impacted by the redirection of groundwater caused by subsidence (NSW Scientific Committee 2005a).

The action therefore has the potential to disrupt the life cycle of a viable local population, if it exists, by modifying potential breeding, larval development and foraging habitat for the Giant Dragonfly. The Giant Dragonfly's long-lived larval stage is limited to the swamp environment, the adults require swamp habitat to breed and dispersal between swamps by this species is largely undocumented and unknown. Thus, using the precautionary principle, a local population must be considered to be restricted to one isolated Upland Swamp. As such, the modification of an Upland Swamp containing a viable population of the Giant Dragonfly is likely to place this local population at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

An Endangered Population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in New South Wales in the near future. A population is not eligible to be listed as an Endangered Population if it is a population of a species already listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, there are no Endangered Populations listed for the Giant Dragonfly.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality**

Potential breeding, larval development and foraging habitat for the Giant Dragonfly is present within the Upland Swamps of the Study Area.

- The Study Area contains approximately 159 ha of potential Upland Swamp habitat for this species;

- Specifically, microhabitats including seepage creeklets, groundwater-fed creeks and soaks, burrows in moist organic/peaty soil and swamp vegetation are likely to be important for the species within the Study Area;

- Subsidence has the potential to alter a proportion of these habitat features within the Study Area though it is unlikely that all of this habitat within the Study Area would be impacted (MSEC 2007);

- Upland Swamps are distributed within the Locality (approximately 994 ha). The potential habitat for the Giant Dragonfly in the Study Area represents 16 per cent of potential habitat within the Locality; and

- Section 9.2.1 of the SIS details the "predicted" impacts of subsidence on these habitat types.

Upland Swamps occur within the Study Area within small stands where appropriate soil, geological and hydrological conditions prevail. The Proposal has the potential to modify water supply to Upland Swamps. Upland Swamps exist in small areas surrounded by other vegetation types such as forest and woodland within the Study Area. The adult Giant Dragonfly is known to forage within and around the Upland Swamp where it has spent its larval stage (NSW Scientific Committee 2004). In this context, subsidence is unlikely to fragment or isolate Upland Swamps in the Study Area any more than they naturally are at present. However, the larval stage of the Giant Dragonfly (which encompasses the majority of the life cycle of this species) is limited to burrows it constructs nearby its hatching site. If any partial drying of these areas occurred this could fragment larval burrow systems and impact larval development.

Potential habitat for the Giant Dragonfly occurs within the Study Area in Upland Swamps which are considered to be good quality habitat for the Giant Dragonfly. Upland Swamps of the Study Area vary seasonally in their moisture content, with many swamps being dry for part of the year and containing ephemeral water sources. These swamps support a diversity of flying and terrestrial insect prey items, making them good quality foraging habitat for both larval and adult stages of the Giant Dragonfly. Within the Upland Swamps, year-round groundwater-fed soak areas or creeklets provide moist, organic strata for breeding and larval diurnal burrowing habitat. In addition, surrounding fringing woodland vegetation and creek lines provide further foraging and sheltering habitat for adult Giant Dragonflies. All of these potential habitat types within or surrounding the Upland Swamps of the Study Area are considered to be good quality for the Giant Dragonfly and of high importance to the long-term survival of the species within the Locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Giant Dragonfly (DECC Threatened Species Unit).

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery or threat abatement plan has been prepared for the Giant Dragonfly to date. However, the DECC has listed 15 Priority Actions and recovery strategies to help recover this species. Those relevant to the Proposal are:

- Identify and map potential swamp habitat;
- Survey previously known and potential new habitat for presence – monitoring of any populations are recommended for the Study Area;
- Retain or reintroduce natural water flows to swamp habitats – subsidence may have the potential to alter water flows and/or the catchment size of Upland Swamps, although, large-scale impacts are not predicted; and
- Protect natural swamps from modification or disturbance – subsidence may have the potential to alter water flows, plant species composition and/or the catchment size of Upland Swamps, although, significant impacts are not predicted.

The Proposal may have the potential to modify or reduce the extent of Upland Swamp habitat available to this species as well as the potential to alter natural water flow regimes, which could modify the suitability of some currently available habitat for this species, thereby potentially threatening the recovery of this species if a population or populations are present within the Study Area.

Recommendations have been made in Section 8.0 for ongoing monitoring of the area for this species.

Whether the action proposed is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

KTPs are listed under Schedule 3 of the TSC Act. KTPs relevant to the Proposal that may impact on potential habitat for the Giant Dragonfly include:

- ‘Alteration of habitat following subsidence due to longwall mining’ (NSW Scientific Committee 2005a) – subsidence may impact Upland Swamps which provide potential habitat for the Giant Dragonfly. The predicted subsidence movements for the Upland Swamps within the Study Area may result in modified water levels within the swamps. It is also likely that the extraction of the longwalls within the Study Area would result in cracking in the swamp beds, particularly where the swamps are located with incised valleys. This fracturing and dilation of the underlying strata, could in turn result in the diversion of water into strata below. However, it is not predicted that the Upland Swamps within the Study Area would drain as a result of the Proposal because this fracturing would not connect to the mine workings or other deep storage;

- ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ (NSW Scientific Committee 2002a) – Subsidence can affect the flow of natural water sources which may alter habitats. However, significant changes to vegetation within the Study Area are not anticipated; and

- ‘Human-caused Climate Change’ (NSW Scientific Committee 2000b) – anthropogenic global warming has the potential to change average temperature conditions and the frequency of occurrence of extreme events (e.g. fire). Such outcomes may alter the suitability of potential habitat for the Giant Dragonfly.

If a Giant Dragonfly population exists within the Study Area, its Upland Swamp habitat may be modified by hydrological changes induced by subsidence-related cracking. Subsidence-related cracking could influence impeded drainage flow regimes, redirect ground water flows and reduce swamp catchment areas. These actions may have the potential to result in localised or whole of swamp drying Upland Swamp potentially leading to changes in fire regimes and erosion (large-scale drying of Upland Swamps is not predicted for the Proposal). This would result in the modification or loss of potential breeding, larval development and foraging habitat for the Giant Dragonfly.

Conclusion

The Giant Dragonfly has not been previously recorded within the Study Area, however a record for the species in the Locality has recently been confirmed. The Giant Dragonfly is a very cryptic species and difficult to detect. The Proposal has the potential to modify a proportion of 159 hectares of potential habitat for this species which represents approximately 16 per cent of potential habitat of similar quality within the Locality. However, potential breeding microhabitat requirements do not necessarily occur in all Upland Swamps of the Study Area. The potential habitat within the Study Area is considered to be good quality habitat for the Giant Dragonfly with potential foraging, breeding and larval development habitat present.

The Proposal would involve the operation of three KTPs, which have the potential to alter the current natural hydrology of the Upland Swamps, redirect flows within groundwater fed areas and reduce the catchment area of the swamps, which could lead to drying out of potential habitat and vegetation change. As the Giant Dragonfly's larval stage is limited to the swamp environment, the adults require swamp habitat to breed and dispersal between swamps by this species is largely unknown, using the precautionary principle, a local population must be considered to be restricted to one isolated Upland Swamp. As such, the modification or loss of any Upland Swamp within the Study Area containing a viable population of the Giant Dragonfly is likely to place this local population at risk of extinction.

Considering the above, it is **likely** that a local population of Giant Dragonfly would be significantly impacted by the Proposal.

9.3 Comparison of Impact Assessment With Previous Studies

The project has been previously assessed in the *Dendrobium Coal Project Likely Impacts of Subsidence on Terrestrial Ecology* (Biosis Research 2001a). This previous assessment addressed the likely impacts of subsidence on ecological features (with the exception of fish and fish habitat) above Areas 1, 2 and 3 of the proposed Dendrobium Coal mine. The Dendrobium Area 3 Study Area has been modified and is larger than the original area for the Biosis Research (2001a) report. The current study assesses potential impacts of the proposed Dendrobium Area 3 longwall mining only.

Since 2001, the procedures related to the assessment of threatened species in NSW, as listed in Schedules of the TSC Act, have changed. Prior to October 2005, Assessments of Significance were previously based on a regional and species-wide level of assessment, otherwise known as the Eight Part Test (NPWS

1996). Since October 2005 Assessments of Significance are referred to as Seven Part Tests and are based on an assessment of impacts to local populations of threatened species and local occurrences of Endangered Ecological Communities (DEC 2005). Thus, the current study is based on an assessment of impacts to threatened species at a local level as opposed to a regional or species-wide level.

A *local population* is defined in DEC (2005) as a population of a threatened species that occurs in the Study Area. In this SIS, the Study Area (the areas of direct and indirect impact) is the area above the proposed longwalls and 900 m downstream of the Subject Site. Therefore, any population of a threatened species occurring within the Subject Site and/or 900 m downstream of the Subject Site is defined as a *local population* in this study. This and other definitions are included in Section 1.1.

Table 17 below outlines the differences in the outcomes of the Eight Part Tests (regional and species-wide level of assessment) prepared for the 2001 assessment (Biosis Research 2001a) and the Seven Part Tests (local level of assessment) prepared in this study. The Stuttering Frog and Red-crowned Toadlet have now being assessed as *significantly impacted* where previously they were not. However, a reduction in a *local* population of the Red-crowned Toadlet was predicted in 2001. The difference is also a reflection of the changes in the extent and layout of the Dendrobium Area 3 longwalls between 2001 and 2007. The Giant Dragonfly has been assessed in the current SIS as *significantly impacted*, where, previously it was not assessed.

Table 17: Comparison of significance assessment from Biosis Research (2001a) and this study

Species	2001 Impact Assessment Outcome	2007 Impact Assessment Outcome
Fauna species assessed to be impacted significantly by the Proposal		
Giant Burrowing Frog	NOT DETECTED – Significant impact on species likely	DETECTED – Significant impact at local population level
Littlejohn’s Tree Frog	NOT DETECTED – Significant impact on species likely	DETECTED – Significant impact at local population level
Stuttering Frog	NOT DETECTED – Significant impact on species unknown	NOT DETECTED – Significant impact at local population level
Red-crowned Toadlet	DETECTED – No significant impact on species (impact on a local population predicted)	DETECTED – Significant impact at local population level
Giant Dragonfly	This species was not assessed in 2001.	NOT DETECTED – Significant impact at local population level. Record in Locality recently confirmed.

10.0 ADDITIONAL INFORMATION

10.1 Qualifications and Experience

Detailed curriculum vitae's for all staff members involved in the study are provided in Appendix 6.

10.2 Other Approvals Required for the Development

There are no other approvals relating to terrestrial flora and fauna required for the Proposal.

10.2.1 *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act)

On 20 December 2001, the proposed Dendrobium underground coal mine was approved by the Commonwealth of Australia as a controlled action in respect to Sections 18 and 18A listed threatened species and ecological communities) of the EPBC Act (Commonwealth of Australia 2001). Approval of the project was subject to five conditions which are summarised below:

1. Before clearing any native vegetation, BHPBIC must conduct a survey to identify any *Cryptostylis hunteriana* or *Caladenia tessellata* present in the area to be cleared.

2. BHPBIC must establish a monitoring program to establish whether Kembla Creek is used by Macquarie Perch *Macquaria australasica* for spawning.

3. If BHPBIC clear any vegetation which includes *Persoonia hirsuta*, the area must be revegetated to resemble the original vegetation community.

4. BHPBIC must take all reasonable measures to minimise the effect of the proposed action on the Giant Burrowing Frog *Heleioporus australasicus* in the vicinity of Sandy Creek.

5. BHPBIC must submit for the Ministers approval a plan for managing the impacts of the action on the Broad-headed Snake *Hoplocephalus bungaroides*. The plan must be implemented. No vegetation may be cleared as part of West Cliff Stage 3 Coal Wash Emplacement until the plan has been approved by the Minister.

Recent correspondence from the DEW dated 30 July 2007 has confirmed further approval under the EPBC Act for the modified footprint for Dendrobium Area 3 is **not** required.

10.3 Licensing Matters Relating to the Survey

Relevant licences and approvals for flora and fauna survey held by Biosis Research are:

- NSW *National Parks and Wildlife Act* 1974 - License Number S10318 to harm/trap/pick/hold/study protected fauna and native flora; and

- NSW *Animal Research Act* 1985 – Certificate of Approval by the Animal Care and Ethics Committee of the Director-General of NSW Agriculture to conduct fauna survey work carried out as part of Environmental Impact Statements, Species Impact Statements and general wildlife research.

10.4 Section 110 (5) reports

Section 110(5) of the TSC Act states that

"*The requirements of subsections (2) and (3) in relation to information concerning the State-wide conservation status of any species or population, or any ecological community, are taken to be satisfied by the information in that regard supplied to the principal author of the species impact statement by the National Parks and Wildlife Service, which information that Service is by this subsection authorised and required to provide*".

The information provided by the DECC in fulfilment of this requirement is available at http://www.threatenedspecies.environment.nsw.gov.au/index.aspx. This website provides profiles for threatened species, populations and ecological communities, and links to more detailed information.

Information provided by the DECC has been utilised in the preparation of this report and is cited where appropriate.

11.0 CONCLUSION

In accordance with the requirements of the Director General of DECC, a SIS has been prepared for the proposed Dendrobium Area 3 coal mine. The project has been previously assessed in the *Dendrobium Coal Project Species Impact Statement* (Biosis Research 2001c), although this report assessed the impacts of Dendrobium Areas 1-3 in combination with other projects associated with the Dendrobium Coal Mine, including West Cliff, Nebo and Kemira Valley. Due to a change in the assessment process between these two documents (i.e. Eight Part Tests at a species level in 2001, compared with Seven Part Tests at a local population level currently), two species (Stuttering Frog and Red-crowned Toadlet) previously assessed to not be significantly impacted have been determined to be significantly impacted in this document. A species previously not assessed (Giant Dragonfly) was determined to be significantly impacted in this document. The table below provides a comparison of the significance assessments for the five threatened species assessed to be significantly impacted by the Proposal during this study with the outcomes of the 2001 SIS (Biosis Research 2001d).

Flora Species

The Director General's requirements listed nine threatened plant species to be considered in this SIS. An additional 14 threatened plant species listed on the *Threatened Species Conservation Act* 1995 (TSC Act) and/or *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) that have been recorded or have potential habitat within 10 km of the Study Area were also considered. Of these, two threatened plant species, *Acacia bynoeana* and *Pultenaea aristata,* were recorded within the Study Area.

Potential habitat for a further nine threatened species occurs within the Study Area, these are: *Acacia baueri* ssp. *aspera, Cryptostylis hunteriana, Epacris purpurascens* var. *purpurascens, Grevillea parviflora* ssp. *parviflora, Leucopogon exolasius, Melaleuca deanei, Persoonia acerosa, Persoonia hirsuta* and *Persoonia bargoensis.* Seven Part Tests concluded that the Proposal was unlikely to have a significant impact on any threatened flora with known or potential habitat in the Study Area.

Fauna Species

Of the 55 fauna subject species (threatened fauna with potential habitat in the Study Area) 22 species were recorded in the Study Area, either during this study or during previous studies conducted by Biosis Research. Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Gang-gang Cockatoo, Glossy Black-cockatoo, Barking Owl, Eastern Freetail Bat, Grey-headed Flying-fox, Eastern Bentwing-bat, Large-eared Pied Bat, and Southern Myotis were recorded within the Study Area during the current surveys. As were the following threatened microbats, recorded with ‘probable’ certainty: Little Bentwing-bat, Eastern False Pipistrelle, Yellow-bellied Sheathtail Bat and Greater Broad-nosed Bat; and, ‘possible’ certainty: Golden-tipped Bat and Eastern Cave Bat.

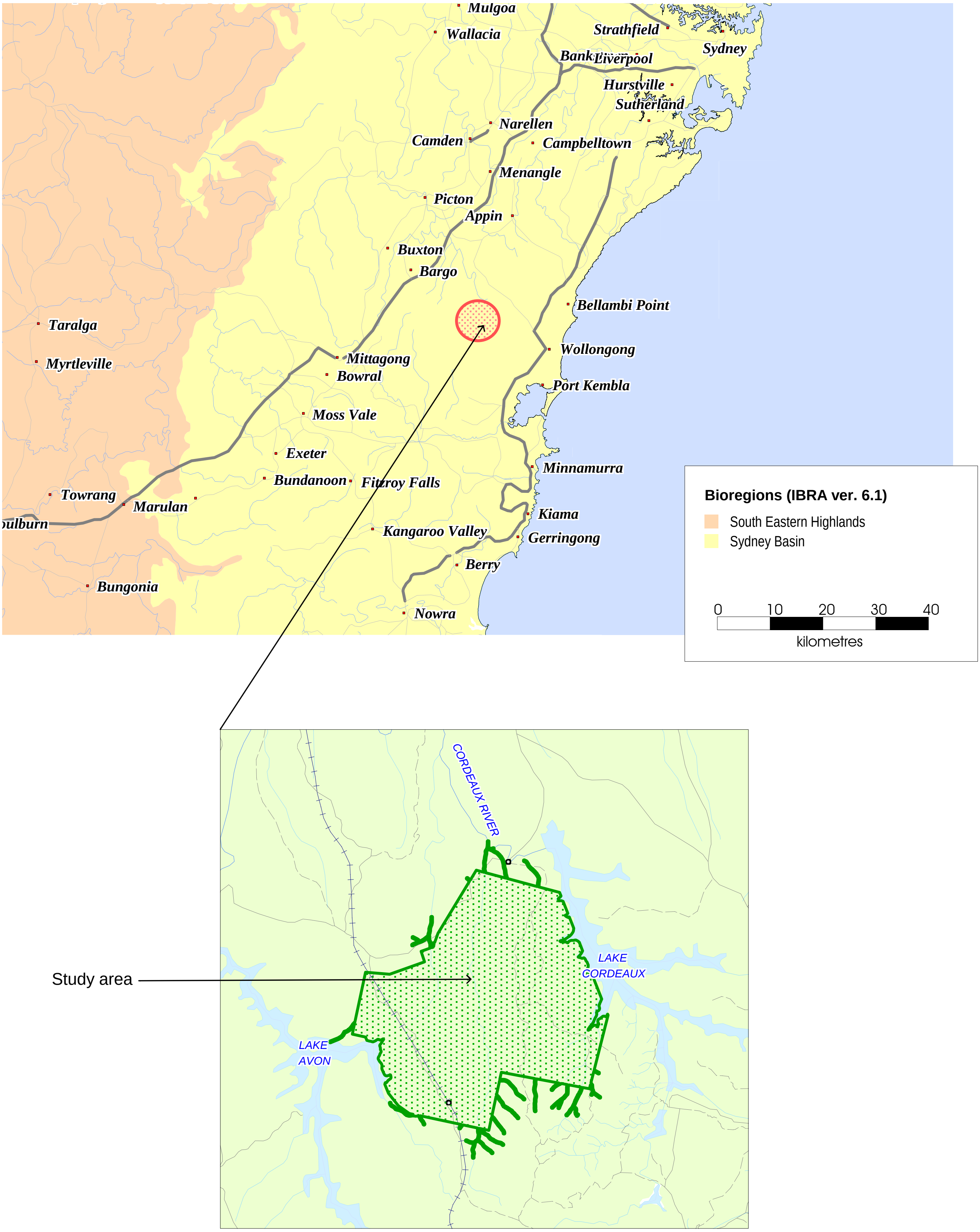
Olive Whistler, Powerful Owl, Eastern Pygmy-possum, Koala and Rosenberg’s Goanna have also been recorded within the Study Area by Biosis Research during Dendrobium fauna monitoring surveys or as incidental observations.

The Southern Brown Bandicoot has also been previously recorded within the Study Area (DECC Atlas of NSW Wildlife). Seven Part Tests were conducted for 32 affected fauna (subject fauna whose actual or potential habitat may be impacted by subsidence) and concluded that the Proposal would be likely to have a significant impact on local populations of Littlejohn’s Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Stuttering Frog and the Giant Dragonfly.

Endangered Ecological Communities

One Endangered Ecological Community (EEC), Shale Sandstone Transition Forest (mapped as Transitional Shale Stringybark Forest), as listed on both the TSC and EPBC Acts, was recorded within the Study Area during the field surveys. Drainage lines and other areas which may be subject to potential subsidence impacts are not significant landscape features within this occurrence of Shale Sandstone Transition Forest. On this basis, this community is considered unlikely to be significantly impacted by the Proposal.

FIGURES



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BIOSIS RESEARCH Pty. Ltd. 15 - 17 Henrietta Street Chippendale NEW SOUTH WALES 2008	Figure 1: Location of the Study Area in a regional context.			
	DATE: 4 Sep 07	Checked: JR	File: S4447	Scale: 0 1.5 3.0 4.5 6.0 kilometres
	Location:-...4000\4400s\4447\Mapping\SIS figures\S4447 F1_region.WOR			

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Figure 2: Aerial photograph of the Locality showing the boundaries of the Study Area and Subject Site.

Figure 2: Aerial photograph of the Locality showing the boundaries of the Study Area and Subject Site.

DATE: 5 September 2007

Checked by: RH | File number: S4447

Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F2_overview.WOR

Scale: 0 0.5 1.0 1.5 2.0 2.5 kilometres

N W E S

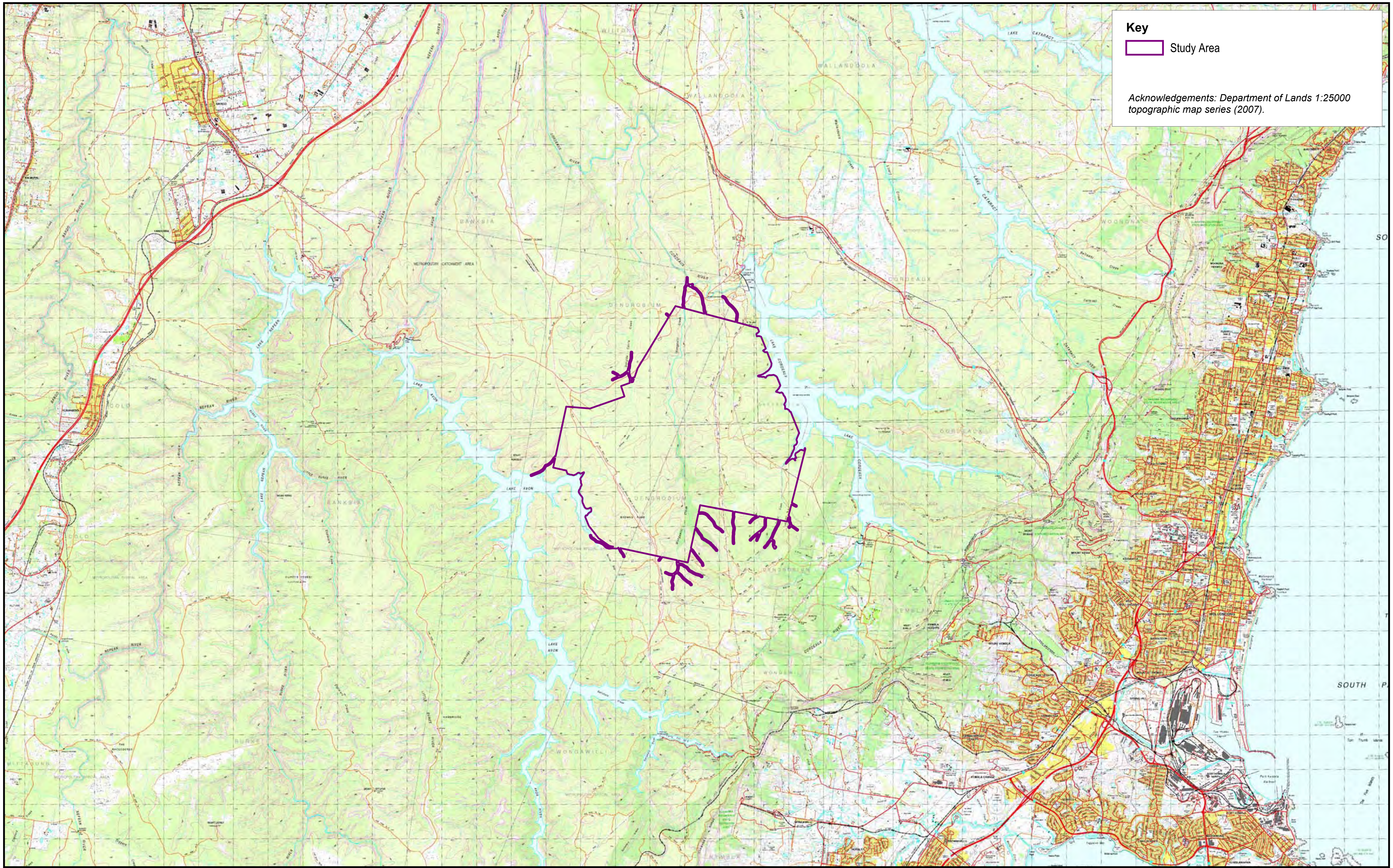

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Figure 3: Topographic map of the Study Area showing land use at a scale of 1:250,000).

Figure 3: Topographic map of the Study Area showing land use at a scale of 1:250,000).

DATE: 17 August 2007

Checked by: MR

File number: S4447

Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F3_topo.WOR

Scale: 0 1 2 3 4 5 kilometres

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Figure 4: Comparison of site boundaries - 2001 vs 2007 boundaries.

Figure 4: Comparison of site boundaries - 2001 vs 2007 boundaries.

DATE: 4 September 2007

Checked by: MR | File number: S4447

Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F4_boundaries.WOR

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N W E S

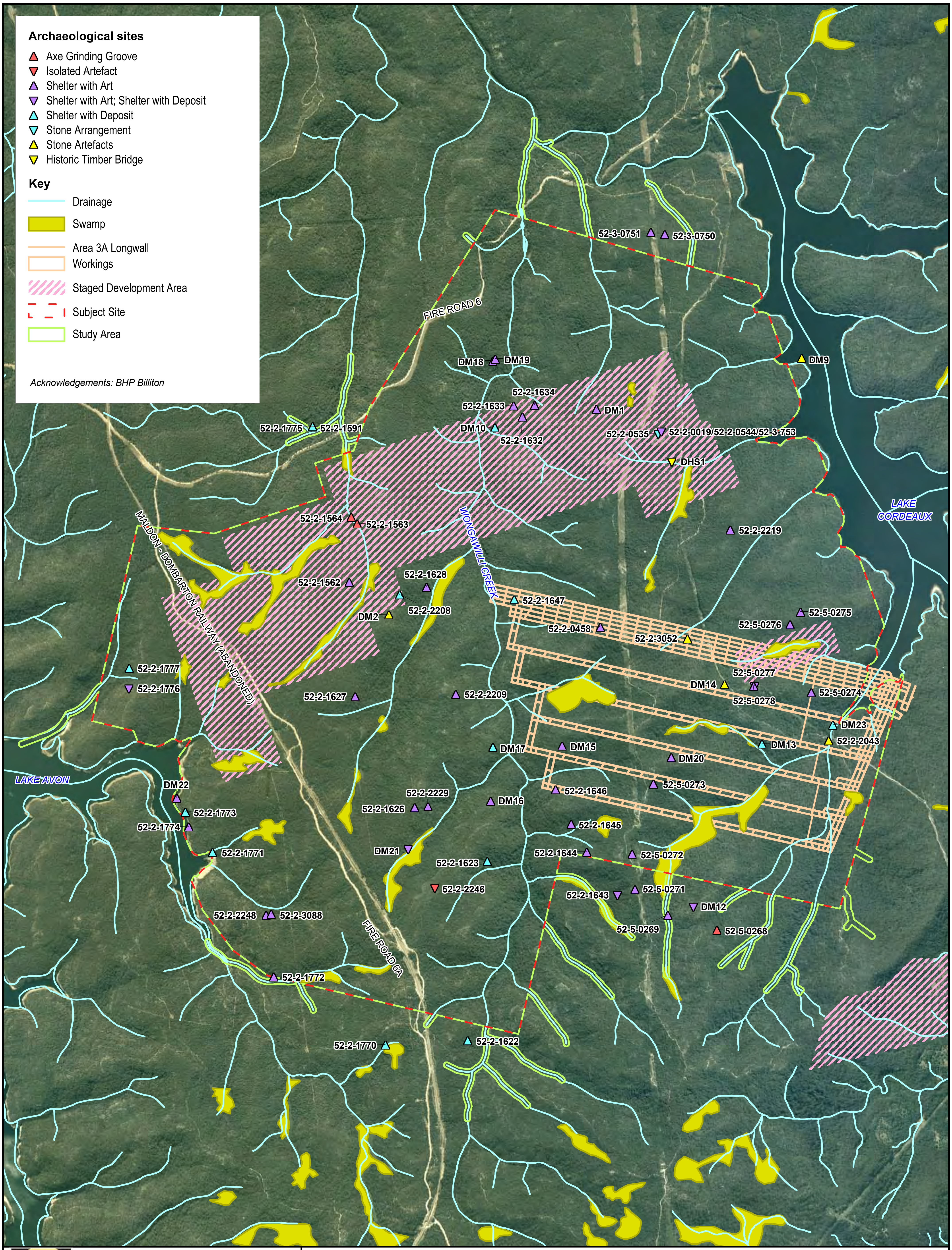

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Figure 5: Dendrobium Area 3: watercourses, swamps (MSEC (2007) 311-020) and archaeological sites.

DATE: 17 October 2007

Checked by: MR | File number: S4447

Location:-4000\4400s\4447\Mapping\SIS figures\S4447 F5_watercourses.WOR

Scale: 0 0.3 0.6 0.9 1.2 1.5 kilometres

N W E S

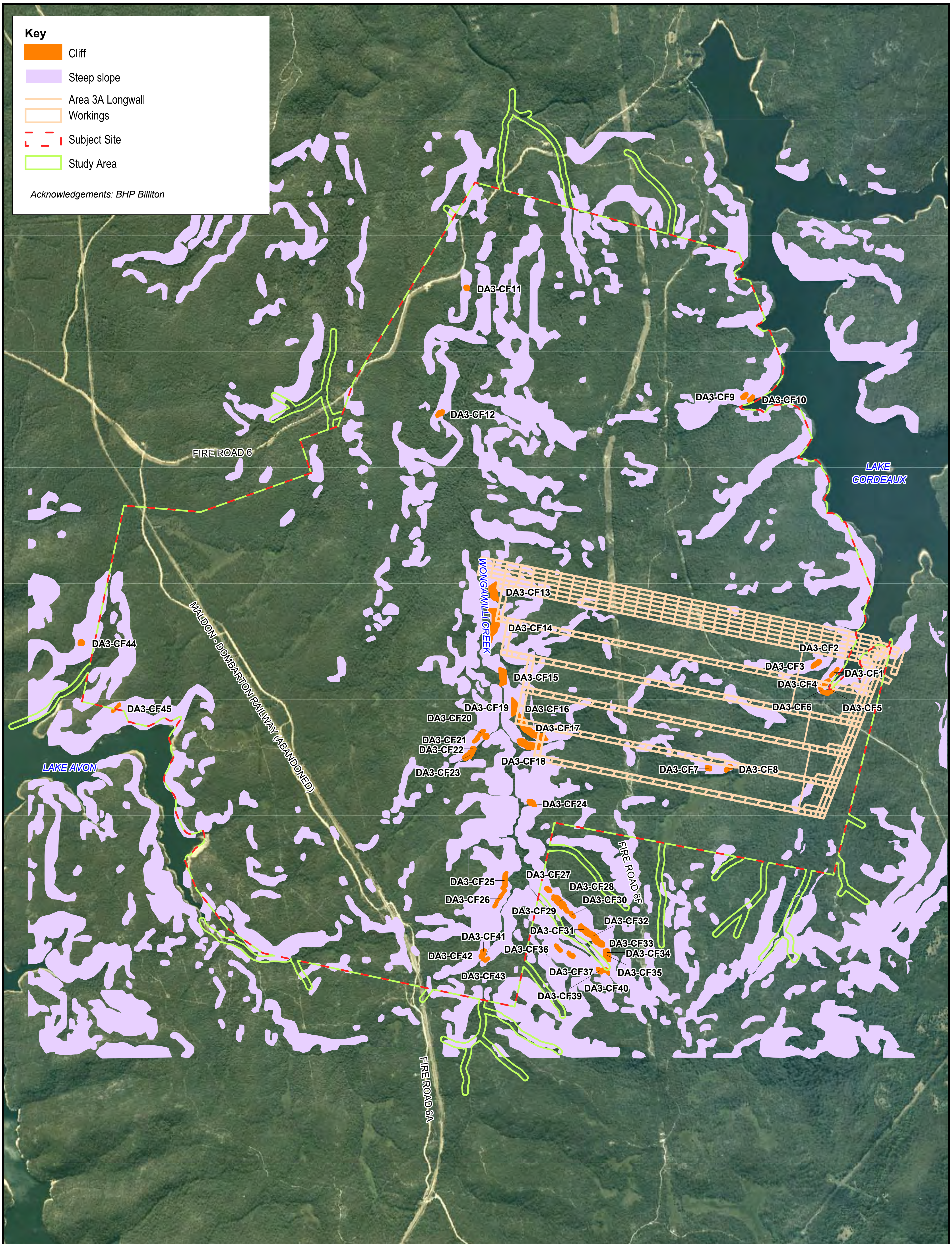

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Figure 6: Cliffs and steep slopes.

DATE: 17 October 2007

Checked by:

File number:

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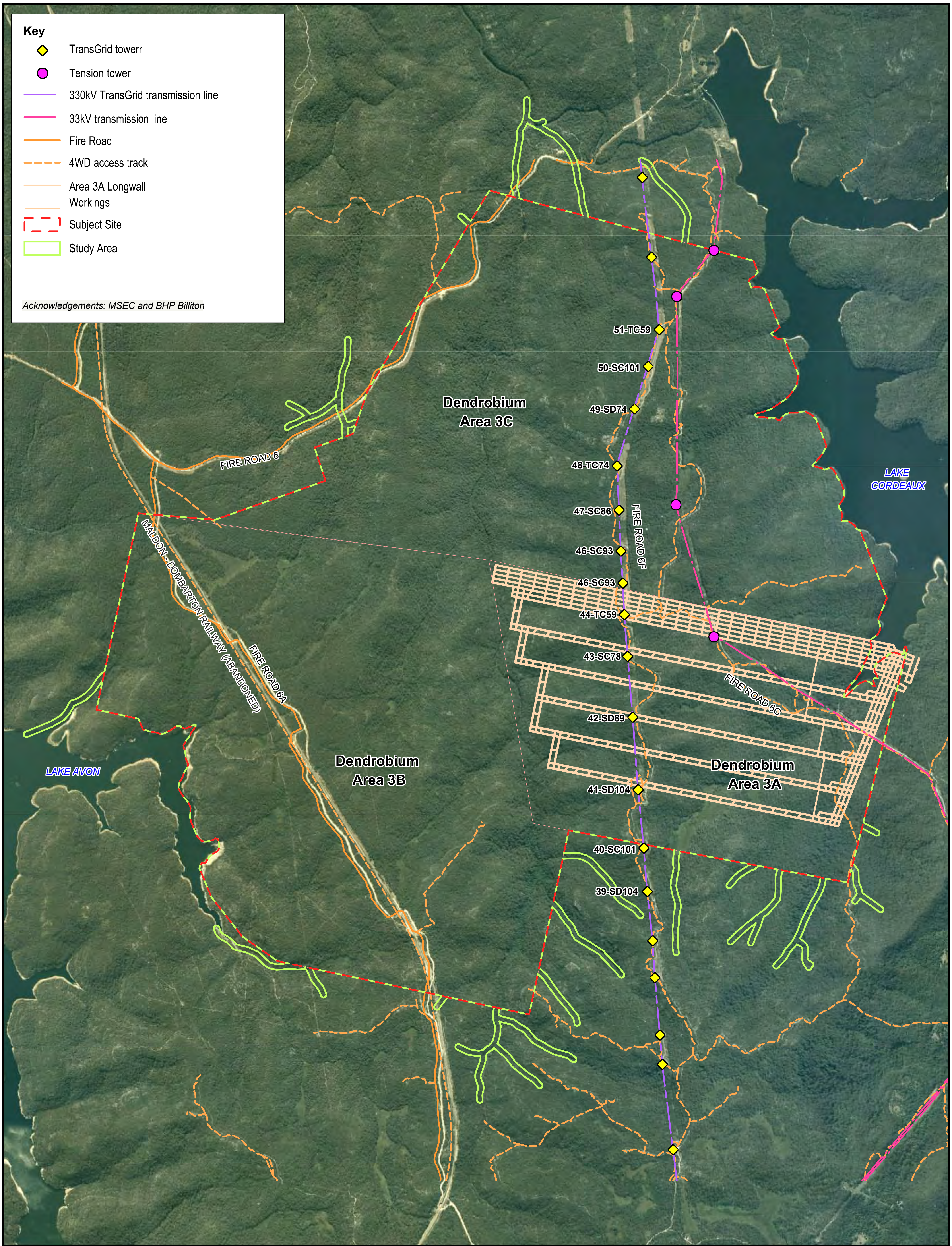

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Figure 7: Surface infrastructure.

DATE: 17 October 2007

Checked by:

File number: S4447

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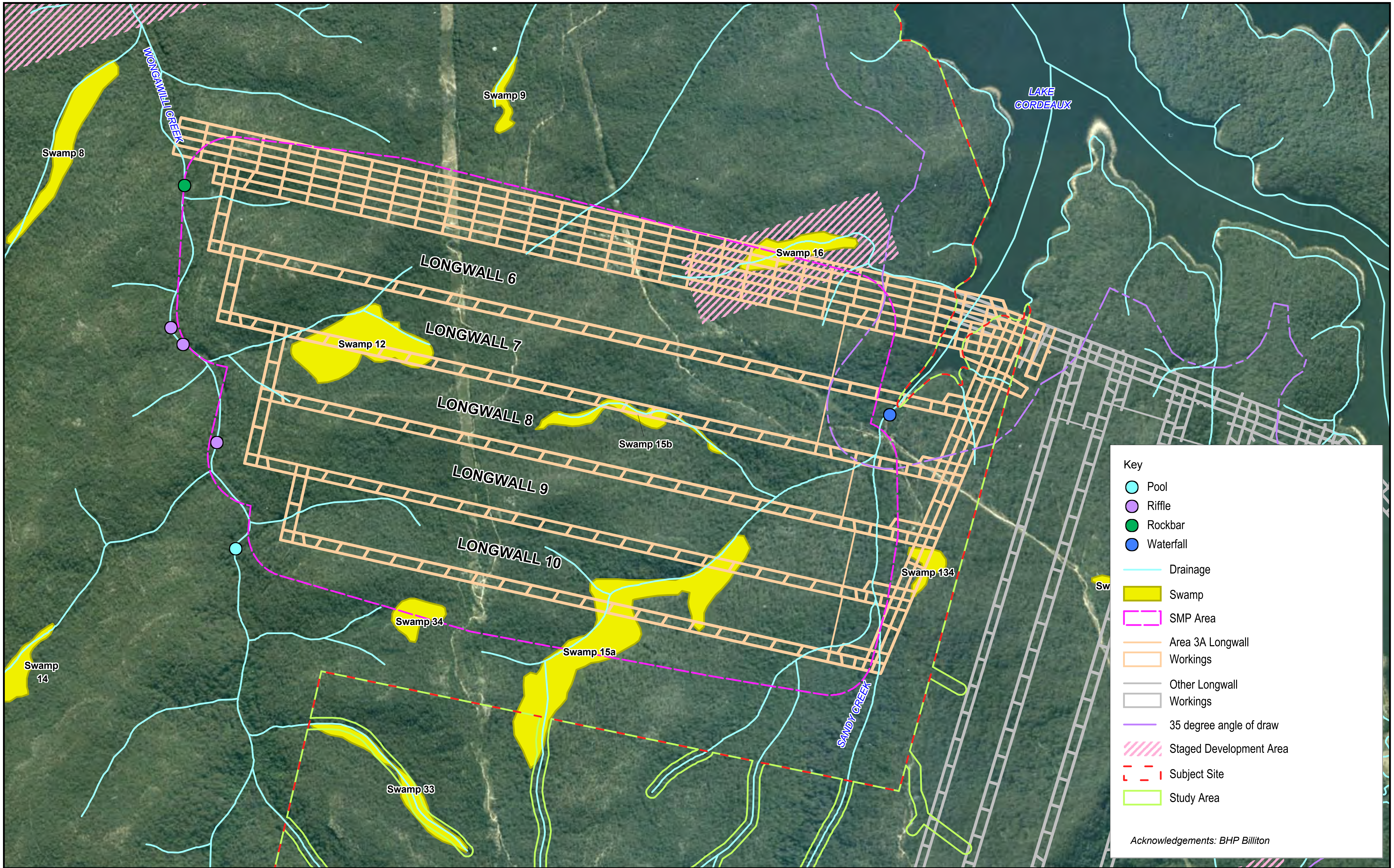

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Figure 8: Dendrobium Area 3A watercourses and swamps (MSEC (2007) 311-008 and MSEC (2007) 311-009.

Figure 8: Dendrobium Area 3A watercourses and swamps.

DATE: 17 October 2007
Checked by: RH
File number: S4447
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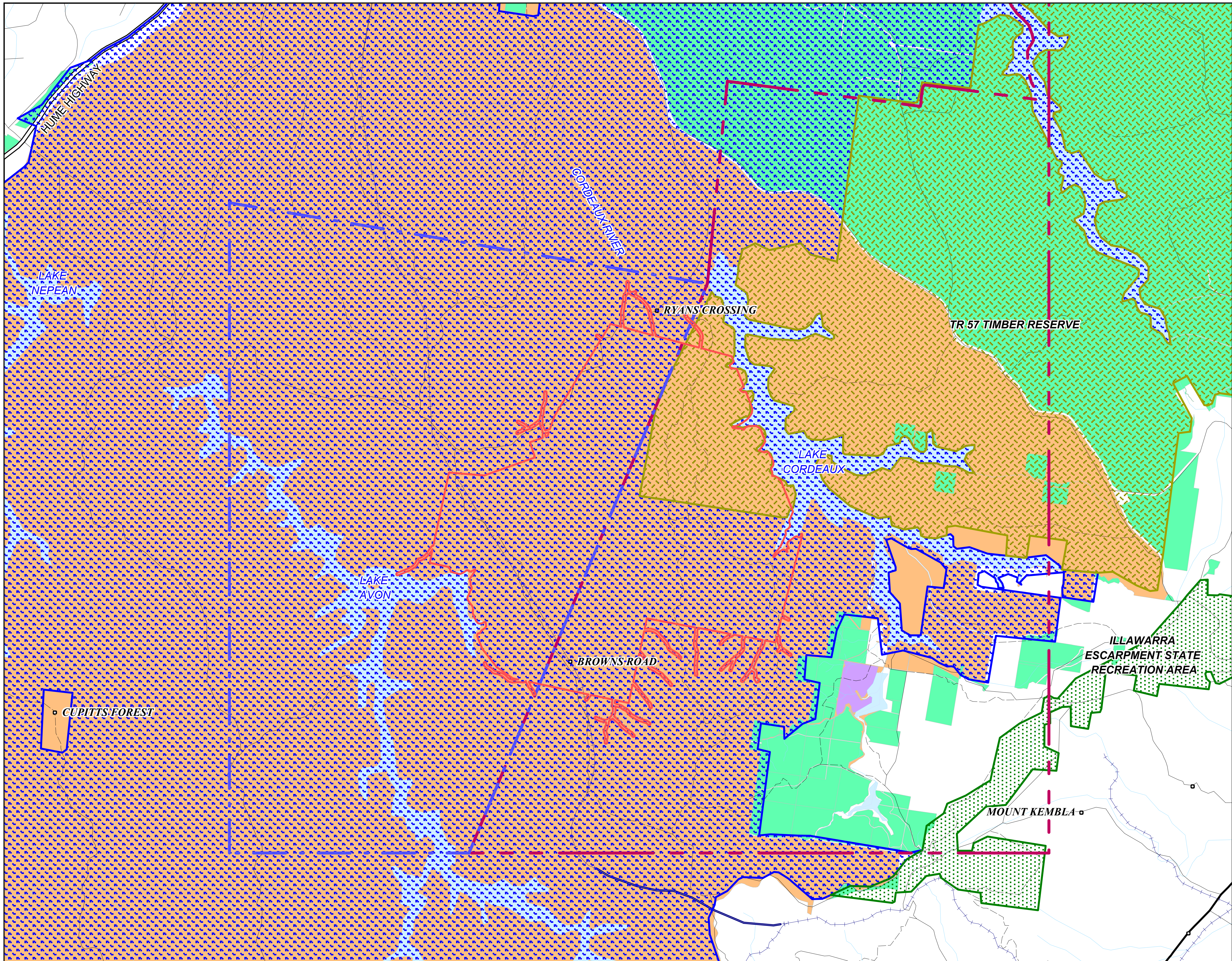

Acknowledgements: Cardno Forbes Rigby
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Figure 9: Locality map showing zoning, land tenure, parks and reserves and townships.

Figure 9: Locality map showing zoning, land tenure, parks and reserves and townships.

DATE: 5 September 2007
Checked by: MR
File number: S4447
Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F9_tenure.WOR

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N W E S

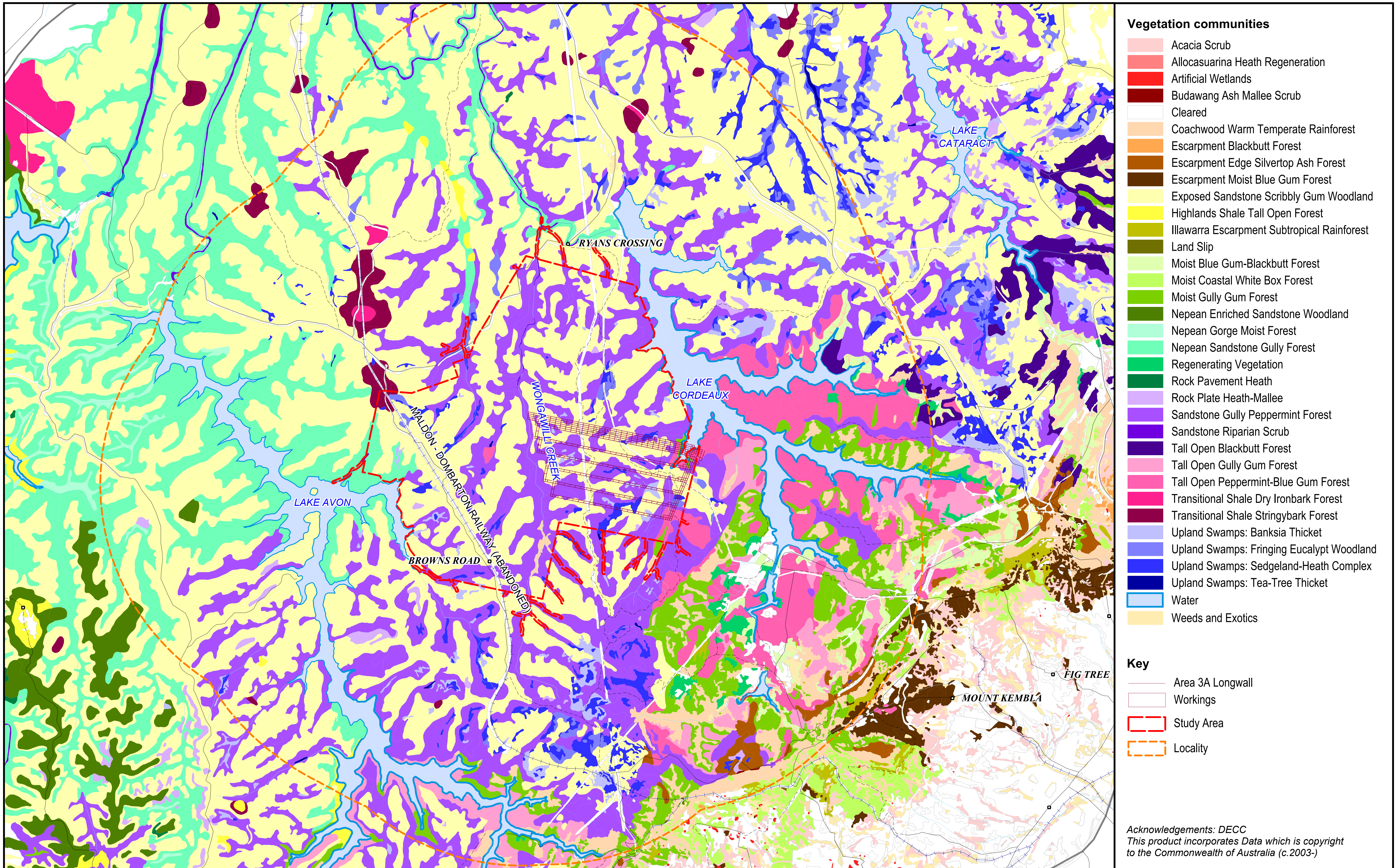

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Figure 10: Plant communities within the Locality and Study Area.

Figure 10: Plant communities within the Locality and Study Area.

DATE: 5 September 2007

Checked by: MR

File number: S4447

Loc:..4000\4400s\4447\Mapping\SIS figure\S4447 F10_veg.WOR

Scale: 0 0.75 1.5 2.25 3.0 3.75 kilometres

N W E S

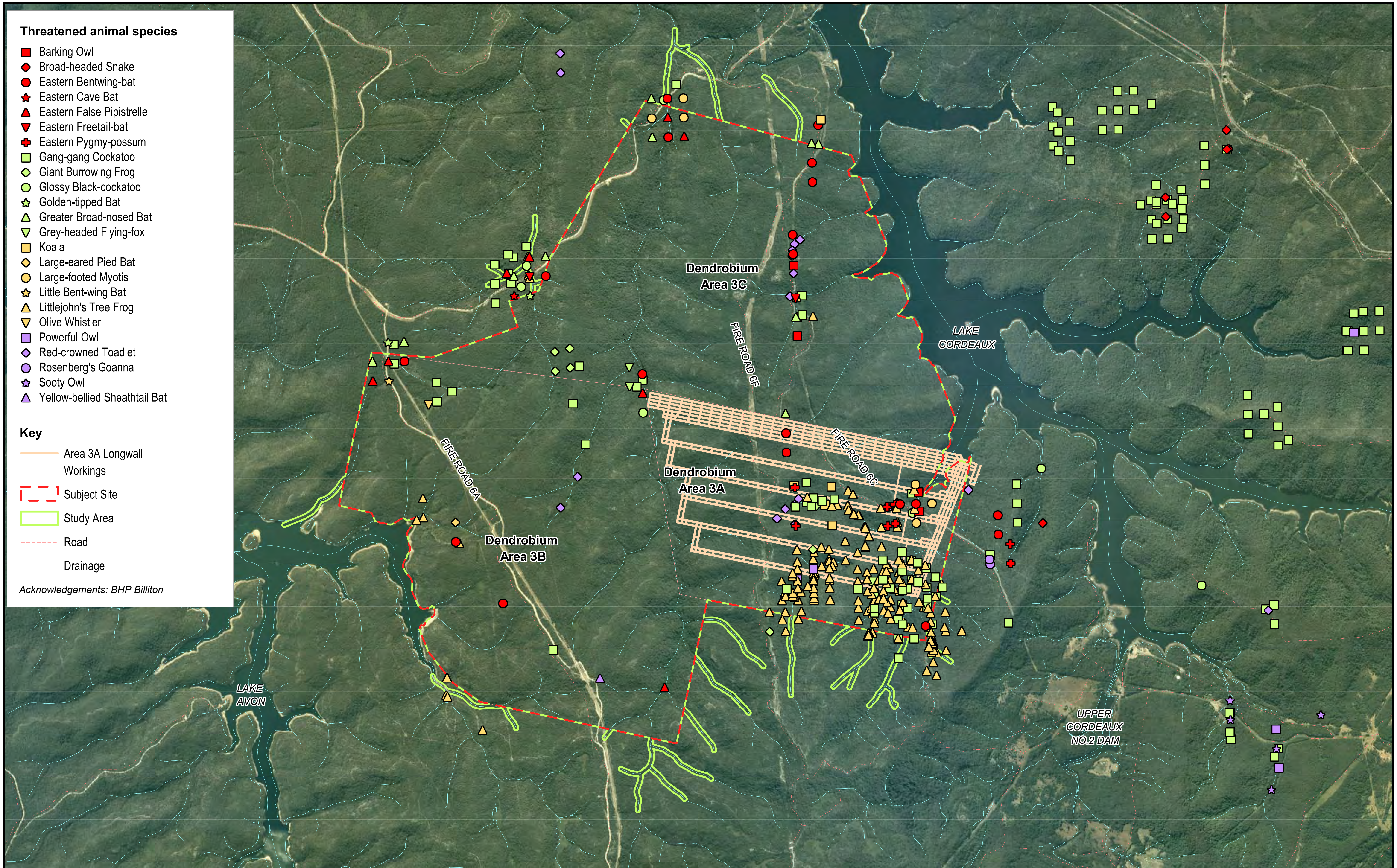

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Figure 11: Threatened animal species recorded by Biosis Research from within the Study Area.

Figure 11: Threatened animal species recorded by Biosis Research from within the Study Area.

DATE: 4 September 2007
Checked by: MR
File number: S4447
Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F11_biosis fauna.WOR

Scale: 0 0.4 0.8 1.2 1.6 2.0 kilometres

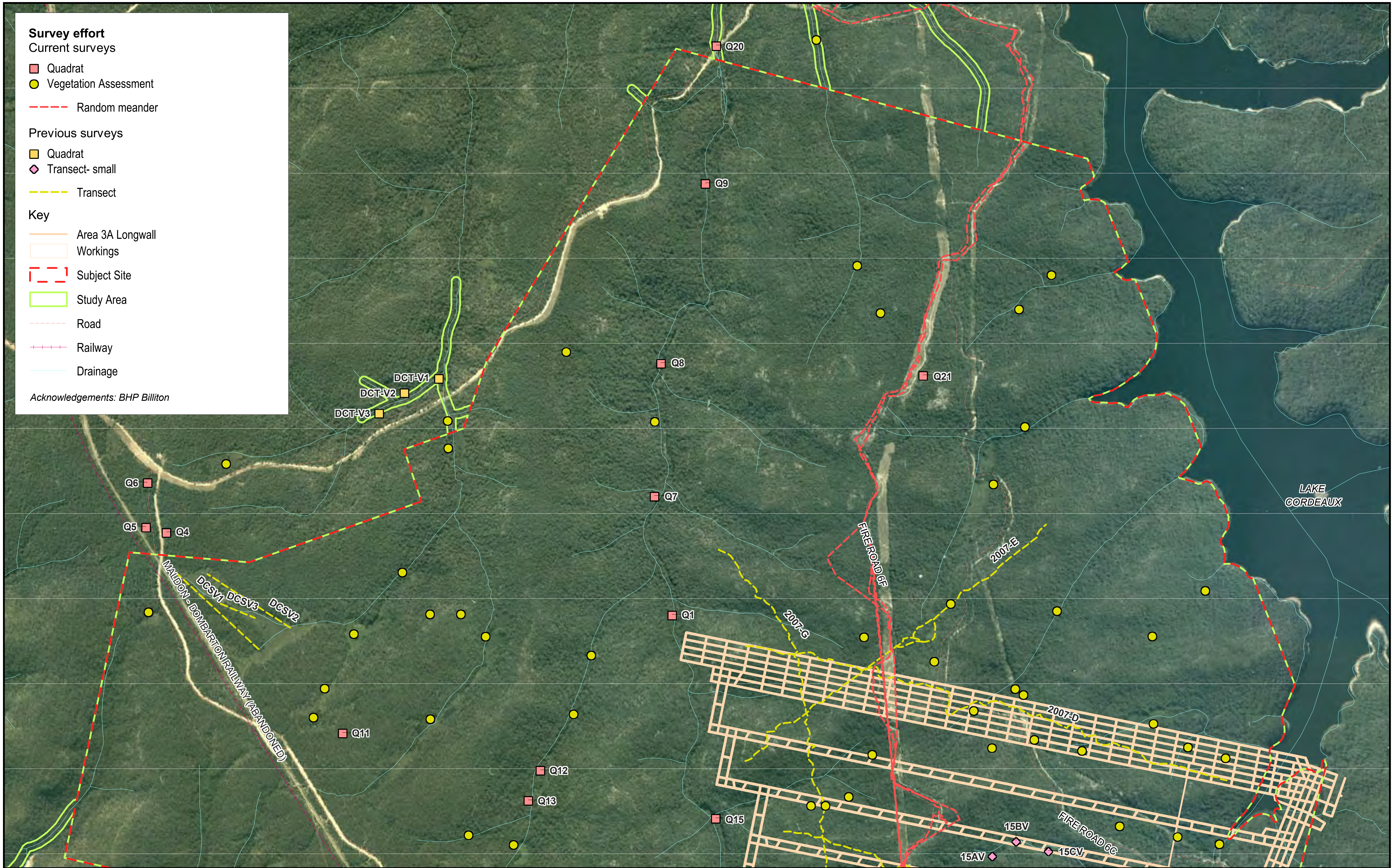

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Figure 11a: Previous and current flora survey locations.

Figure 11a: Previous and current flora survey locations.

DATE: 5 September 2007		Scale: 0 0.2 0.4 0.6 0.8 1.0 kilometres
Checked by: MR	File number: S4447	
Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F11_surveys flora.WOR		

N S E W

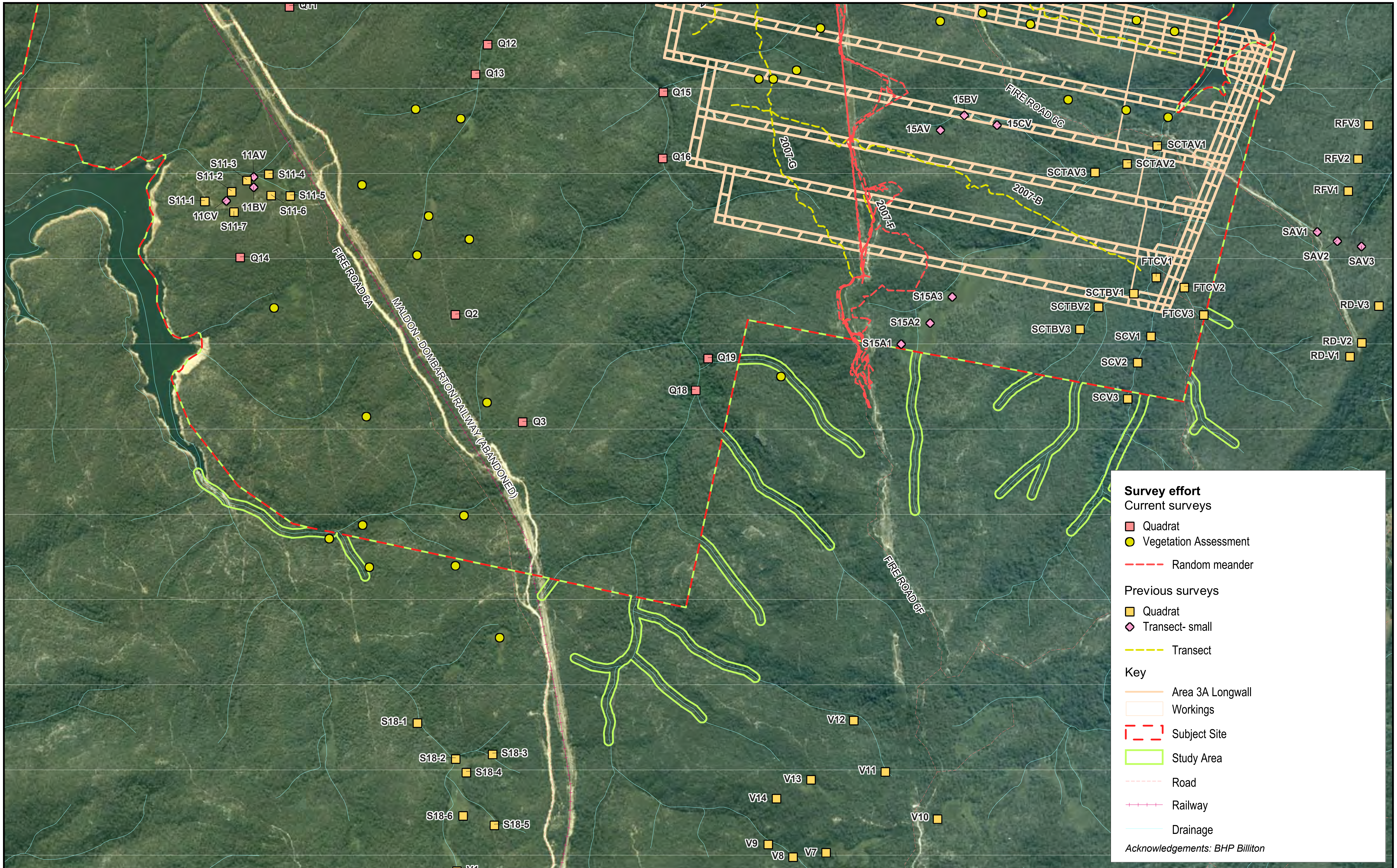

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Figure 11b: Previous and current flora survey locations.

Figure 11b: Previous and current flora survey locations.

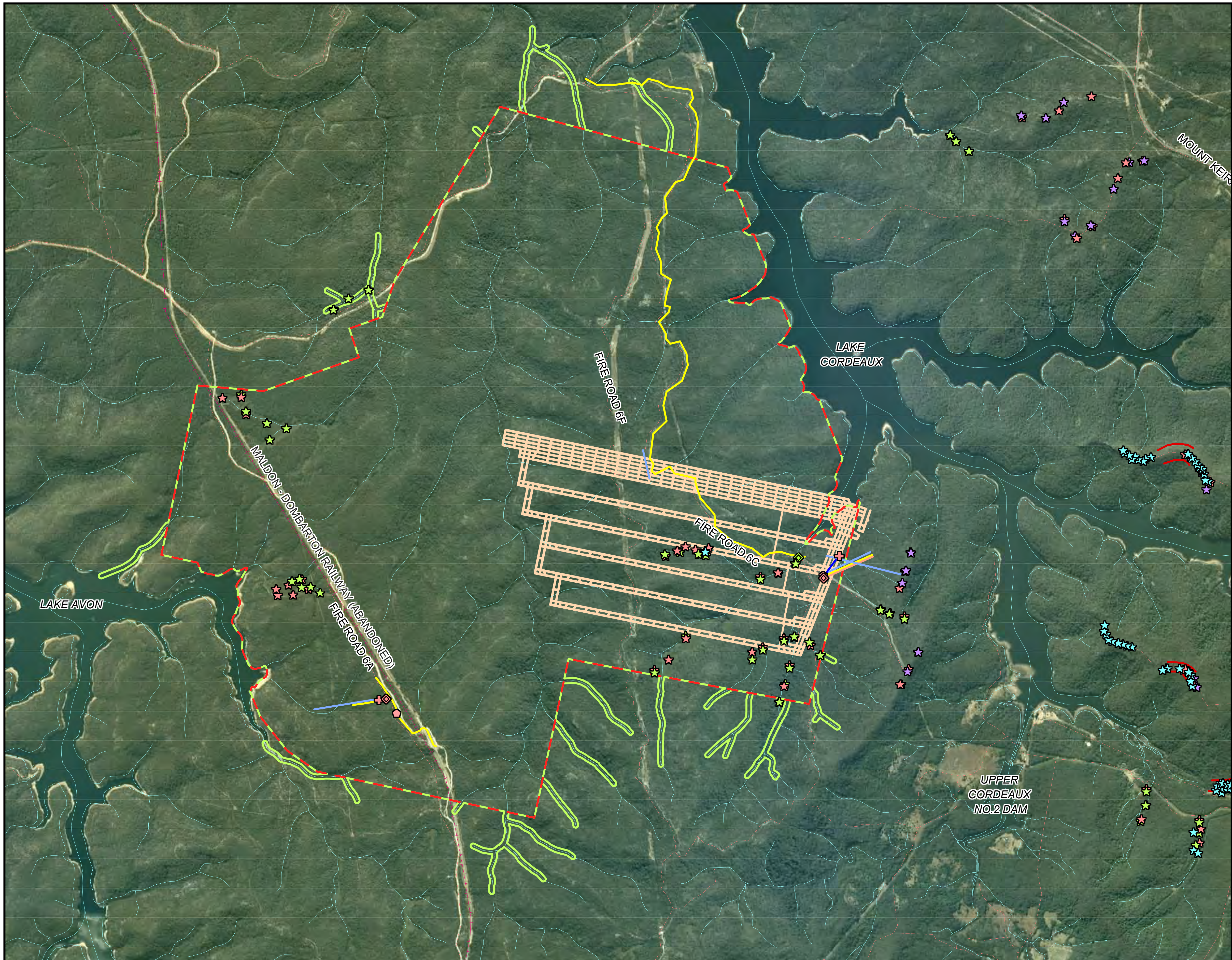
DATE: 11 October 2007

Checked by: MR

File number: S4447

Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F11_surveys flora.WOR

Scale: 0 0.2 0.4 0.6 0.8 1.0 kilometres



Survey effort

Sites

- Anabat
- Call Playback
- Call Playback - Frog
- Diurnal Bird Survey
- Habitat Assessment
- Harp Trap
- Monitoring - Birds
- Monitoring - Frogs
- Monitoring - Invertebrates
- Monitoring - Reptiles

Transects

- Cage Traps
- Diurnal Bird Survey
- Elliot Traps
- Habitat Assessment
- Hairtubes
- Nocturnal Herpetofauna Survey
- Pitfall
- Spotlighting

Key

- Area 3A Longwall Workings
- Subject Site
- Study Area
- Road
- Railway
- Drainage

Acknowledgements: BHP Billiton

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Figure 12: Previous fauna survey locations.

Figure 12: Previous fauna survey locations.

DATE: 5 September 2007

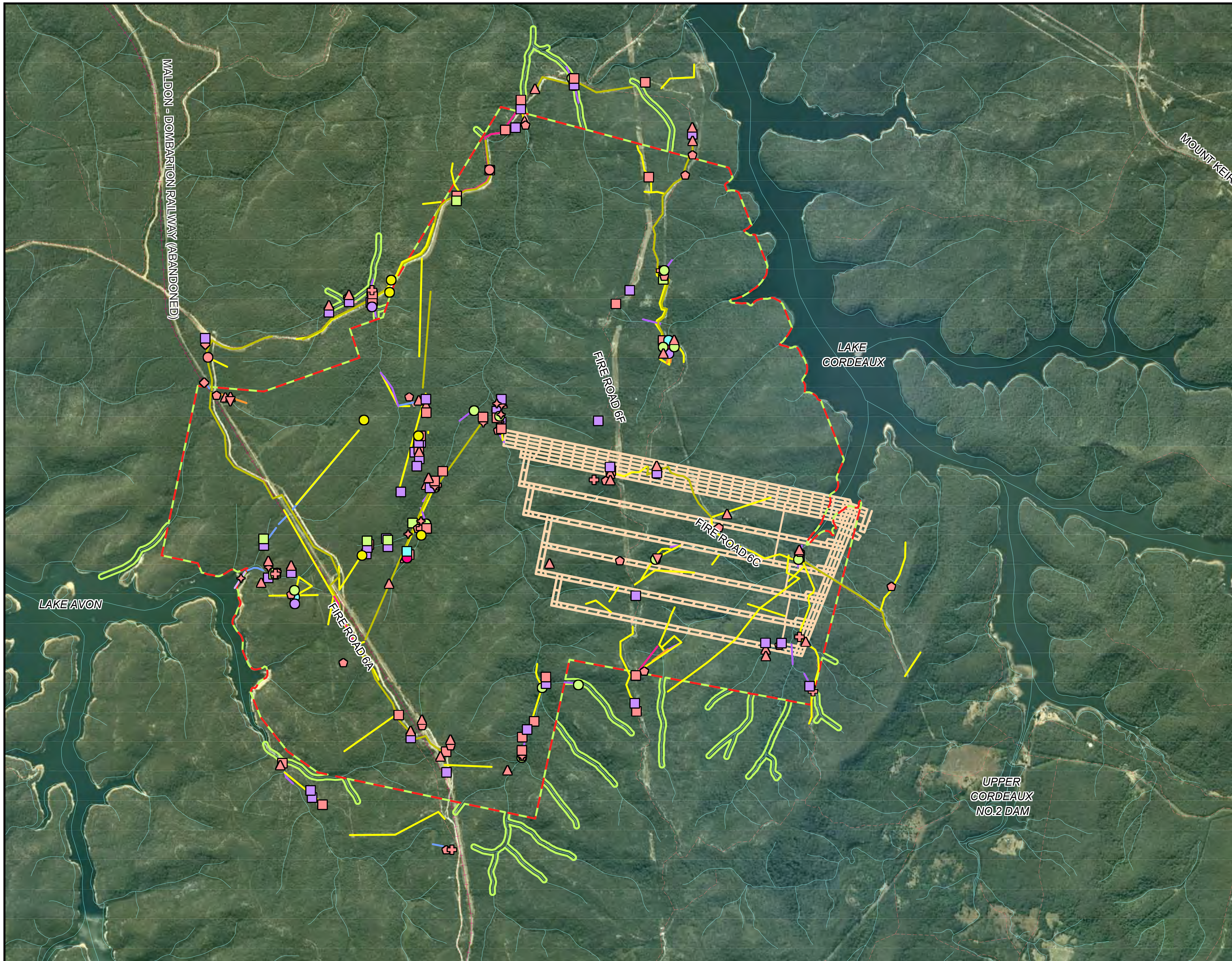
Checked by: MR

File number: S4447

Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F12_surveys fauna previous.WOR

Scale: 0 0.4 0.8 1.2 1.6 2.0 kilometres

N W E S



Survey effort
Sites

- Anabat
- Diurnal Bird Survey
- Diurnal Frog Call Playback
- Diurnal Frog Habitat Search
- Diurnal Herpetofauna Search
- Habitat Assessment
- Harp Trap
- Koala Habitat Search
- Nocturnal Call Playback - Bush Stone-curlew
- Nocturnal Call Playback - Frogs
- Nocturnal Call Playback - Mammals
- Nocturnal Call Playback - Owls
- Nocturnal Frog Habitat Search
- Nocturnal Herpetofauna Search
- Scat Collection
- Stag Watch

Transects

- Arboreal Elliots/Hair Tubes
- Cage Traps
- Diurnal Bird Survey
- Nocturnal Frog Habitat Search
- Nocturnal Watercourse Search - Frogs
- Scat Transect
- Spotlighting (mammals, reptiles, birds) - Foot
- Spotlighting (mammals, reptiles, birds) - Vehicle

Key

- Area 3 Longwall
- Workings
- Subject Site
- Study Area
- Road
- Railway
- Drainage

Acknowledgements: BHP Billiton

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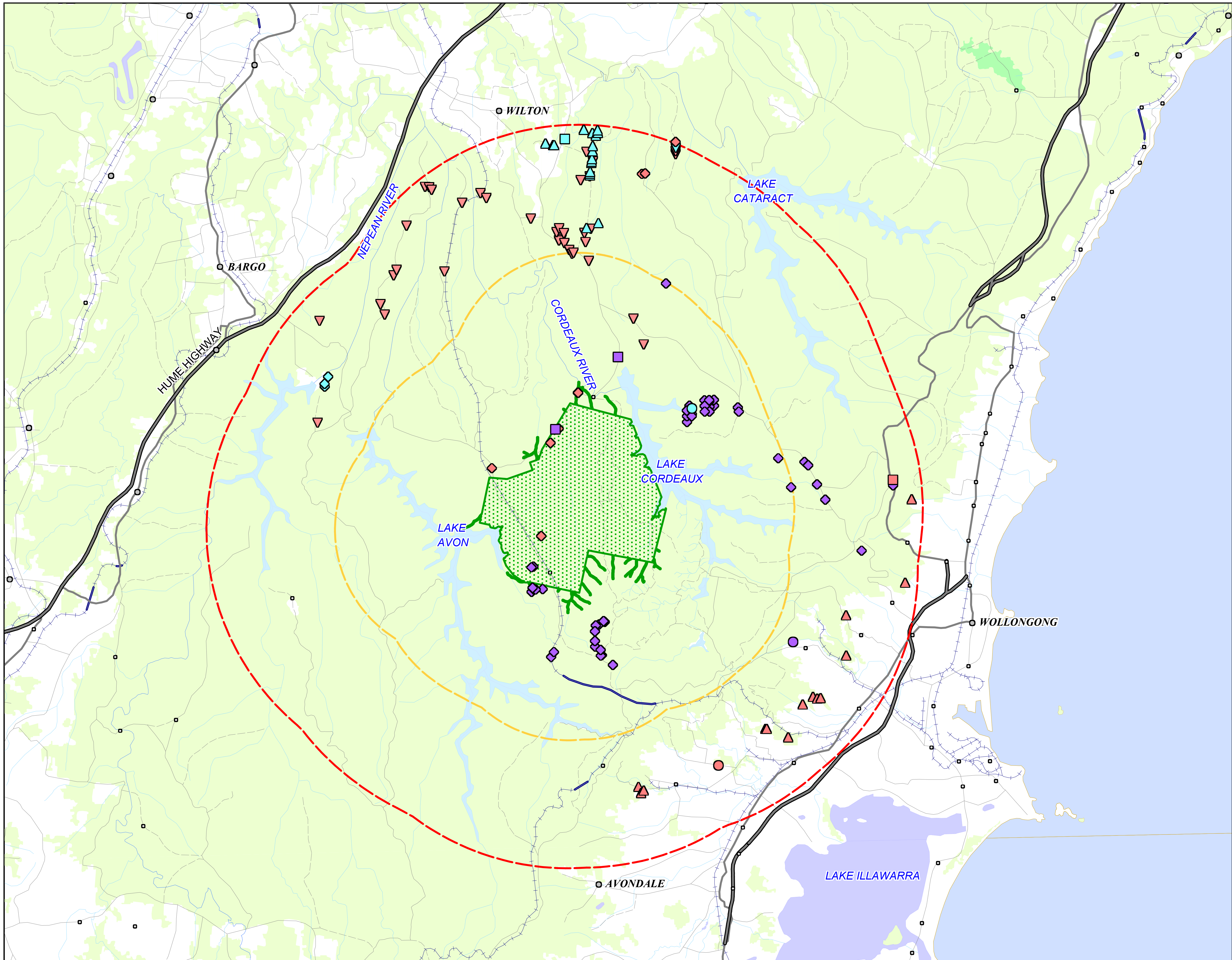
Figure 13: Current fauna survey locations.

DATE: 5 September 2007
Checked by: MR
File number: S4447
Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F13_surveys fauna current.WOR

Figure 13: Current fauna survey locations.

Scale: 0 0.4 0.8 1.2 1.6 2.0 kilometres

N W E S



Threatened flora

- *Acacia baueri subsp. aspera*
- *Acacia bynoeana*
- *Chorizema parviflorum*
- *Cynanchum elegans*
- *Epacris purpurascens var. purpurascens*
- *Grevillea parviflora subsp. parviflora*
- *Melaleuca deanei*
- *Persoonia acerosa*
- *Persoonia bargoensis*
- *Persoonia hirsuta*
- *Pomaderris brunnea*
- *Pultenaea aristata*
- *Solanum celatum*

Key

- Study Area
- Locality
- 10km search area
- City/Town
- Locality
- Dual Carriageway
- Major road
- Secondary/minor road
- Track
- Railway
- Rail tunnel
- Canal
- River/creek - perennial
- River/creek - ephemeral
- Lake
- Reservoir
- Watercourse
- Forest
- Orchard

Acknowledgements:
- Species records from NPWS and Biosis Research Pty Ltd.
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Figure 14: Threatened flora species recorded within 10km of the Study Area, as derived from DECC Atlas of NSW Wildlife.

Figure 14: Threatened flora species recorded within 10km of the Study Area, from DECC Atlas of NSW Wildlife.

DATE: 5 September 2007
Checked by: MR
File number: S4447
Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F14_flora.WOR

Scale: 0 1.5 3.0 4.5 6.0 7.5 kilometres

N W E S

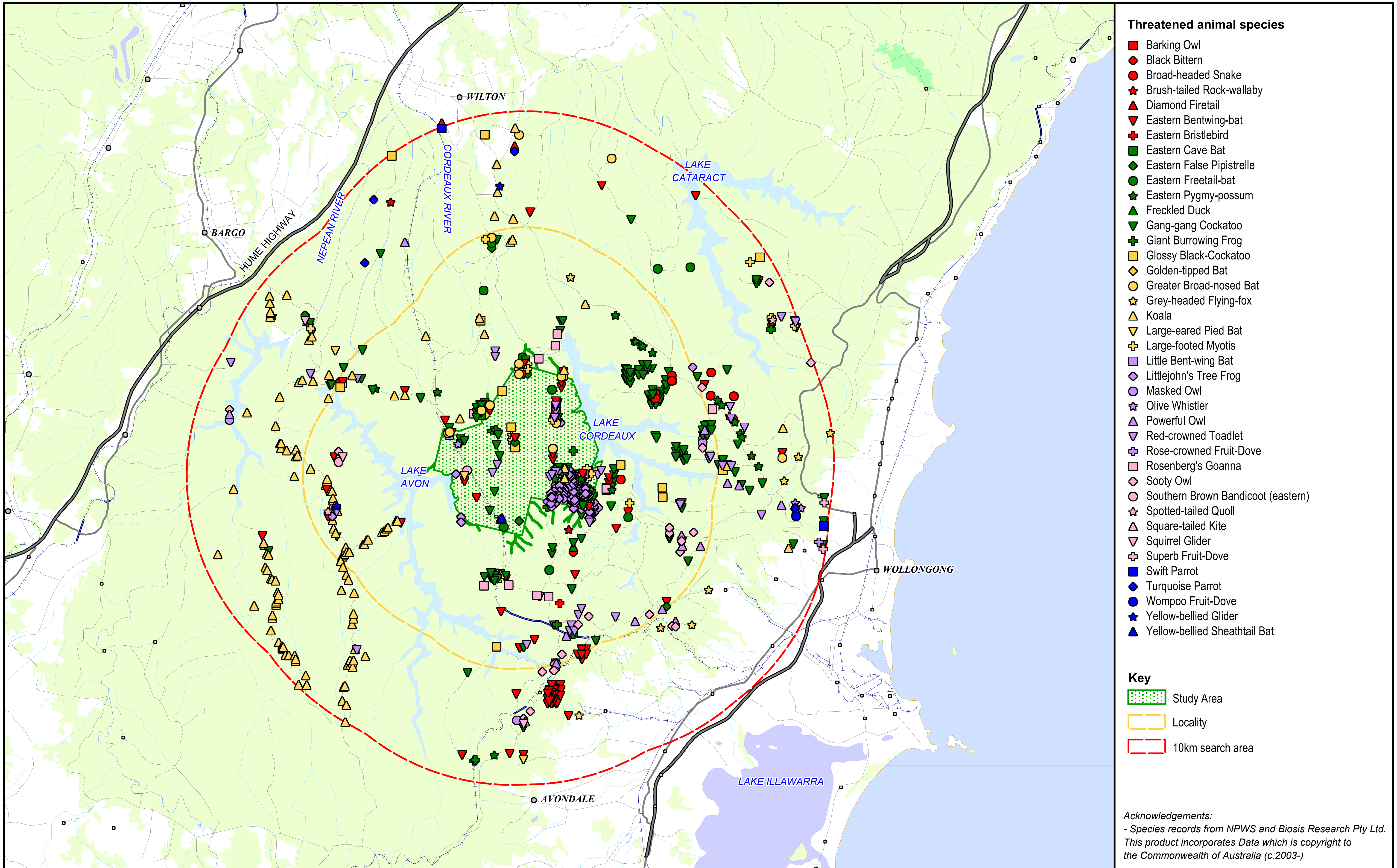

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Figure 15a: Threatened animal species recorded within 10km of the Study Area, as derived from the DECC Atlas of NSW Wildlife.

Figure 15a: Threatened animal species recorded within 10km of the Study Area, from DECC Atlas of NSW Wildlife.

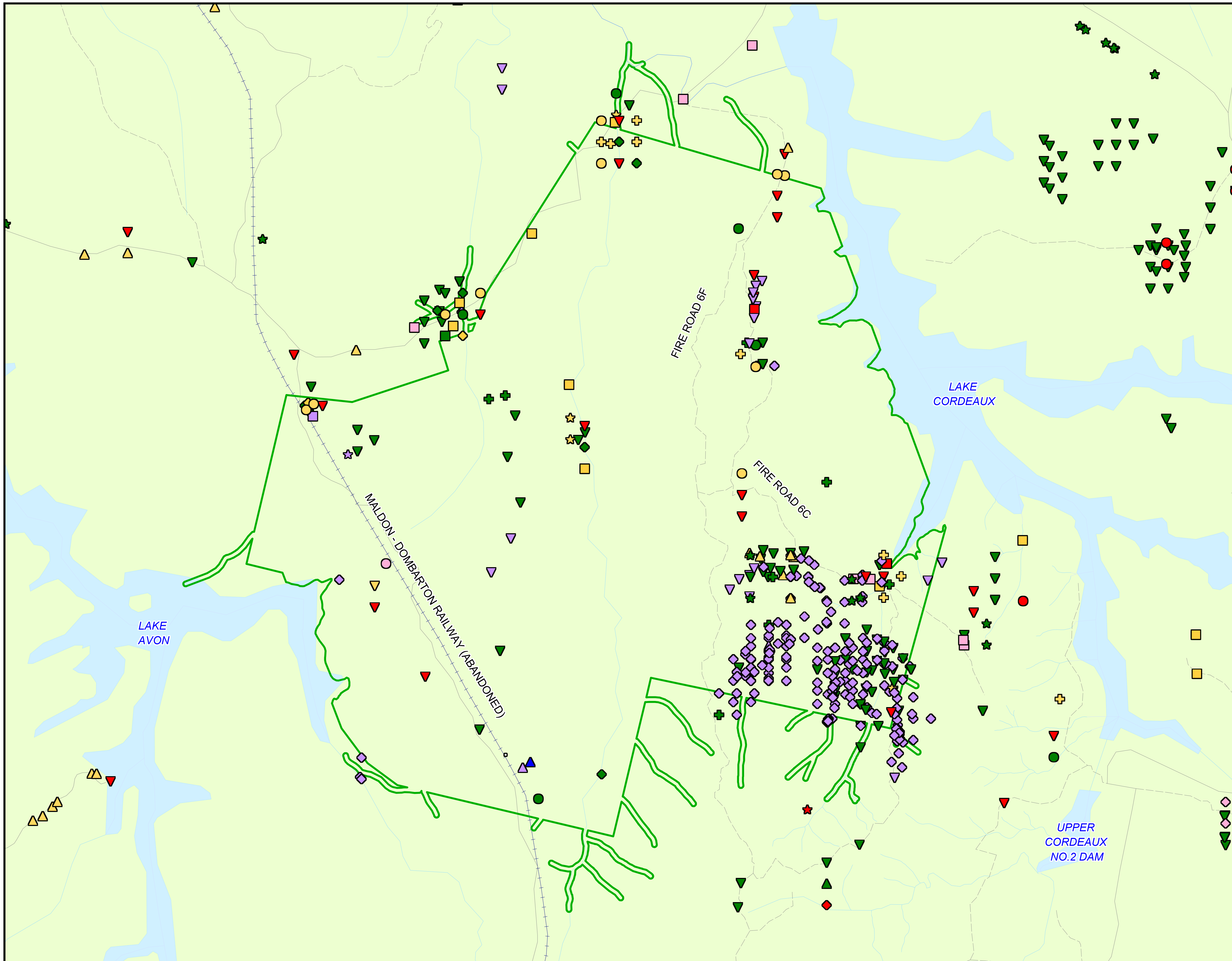
DATE: 5 September 2007

Checked by: MR | File number: S4447

Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F15_fauna.WOR

Scale: 0 1.5 3.0 4.5 6.0 7.5 kilometres

N W E S



Threatened animal species

- Barking Owl
- Black Bittern
- Broad-headed Snake
- Brush-tailed Rock-wallaby
- Diamond Firetail
- Eastern Bentwing-bat
- Eastern Bristlebird
- Eastern Cave Bat
- Eastern False Pipistrelle
- Eastern Freetail-bat
- Eastern Pygmy-possum
- Freckled Duck
- Gang-gang Cockatoo
- Giant Burrowing Frog
- Glossy Black-Cockatoo
- Golden-tipped Bat
- Greater Broad-nosed Bat
- Grey-headed Flying-fox
- Koala
- Large-eared Pied Bat
- Large-footed Myotis
- Little Bent-wing Bat
- Littlejohn's Tree Frog
- Masked Owl
- Olive Whistler
- Powerful Owl
- Red-crowned Toadlet
- Rose-crowned Fruit-Dove
- Rosenberg's Goanna
- Sooty Owl
- Southern Brown Bandicoot (eastern)
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- Superb Fruit-Dove
- Swift Parrot
- Turquoise Parrot
- Wompoo Fruit-Dove
- Yellow-bellied Glider
- Yellow-bellied Sheathtail Bat

Key

Study Area

Acknowledgements:
- Species records from NPWS and Biosis Research Pty Ltd.
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Figure 15b: Threatened animal species recorded within 10km of the Study Area, as derived from the DECC Atlas of NSW Wildlife.

Figure 15b: Threatened animal species recorded within 10km of the Study Area, from DECC Atlas of NSW Wildlife.

DATE: 4 September 2007
Checked by: MR
File number: S4447
Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F15_fauna.WOR

Scale: 0 0.4 0.8 1.2 1.6 2.0 kilometres

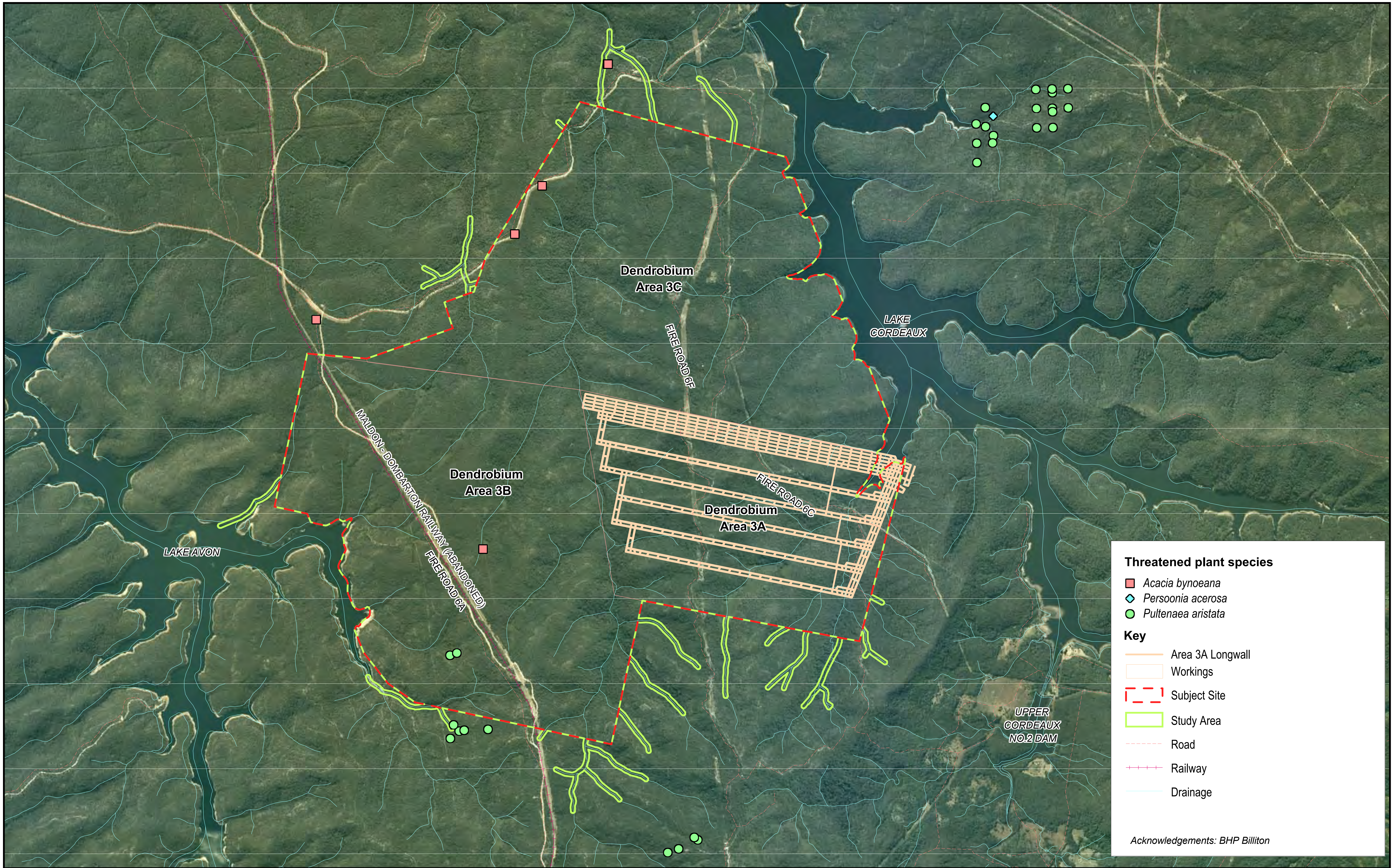

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Figure 16: Threatened plant species recorded by Biosis Research from within the Study Area.

Figure 16: Threatened plant species recorded by Biosis Research from within the Study Area.

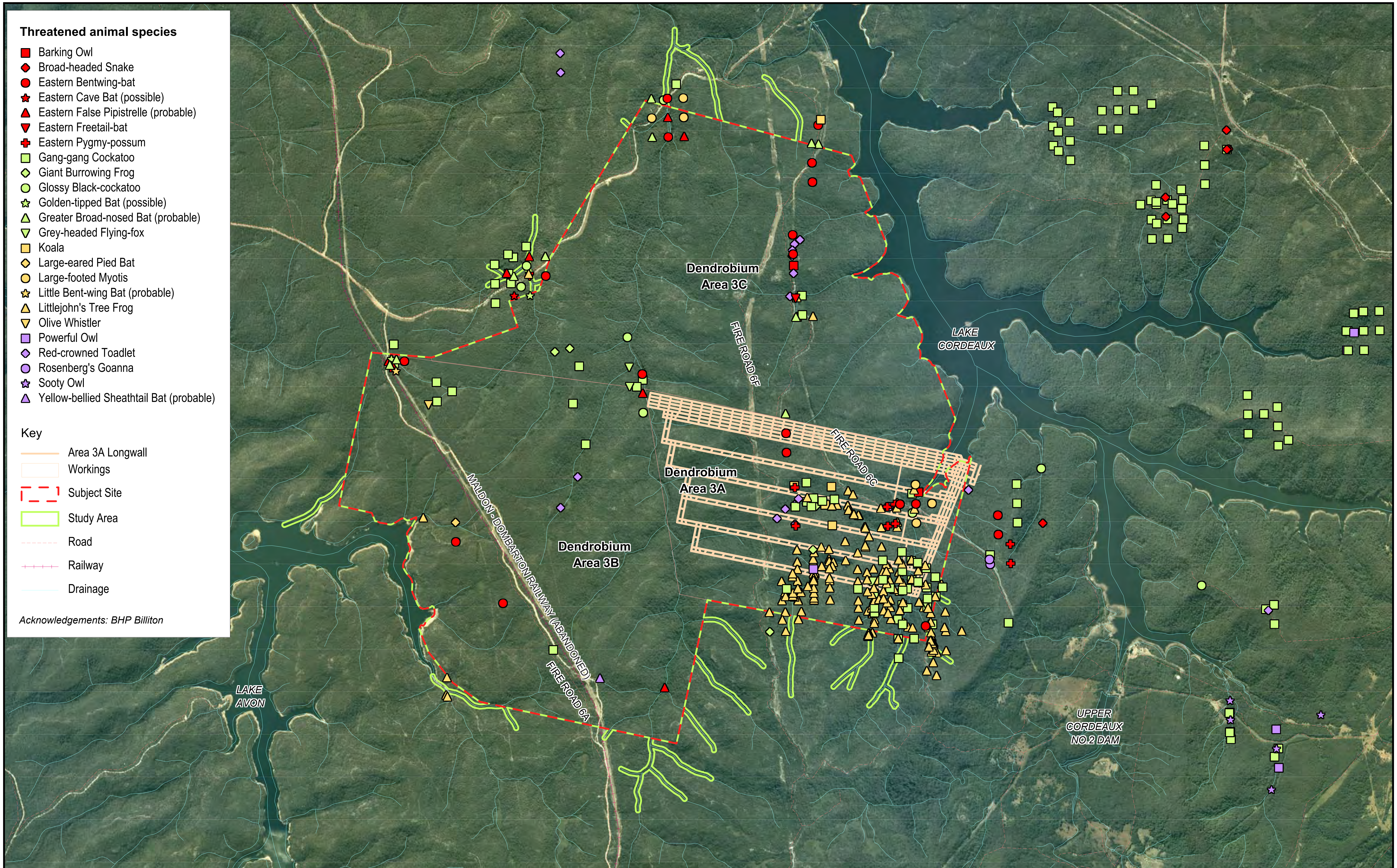
DATE: 11 October 2007

Checked by: MR

File number: S4447

Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F16_biosis flora.WOR

Scale: 0 0.4 0.8 1.2 1.6 2.0 kilometres



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BIOSIS RESEARCH

Figure 17: Threatened animal species recorded by Biosis Research from within the Study Area.

Figure 17: Threatened animal species recorded by Biosis Research from within the Study Area.

DATE: 5 September 2007

Checked by: MR | File number: S4447

Location:-..4000\4400s\4447\Mapping\SIS figures\S4447 F17_biosis fauna.WOR

Scale: 0 0.4 0.8 1.2 1.6 2.0 kilometres

N W E S

APPENDICES

APPENDIX 1

THE DIRECTOR-GENERAL'S REQUIREMENTS FOR A SPECIES IMPACT STATEMENT

APPENDIX 2

COMPLETED FLORA DATA SHEETS

See disk at end of report

APPENDIX 3

COMPLETED FAUNA DATA SHEETS

See disk at end of report

APPENDIX 4

FLORA RECORDED IN THE STUDY AREA

Table 18. Plant species recorded in the Study Area (random meander surveys)

Family		Scientific Name	Common Name
Ferns and Fern-like Plants			
Dennstaedtiaceae			
		Pteridium esculentum	Bracken
Dicksoniaceae			
		Calochlaena dubia	Common Ground Fern
Gleicheniaceae			
		Gleichenia dicarpa	Pouched Coral-fern
		Gleichenia microphylla	Scrambling Coral-fern
Lindsaeaceae			
		Lindsaea linearis	Screw Fern
Osmundaceae			
		Todea barbara	King Fern
Selaginellaceae			
		Selaginella uliginosa	Swamp Selaginella
Monocotyledons			
Cyperaceae			
		Baumea teretifolia	
		Caustis flexuosa	Curly Wig
		Chorizandra sphaerocephala	Roundhead Bristle-sedge
		Cyathochaeta diandra	Sheath Sedge
		Gahnia sieberiana	Red-fruit Saw-sedge
		Gymnoschoenus sphaerocephalus	Button Grass
		Lepidosperma forsythii	Large-flower Rapier-sedge
		Lepidosperma laterale	Variable Sword-sedge
		Lepidosperma limicola	Razor Sword-sedge
		Lepidosperma neesii	Stiff Rapier-sedge
		Lepidosperma urophorum	Tailed Rapier-sedge
		Ptilothrix deusta	
		Schoenus brevifolius	Zig-zag Bog-sedge
		Schoenus melanostachys	Black Bog-sedge
Haemodoraceae			
		Haemodorum planifolium	
Iridaceae			
		Patersonia sericea	Silky Purple-flag
Lomandraceae			
		Lomandra cylindrica	Needle Mat-rush
		Lomandra glauca	Pale Mat-rush
		Lomandra longifolia	Spiny-headed Mat-rush
		Lomandra multiflora ssp. *multiflora*	Many-flowered Mat-rush
		Lomandra spp.	
Orchidaceae			
		Thelymitra spp.	
Poaceae			
		Anisopogon avenaceus	Oat Speargrass
		Entolasia stricta	Wiry Panic
		Hemarthria uncinata var. *uncinata*	Mat Grass
Restionaceae			
		Baloskion gracile	
		Empodisma minus	Spreading Rope-rush
		Leptocarpus tenax	Slender Twine-rush

Family		Scientific Name	Common Name
		Lepyrodia scariosa	
		Saropsis fastigiata	
Xyridaceae			
		Xyris operculata	Tall Yellow-eye
Dicotyledons			
Apiaceae			
		Actinotus minor	Lesser Flannel Flower
		Platysace linearifolia	
		Xanthosia pilosa	Woolly Xanthosia
Araliaceae			
		Astrotricha longifolia	
Baueraceae			
		Bauera microphylla	
Casuarinaceae			
		Allocasuarina littoralis	Black Sheoak
		Allocasuarina nana	Stunted Sheoak
		Allocasuarina torulosa	Forest Oak
Cunoniaceae			
		Ceratopetalum apetalum	Coachwood
Dilleniaceae			
		Hibbertia riparia	Erect Guinea-flower
Epacridaceae			
		Epacris microphylla var. *microphylla*	Coast Coral Heath
		Epacris obtusifolia	Blunt-leaf Heath
		Leucopogon microphyllus var. *microphyllus*	Hairy Beard-heath
		Sprengelia incarnata	Pink Swamp-heath
Fabaceae (Mimosoideae)			
	Ve	*Acacia bynoeana*	Bynoe's Wattle
		Acacia linifolia	Flax-leaved Wattle
		Acacia longifolia	Coast/Sallow Wattle
		Acacia rubida	Red-leaved Wattle
		Acacia suaveolens	Sweet Wattle
		Acacia terminalis	Sunshine Wattle
		Acacia ulicifolia	Prickly Moses
Fabaceae (Faboideae)			
		Almaleea paludosa	Marsh Bush-pea
		Dillwynia floribunda	
		Dillwynia rudis	Rough Parrot-pea
		Gompholobium minus	Dwarf Wedge Pea
	Vv	*Pultenaea aristata*	
		Pultenaea elliptica	
		Pultenaea flexilis	
		Viminaria juncea	Native Broom
Goodeniaceae			
		Dampiera stricta	Blue Dampiera
		Goodenia dimorpha var. *dimorpha*	
Haloragaceae			
		Gonocarpus teucrioides	Germander Raspwort
Myrtaceae			
		Backhousia myrtifolia	Grey Myrtle
		Baeckea imbricata	

Family		Scientific Name	Common Name
		Baeckea linifolia	Swamp Baeckea
		Callistemon citrinus	Crimson Bottlebrush
		Corymbia gummifera	Red Bloodwood
		Darwinia grandiflora	
		Eucalyptus piperita	Sydney Peppermint
		Eucalyptus racemosa	Narrow-leaved Scribbly Gum
		Eucalyptus sieberi	Silvertop Ash
		Eucalyptus stricta	Mallee Ash
		Kunzea ambigua	Tick Bush
		Leptospermum continentale	Prickly Teatree
		Leptospermum juniperinum	
		Leptospermum lanigerum	Woolly Teatree
		Leptospermum polygalifolium ssp. *polygalifolium*	Tantoon
		Leptospermum squarrosum	
		Leptospermum trinervium	Paperbark Tea-tree
		Melaleuca linariifolia	Budjur
		Melaleuca squarrosa	Scented Paperbark
		Melaleuca thymifolia	
		Tristaniopsis laurina	Kanuka
Proteaceae			
		Banksia ericifolia ssp. *ericifolia*	
		Banksia marginata	Silver Banksia
		Banksia paludosa ssp. paludosa	
		Banksia robur	
		Banksia serrata	Saw Banksia
		Conospermum tenuifolium	
		Grevillea mucronulata	
		Grevillea sericea ssp. sericea	
		Hakea dactyloides	Finger Hakea
		Hakea sericea	Bushy Needlewood
		Hakea teretifolia ssp. *teretifolia*	
		Isopogon anemonifolius	
		Lambertia formosa	Mountain Devil
		Lomatia myricoides	River Lomatia
		Persoonia levis	Broad-leaved Geebung
		Persoonia linearis	Narrow-leaved Geebung
		Petrophile pulchella	
		Petrophile sessilis	
Rutaceae			
		Boronia ledifolia	Sydney Boronia
		Boronia parviflora	Swamp Boronia
Thymelaeaceae			
		Pimelea linifolia ssp. *linifolia*	Slender Rice-flower

Note: V – Vulnerable on the EPBC Act; v – vulnerable on the TSC Act; e – endangered on the TSC Act.

Table 19. Plant species recorded in the Study Area (quadrats from current surveys)

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
Acacia binervata								1	2	1					3	1					
Acacia floribunda																	1				
Acacia hispidula																				1	
Acacia irrorata	1							1	2							1	1				
Acacia irrorata ssp. *irrorata*							4								1						
Acacia linifolia	2	2				2		4	2	3	3									1	2
Acacia longifolia									3								2				
Acacia longifolia ssp. l*ongifolia*										2											
Acacia myrtifolia		4	4								3										4
Acacia obtusifolia				4	3	2		1									1				2
Acacia rubida								4		3											
Acacia suaveolens			3											1						2	2
Acacia terminalis	2								2	2		2	4		1		1				
Acacia ulicifolia		3			1	2		1	1	1	2						1			2	
Acianthus fornicatus					3	2															
Acianthus sp. A sensu Harden (1993)									1												
Acianthus spp.											1	1	2		1						
Acrotriche divaricata															1						
Actinotus helianthi	2							2	1	2										2	
Actinotus minor								1		1				3							
Allocasuarina littoralis	1					1	4		4	2					3	5	1				
Allocasuarina nana														1							
Almaleea paludosa														3							
Amperea xiphoclada var. *xiphoclada*	2	1		2			1	1	2	2	3	2									
Anisopogon avenaceus		1	2	2		2		1		2	2										2
Aotus ericoides	2			1																	
Astroloma humifusum										1											
Astrotricha longifolia	2						2	2	3	2						2					
Babingtonia densifolia														3							
Backhousia myrtifolia															4		1				

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
Baeckea imbricata														1							
Baeckea linifolia										1											
Baeckea spp.																	2				
Baloskion gracile									1	1											
Banksia ericifolia ssp. *ericifolia*								3		2				4			1			1	
Banksia marginata														2			1				
Banksia paludosa ssp. *paludosa*								2		3											
Banksia serrata	1	3	1							3		1		1						2	4
Banksia spinulosa var. *spinulosa*	2	2	4	4	3	2		2	1	2	4	3	2	2							4
Bauera rubioides								2									2				
Billardiera scandens var. *scandens*		1	1	1		1	1		1		1				1	1					2
Blechnum cartilagineum																		2	3		
Blechnum nudum																			2		
Blechnum patersonii ssp. *patersonii*																			2		
Boronia ledifolia			3					3	2	3				3							
Boronia pinnata														3							
Bossiaea heterophylla	2	4	3	3		2		2		2	4			2						1	
Bossiaea obcordata		3	2	2	2	3		2		2	4		1								3
Bossiaea prostrata	3																				
Bossiaea scolopendria			1					1		1				2			1			1	
Brachyloma daphnoides ssp. *daphnoides*										1										1	1
Brachyscome ciliocarpa																	1				
Brunoniella pumilio				2		1															
Bursaria spinosa ssp. *spinosa*									1						3						
Callistemon citrinus									1	1											
Callitris rhomboidea																	1				
Calochlaena dubia												5	5		2				2		
Calytrix tetragona														3							
Carex longebrachiata																			1		
Cassinia aculeata							2		1						1						
Cassinia spp.							1														

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
Cassytha glabella f. *dispar*									2												
Cassytha glabella f. *glabella*		3	1	2		1		2			1	1			3		2				
Cassytha pubescens	1	3	1							2											
Caustis flexuosa			2											2						2	
Ceratopetalum apetalum	1						1	1	2						4		2	6	6		
Ceratopetalum gummiferum									2						3	4					
Chiloglottis seminuda							4														
Chiloglottis spp.									2			2	2		2	2					
Chloanthes stoechadis	1							1		1											
Choretrum candollei	1				1																
Clematis aristata					2							1	1			2					
Conospermum taxifolium		3	2							1											2
Conospermum tenuifolium	5	2						2	1	4											
Corybas sp. A sensu Harden (1993)						1															
Corybas spp.																					
Corymbia gummifera		5	4	4	3	4					5		3							4	5
Cryptostylis subulata			1																		
Cyathea australis																			2		
Cyathochaeta diandra		4	4	3		2		3	2	2	5			3							2
Dampiera purpurea	2						4		2	1		2									
Dampiera stricta		1									2										1
Darwinia grandiflora								1													
Dendrobium spp.																		1	1		
Dianella caerulea var. *caerulea*									2												
Dianella caerulea var. *producta*					2	2	2					1	2		2	1					
Dianella revoluta var. *revoluta*	1			1	1	1					1	1									
Dillwynia floribunda								3		1				4							
Dillwynia retorta (J.C.Wendl.) Druce species complex	1							1		1				3						3	4
Dodonaea camfieldii								2													
Dodonaea multijuga	2						2	1	3	1							1				
Dodonaea triquetra	3				1		2	1	5	1					3	4	1				

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
Doryphora sassafras																		3			
Dracophyllum secundum															1						
Elaeocarpus reticulatus															1				1		
Entolasia marginata	3						2		2		3				3		1				
Entolasia stricta			1	2		2		2		2		2				2				2	1
Epacris microphylla var. *microphylla*								1						3							
Epacris pulchella								2													
Eriostemon australasius		2	1					1		2	3			1						1	1
Eucalyptus capitellata			2																		
Eucalyptus eugenioides													2								
Eucalyptus globoidea				5	5	5															
Eucalyptus oblonga											4										
Eucalyptus piperita	5	4	2				4	2	4	1		5	4			5		1		1	4
Eucalyptus racemosa	1		4	2				4		4	2			1							2
Eucalyptus sieberi		4	3	2	1						4									1	
Eucalyptus stricta														5							
Euchiton gymnocephalus							1														
Gahnia sieberiana							1			1							1				
Geijera salicifolia var. *latifolia*																			1		
Gleichenia dicarpa								1	1			3					1				
Gompholobium grandiflorum		2	1	1				1		1	3										1
Gompholobium latifolium								1	2						2						
Gompholobium minus		2		1				1						2							
Gonocarpus teucrioides	4				1		3	3	4	3		5	2		3	5					
Goodenia bellidifolia ssp. *bellidifolia*				2	3	3	1														
Goodenia dimorpha var. *dimorpha*								2						5							
Goodenia hederacea ssp. *hederacea*											3				1	2					2
Goodenia heterophylla ssp. *eglandulosa*							1								1						
Goodenia heterophylla ssp. *heterophylla*									1			1									
Grammitis billardierei																			2		
Grevillea mucronulata	3				5	4	3		3	3					2	4	2				

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
Grevillea oleoides			2							1				2							
Grevillea speciosa	1																				
Grevillea sphacelata		4	4					2		2	4			2							3
Grevillea triternata														2							
Haemodorum corymbosum														1							
Hakea dactyloides	2	3	3				4	2	1	2	3	4	3	3		2	2			1	3
Hakea gibbosa														3							
Hakea sericea	3		4			1	1	2	3	2	2		1			3				1	3
Hakea teretifolia ssp. *teretifolia*														2							
Hardenbergia violacea					2	2			1												
Hibbertia aspera ssp. *aspera*			1		1																
Hibbertia bracteata									3	2							1				
Hibbertia circumdans	1	1						3	2	3											
Hibbertia riparia	1	2	2	2		2		1			3										
Hovea linearis		2	2						1		2					1					1
Hybanthus monopetalus						1															
Hymenophyllum cupressiforme																			2		
Imperata cylindrica var. *major*					1																
Isopogon anemonifolius	3	3	1					1		3	3			3							3
Kennedia prostrata	1																				
Kennedia rubicunda					2							1	1			1					
Kunzea ambigua																				3	
Lagenifera stipitata				1		2	1														
Lambertia formosa	4	3	4	4					2	3	4										2
Lasiopetalum ferrugineum var. *cordatum*									2												
Lasiopetalum ferrugineum var. *ferrugineum*	3						3	3							1	3					
Laxmannia gracilis		1						2						2							1
Lepidosperma filiforme														2							
Lepidosperma laterale	3	3	3	3	3		3		4	3			1	1	2	3				1	
Lepidosperma urophorum	2							1							1					1	
Leptocarpus tenax								3						3							

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
Leptomeria acida		1	1								1	1		1							+
Leptospermum arachnoides														2							
Leptospermum polygalifolium ssp. *polygalifolium*							1	1		2		2			2						
Leptospermum rotundifolium								1													
Leptospermum trinervium	3	2						4	1	4				3	1	1					2
Lepyrodia muelleri																					
Lepyrodia scariosa	3	2						3		1				4							3
Leucopogon ericoides	4							2									1			2	
Leucopogon lanceolatus var. *gracilis*							1														
Leucopogon lanceolatus var. *lanceolatus*					1				1			1			2	1					
Leucopogon spp.																					
Lindsaea linearis				2	2			1			2			1							
Lindsaea microphylla					1										2						
Livistona australis																		1			
Logania albiflora												1				1					
Lomandra cylindrica		2	1					2													1
Lomandra filiformis ssp. *coriacea*																				2	
Lomandra filiformis ssp. *filiformis*		1		1	2	2		1	1	2	3					3					1
Lomandra fluviatilis																	3				
Lomandra glauca								2													3
Lomandra longifolia	3				3	2	2	1	3	1		2	1		3		1			2	
Lomandra micrantha ssp. *tuberculata*																					
Lomandra multiflora ssp. *multiflora*				1	1	2				1											1
Lomandra obliqua	1	2	2	3		2		1	1		3									1	3
Lomatia myricoides							3	1							3		2		3		
Lomatia silaifolia	1	1	2	2	2	2	1	1	2		3	2				1					
Marsdenia suaveolens																1					
Melaleuca squamea									1												
Micrantheum ericoides								2	2	2	3										
Microlaena stipoides var. *stipoides*					1	1	3	1	2			1				2					
Mirbelia rubiifolia								1		1				3							

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
Mitrasacme pilosa var. *pilosa*																					1
Mitrasacme polymorpha								1													
Monotoca scoparia	1	1	1	1				1			1										1
Morinda jasminoides																		2	2		
Nematolepis squamea ssp. *squamea*	2						3		1						2	2					
Nephrolepis cordifolia																					
Notelaea longifolia						1										1		1	1		
Olax stricta		1						1						1							
Opercularia aspera							2		2						1	2	1				
Opercularia diphylla						1															
Oxalis spp.							2														
Parsonsia brownii																			1		
Parsonsia straminea															1			2			
Patersonia glabrata			4	5	4	4		3	2	2	2			3							3
Patersonia sericea	1	2						1												1	
Persoonia lanceolata														1							
Persoonia laurina ssp. laurina											1										
Persoonia levis	1	2		3		3					3	2									1
Persoonia linearis					3	3			1				4		2	4					
Persoonia pinifolia							1										2				
Petrophile pulchella	1	2	2				1	1						3							1
Petrophile sessilis				3		1		1		3	1										
Phebalium squamulosum ssp. *argenteum*							2														
Phebalium squamulosum ssp. *coriaceum*	2																				
Phebalium squamulosum ssp. *squamulosum*								1	1						1	1	1				
Philotheca myoporoides ssp. *myoporoides*																	2				
Phyllanthus hirtellus					3	2			2												2
Phyllota phylicoides			1																		
Pimelea linifolia ssp. *linifolia*	2	3	2	3	2	2	2	2	2	3	5	3	3	2		2					3
Pittosporum multiflorum																		1			
Pittosporum revolutum															1						

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
Platysace ericoides								2		2			1								1
Platysace lanceolata							1								1	2					
Platysace linearifolia	2	3	2	2				3	1	2	2			2						3	2
Pomaderris elliptica ssp. *elliptica*	2																				
Pomaderris intermedia							2								2						
Pomax umbellata																				2	
Poranthera corymbosa			2		2		1	1				2	1								
Poranthera ericifolia										2											
Poranthera microphylla							1		1							1					
Pratia purpurascens					1																
Prostanthera incisa							1														
Prostanthera lasianthos							4		1						1						
Pseudanthus pimeleoides																	1				
Pteridium esculentum	4				3		3	2	2			4	4		4	3				3	1
Ptilothrix deusta		3	1																		
Pultenaea daphnoides												4	5								
Pultenaea elliptica			3	1	1									3							
Pultenaea rosmarinifolia				2	1	1						1									
Pultenaea villosa									1							2					
Ricinocarpos pinifolius										2											
Scaevola ramosissima			1		1						1										
Schoenus apogon										2											2
Schoenus brevifolius																					
Schoenus melanostachys							4	1	2	2		2				2	2				
Selaginella uliginosa	1							1													
Smilax glyciphylla					1	1						1			2				1		
Solanum prinophyllum									1												
Stenocarpus salignus																2	2	3	2		
Sticherus flabellatus var. *flabellatus*									1						4		1	3	3		
Stylidium lineare														2							
Styphelia triflora								1		1				3							

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
Tasmannia insipida																		1	1		
Telopea speciosissima	2		2							1		1	2								1
Thysanotus tuberosus ssp. *tuberosus*								1													
Todea barbara																			4		
Tristania neriifolia															4		5				
Tristaniopsis laurina															4		4				
Veronica plebeia							1														
Viminaria juncea																	1				
Viola hederacea					1										1	1					
Viola sieberiana					3			1					2								
Woollsia pungens																				2	
Xanthorrhoea media	3	3		2			1	1		2	1			2							
Xanthosia dissecta		2																		2	
Xanthosia pilosa	2							3	1	2			1			1	1				1
Xanthosia tridentata				2	1	1		3	1							3	1				1
Xylomelum pyriforme		1	2	2		1					3										

Key: 1: <5% - 3 or less individuals; 2: <5% - more than 3 sparsely scattered; 3: <5% - common throughout plot; 4: 5% - 25%; 5: 25% - 50%; 6: 50% - 75%; 7: 75% - 100%

Table 20. Plant species recroded in the Study Area (quadrats from previous surveys)

Species	SCV1	SCV2	SCV3	FTCV1	FTCV2	FTCV3	SCTAV1	SCTAV2	SCTAV3	SCTBV1	SCTBV2	SCTBV3	DCTV1	DCTV2	DCTV3
Acacia binervata	2	3	3	1		3				2					
Acacia irrorata	1		1	1	2										
Acacia linifolia							3	4	4		4	2	4	3	3
Acacia longifolia											1				
Acacia longifolia ssp. *longifolia*						1	1			1		1	2	2	
Acacia myrtifolia									4			1		1	
Acacia rubida								1					2	1	2
Acacia suaveolens								1							
Acacia terminalis			1	1			3		4	1	3	3	1	1	2
Acacia ulicifolia				2			1	1			1	2		3	
Acianthus spp.						1			2						
Actinotus minor							1	1	3		1	1			
Allocasuarina littoralis				2		3	4		1					1	2
Allocasuarina torulosa						2									
Amperea xiphoclada var. *xiphoclada*							2	3	2			2	1	3	1
Amyema spp.						1	1								
Anisopogon avenaceus				2	1	2	3	3	2		2	3	1		1
Asplenium obtusatum ssp. *northlandicum*						1									
Astroloma pinifolium							1								
Astrotricha latifolia	3														
Astrotricha longifolia	3		3	2		1	3	2	1	3	3	3	5		1
Backhousia myrtifolia			1												
Baeckea linifolia									1						
Baloskion gracile							3	4	1			2	1		1
Banksia ericifolia ssp. *ericifolia*							2	4	3	1	2	3			
Banksia marginata													4		
Banksia paludosa ssp. *paludosa*							3	3	1		2	1	1		
Banksia serrata							4	2	2		4	1	1	3	1
Banksia spinulosa var. *spinulosa*				1	1	3	4	2	1		1		3	2	3
Bauera rubioides											1	1			1

Species	SCV1	SCV2	SCV3	FTCV1	FTCV2	FTCV3	SCTAV1	SCTAV2	SCTAV3	SCTBV1	SCTBV2	SCTBV3	DCTV1	DCTV2	DCTV3
Billardiera scandens var. *scandens*	1				1	2	1	1	2	1	1	2	1		1
Blechnum cartilagineum	1				2	4									
Boronia ledifolia							3	1	2		2	1			
Bossiaea heterophylla							1	1	1		1		3	3	2
Bossiaea obcordata							3	3	1			1	3	1	2
Bossiaea scolopendria											2		2		
Brachyloma daphnoides ssp. *daphnoides*							1		1				2		
Breynia oblongifolia					1										
Brunonia australis					2							1			
Brunoniella australis				1		1				1					1
Brunoniella pumilio															1
Caladenia carnea var. *carnea*				1										1	2
Callistemon citrinus													1		
Calochlaena dubia					4	2				3					
Cassytha glabella f. *glabella*		1	2	1	2	1	3	1	3	1	3				
Cassytha pubescens							1		2						
Caustis flexuosa											1				
Ceratopetalum apetalum	2	2	1												
Ceratopetalum gummiferum	5	4	5	3											
Chloanthes stoechadis		2	1		2	1	3					1			
Choretrum candollei														3	1
Cinnamomum oliveri															1
Cissus hypoglauca	1				1										
Clematis aristata	1				1	3							1		
Comesperma sphaerocarpum						1									
Comesperma volubile				1											
Conospermum ericifolium							1								
Conospermum spp.							2								
Conospermum tenuifolium							2	5	3				2		1
Correa reflexa var. *reflexa*	1			2						3					
Corybas spp.				1		1				1					

Species	SCV1	SCV2	SCV3	FTCV1	FTCV2	FTCV3	SCTAV1	SCTAV2	SCTAV3	SCTBV1	SCTBV2	SCTBV3	DCTV1	DCTV2	DCTV3
Corymbia gummifera						2			1		2	4			
Corymbia intermedia													3		
Cryptostylis erecta									1			1			
Cryptostylis spp.				1	1					1					
Cyathochaeta diandra								4	2		1	2	2		3
Dampiera purpurea	2			3	2	3				2			1		
Dampiera stricta							2	3	4		2			1	2
Darwinia grandiflora							1								
Daviesia acicularis													1		
Daviesia corymbosa								1							
Desmodium rhytidophyllum				1											
Desmodium varians					1										
Dianella caerulea var. *caerulea*	3	3	2										1	1	
Dianella caerulea var. *producta*	2	1	2	3	3	3	2		2	3		1	1	1	
Dianella revoluta var. *revoluta*				1			2		1		2	2	1	1	1
Dillwynia floribunda							2	3	4		4	3	1	3	1
Dillwynia retorta (J.C.Wendl.) Druce species complex												1	1	3	
Dillwynia rudis											1				
Dodonaea camfieldii												1			
Dodonaea triquetra	2			4						5		3			
Elaeocarpus reticulatus	3	3	1		1	1						1		2	
Empodisma minus							1	3	3		4	3			1
Entolasia marginata	1			3	2		3	2	3	1		3		1	2
Entolasia stricta				2	1	1	2	2	2	1	3	2	4	1	3
Epacris microphylla var. *microphylla*									2			1			
Epacris obtusifolia								1							
Epacris pulchella							1	1	2	1	2	3		1	2
Eriostemon australasius							1	1	2		2		1		
Eucalyptus eugenioides						3									
Eucalyptus haemastoma							4	4	4		4	4	3	2	3
Eucalyptus piperita	4	4	4	4	4	2	4			4		4	1	4	2

Species	SCV1	SCV2	SCV3	FTCV1	FTCV2	FTCV3	SCTAV1	SCTAV2	SCTAV3	SCTBV1	SCTBV2	SCTBV3	DCTV1	DCTV2	DCTV3
Eucalyptus racemosa							4	4	4		5	4	4	2	4
Eustrephus latifolius	1				1										
Exocarpos cupressiformis													1		
Gahnia sieberiana	1									2		3		3	
Geijera salicifolia var. *latifolia*															
Gleichenia dicarpa							3		3		2	4			
Glycine clandestina			1		1	3									
Gompholobium glabratum								1				1	3		1
Gompholobium grandiflorum			3				2	4	1		2		2		
Gompholobium minus											1				1
Gompholobium pinnatum								1			2	1	2		
Gonocarpus teucrioides	5	5	5	4	4	3	4	3	5	5	2	5	5	2	2
Goodenia bellidifolia ssp. *bellidifolia*									2						
Goodenia hederacea ssp. *hederacea*	3							1		3					1
Goodenia heterophylla ssp. *heterophylla*				3		4							1		
Goodenia stelligera								2			3	2			
Grevillea mucronulata	1		1	3	1	1	4			4	3	3	1	2	
Grevillea oldei											3				
Grevillea oleoides							2	3	2						
Grevillea sphacelata							1	2	1		2				
Haemodorum planifolium								2	2		1	1	1		
Haemodorum spp.									1						
Hakea dactyloides				3	1		4	4	3	4	3	3	4	1	3
Hakea salicifolia ssp. *salicifolia*				3	1										
Hakea sericea							1				1	1	1		1
Hakea teretifolia ssp. *teretifolia*							2	1	1		1	2	1		
Hardenbergia violacea				1	1									2	
Helichrysum elatum	3					1									
Helichrysum rutidolepis					1										
Hemarthria uncinata var. *uncinata*							1								
Hibbertia aspera ssp. *aspera*						3				1					1

Species	SCV1	SCV2	SCV3	FTCV1	FTCV2	FTCV3	SCTAV1	SCTAV2	SCTAV3	SCTBV1	SCTBV2	SCTBV3	DCTV1	DCTV2	DCTV3
Hibbertia bracteata					1						1				
Hibbertia circumdans							1								
Hibbertia dentata	4	3	4	2	3	2									
Hibbertia hermanniifolia				2						2					
Hibbertia obtusifolia				2	2	3									
Hibbertia riparia							3	2	2		3	2	2	1	1
Hibbertia scandens					1	3									
Hibbertia spp.						4									
Hovea linearis										3		2			
Hovea purpurea	1									1					
Hovea spp.													1		
Hybanthus monopetalus							1		1						
Hydrocotyle peduncularis					3	1									
Isopogon anemonifolius							3	3	2		2		1	1	3
Kennedia rubicunda		2	1	1	3	2				1				1	
Lambertia formosa							4	1	3		2	3	5	2	4
Lasiopetalum ferrugineum var. *ferrugineum*													1		
Lepidosperma filiforme							1	2	3				3		
Lepidosperma forsythii							1								
Lepidosperma laterale	1			1	2	1				1			5		2
Lepidosperma neesii											1	1			
Lepidosperma urophorum											1	1			
Leptocarpus tenax							3	4	4		3	2	5		3
Leptomeria acida				1			3	2	1			1		2	
Leptospermum arachnoides											1				
Leptospermum polygalifolium ssp. *polygalifolium*				1			2	1	1	1	5	3	1	1	3
Leptospermum rotundifolium													1		
Leptospermum trinervium							3	3	2		4	4	2	3	4
Lepyrodia muelleri														1	
Lepyrodia scariosa							4	4	4		4	4	4	1	5
Leucopogon amplexicaulis									2						

Species	SCV1	SCV2	SCV3	FTCV1	FTCV2	FTCV3	SCTAV1	SCTAV2	SCTAV3	SCTBV1	SCTBV2	SCTBV3	DCTV1	DCTV2	DCTV3
Leucopogon ericoides														2	2
Leucopogon juniperinus							1	1	2						
Leucopogon lanceolatus var. *lanceolatus*	2	2	2	2	1	1				1				1	1
Leucopogon spp.														3	
Lindsaea linearis				1			1	3	2	1	3	3			
Lindsaea microphylla										1					
Lissanthe strigosa ssp. *strigosa*						1		1							
Litsea australis				2											
Livistona australis	1				1										
Logania albiflora	1			2			1			1					
Lomandra brevis													2		
Lomandra cylindrica			1	2			1	2	3		1	1	2	2	3
Lomandra filiformis ssp. *coriacea*				1	1				1			2			2
Lomandra filiformis ssp. *filiformis*							3	1	3				3	3	3
Lomandra glauca	1						2	3	4		1	1	1		3
Lomandra gracilis				2						1					
Lomandra longifolia	4	4	3	2	3	3	2		3	3	3	2	3	4	1
Lomandra micrantha ssp. *tuberculata*					2									1	
Lomandra multiflora ssp. *multiflora*				2		1	3	1	1		2	2			1
Lomandra obliqua							1	1	2		2	2	2	1	3
Lomatia myricoides				1											
Lomatia silaifolia	2		2	3	3	3	2	1	1	4			3	1	3
Lycopodium deuterodensum									2						
Marsdenia suaveolens			1	1											
Micrantheum ericoides							1								
Microlaena stipoides var. *stipoides*	1			1	3	2									1
Mirbelia platylobioides							1		1						
Mirbelia rubiifolia								2			2		2	1	2
Mirbelia speciosa ssp. *speciosa*							1	4	1		3	1			
Mitrasacme pilosa var. *pilosa*							2	4	3		3	3			1
Mitrasacme polymorpha														3	

Species	SCV1	SCV2	SCV3	FTCV1	FTCV2	FTCV3	SCTAV1	SCTAV2	SCTAV3	SCTBV1	SCTBV2	SCTBV3	DCTV1	DCTV2	DCTV3
Monotaxis linifolia	1		1												
Monotaxis spp.										1				2	
Monotoca elliptica											1				
Monotoca scoparia								2							1
Morinda jasminoides	1				1										
Nematolepis squamea ssp. *squamea*	3	4	3	2											
Nephrolepis cordifolia	2														
Notelaea longifolia	1	1	1		1	1									
Notodanthonia longifolia														1	
Opercularia aspera					2								3		
Opercularia diphylla	1		1	2	3	3	2	1	1		1	1			
Opercularia hispida										1					
Opercularia spp.															1
Oplismenus aemulus	1				2										
Ozothamnus diosmifolius						1									
Panicum spp.									1						
Parsonsia straminea					1										
Patersonia glabrata					1	3	3	2	3	1	3	2	1	3	2
Patersonia sericea				3											2
Persicaria strigosa					3										
Persoonia levis				1			1	1	2		1			1	1
Persoonia linearis	2		3	1	1	2	1			3			2	3	2
Persoonia mollis ssp. *nectens*			1												
Persoonia pinifolia													1		
Petrophile pulchella							2	2	2	2	1	2		1	1
Petrophile sessilis								2					1		3
Phebalium spp.			4												
Phyllanthus hirtellus				1						2	2			2	2
Pimelea linifolia ssp. *linifolia*	2		1	3	2		3	4	4	3	1	3	1	1	3
Pimelea pauciflora			2												
Pittosporum revolutum					3										

Species	SCV1	SCV2	SCV3	FTCV1	FTCV2	FTCV3	SCTAV1	SCTAV2	SCTAV3	SCTBV1	SCTBV2	SCTBV3	DCTV1	DCTV2	DCTV3
Platylobium formosum ssp. *formosum*							1	1	1						
Platysace ericoides							3	2			1	2	3		
Platysace lanceolata		1	1												
Platysace linearifolia	1			1		1	3	2	3	1	5	3	3	1	3
Polyscias sambucifolia						1									
Pomaderris ferruginea				2	2										
Pomaderris intermedia	1			4	2	3	1			4					
Pomaderris spp.						3									
Pomax umbellata														4	
Poranthera ericifolia					1		2	3	3			2	1		3
Poranthera microphylla						3									
Pratia purpurascens			1		2										
Prostanthera lasianthos	1														
Pseuderanthemum variabile					2										
Psychotria loniceroides					1										
Pteridium esculentum	4	3	4	3	3	3	2	1	1	2	2	2	3	4	2
Pterostylis pedoglossa								1	2		2	1			2
Pterostylis spp.	1	2	2	1	3	1								1	
Ptilothrix deusta								1							
Pultenaea daphnoides				2		4				2			1		
Pultenaea flexilis	2		2	2	3	3				1					
Pultenaea linophylla												1			
Pultenaea rosmarinifolia				1		2				1					
Pultenaea spp.				1											
Rapanea variabilis			1			2									
Rhodanthe anthemoides												1			
Rhytidosporum procumbens													2		
Scaevola ramosissima							1	1	3			1			
Schelhammera undulata	1				1	1									
Schizaea bifida								1			1				
Schizomeria ovata	5		2		4										

Species	SCV1	SCV2	SCV3	FTCV1	FTCV2	FTCV3	SCTAV1	SCTAV2	SCTAV3	SCTBV1	SCTBV2	SCTBV3	DCTV1	DCTV2	DCTV3
Schoenus brevifolius							1	2	1						
Schoenus melanostachys	3			1	1					1		1	2		2
Selaginella uliginosa							2	2	1		2		2		4
Senecio vagus ssp. *eglandulosus*			2												
Smilax australis	1														
Smilax glyciphylla		1	1	2	1	1						1			
Solanum pungetium					1										
Sowerbaea juncea											1				
Sphaerolobium vimineum								2	3						
Stackhousia viminea							2	1			1	2			
Stenocarpus salignus	3		1												
Sticherus flabellatus var. *flabellatus*					1								1		
Stylidium lineare									1		1				
Stylidium productum									1		1				
Styphelia laeta ssp. *laeta*												1			
Symphionema paludosum								1							
Telopea speciosissima						1		1				1	2		
Tetrarrhena juncea				1			2		1	1		2			
Thelymitra ixioides var. *ixioides*															1
Thelymitra spp.							1	1	1		1				
Tristaniopsis collina	1	3	4	1	3	2				1					
Trochocarpa laurina			1												
Tylophora barbata	1				1	1									
Viola betonicifolia						1									
Viola hederacea	4		3	3	4	3				1		3	2		1
Viola sieberiana							1	1		1		2			
Xanthorrhoea media							1	2					4		1
Xanthorrhoea resinifera															1
Xanthosia dissecta							3	3	2						
Xanthosia pilosa			2	1			1	1	1			1	4	1	2
Xanthosia tridentata	1						3	3	3	2	3	3	2		1

Species	SCV1	SCV2	SCV3	FTCV1	FTCV2	FTCV3	SCTAV1	SCTAV2	SCTAV3	SCTBV1	SCTBV2	SCTBV3	DCTV1	DCTV2	DCTV3
Xylomelum pyriforme						1									
Xyris gracilis								1							
Xyris operculata													2		2
Zieria smithii	1	1	3						1	2	2	1			

Key: 1: <5% - 3 or less individuals; 2: <5% - more than 3 sparsely scattered; 3: <5% - common throughout plot; 4: 5% - 25%; 5: 25% - 50%; 6: 50% - 75%; 7: 75% - 100%

Table 21. Plant species recorded in the Study Area (transect data from previous surveys)

Species	Swamp 11			Swamp 15A			Swamp 15B			Donalds Castle Swamp A			Donalds Castle Swamp B		
Scientific Name	**11A**	**11B**	**11C**	**15AV1**	**15AV2**	**15AV3**	**15BV1**	**15BV2**	**15BV3**	**DCSAV1**	**DCSAV2**	**DCSAV3**	**DCSBV1**	**DCSBV2**	**DCSBV3**
Acacia rubida	1														
Acacia terminalis	1						6	8							
Acianthus fornicatus							3								
Acianthus spp.									1						
Actinotus minor															
Almaleea paludosa	13	26	22		9	8			10				9	26	2
Almaleea spp.															
Amperea xiphoclada												1			
Anisopogon avenaceus					1					12	1	11			2
Baeckea imbricata		20	24		11	28									
Baeckea linifolia					16		14	1	17			27			
Baeckea spp.			11			28									
Baloskion gracile		5	2				4	7	1						
Banksia ericifolia ssp. ericifolia	12	5	14					8	1						
Banksia oblongifolia											6	7			13
Banksia paludosa														1	10
Banksia robur	12	2	2	7	1		18	2	14				9	13	
Banksia spinulosa var. spinulosa								2		4		1			
Bauera microphylla		3							8	3		4	8	29	14
Bauera rubioides	1	4	1		2				1						
Baumea rubiginosa	1	3					19	5	1	1			2		3
Baumea teretifolia	30	13		30			10	5	11		3	4			5
Billardiera scandens var. scandens												1			
Blandfordia nobilis		6	1				5					1			
Boronia parviflora	4	29	29		23	26	12		3			2	1	30	16
Bossiaea heterophylla							1		1						
Bossiaea scolopendria							1								
Brunoniella australis										7		4			
Brunoniella pumileo							1				2				

Species	Swamp 11			Swamp 15A			Swamp 15B			Donalds Castle Swamp A			Donalds Castle Swamp B		
Scientific Name	**11A**	**11B**	**11C**	**15AV1**	**15AV2**	**15AV3**	**15BV1**	**15BV2**	**15BV3**	**DCSAV1**	**DCSAV2**	**DCSAV3**	**DCSBV1**	**DCSBV2**	**DCSBV3**
Burchardia umbellata		14	3		2					8	9	2		2	
Cassytha glabella f. glabella	2	1	11			2	12	13	4	17	26	12		18	
Catolasia structa		2													
Chorizandra cymbaria	2							14	4						
Chorizandra sphaerocephala	21	12	7					25					5	11	17
Cyathochaeta diandra										24	19				
Dampiera stricta		1			4					13	12	9		3	4
Dillwynia floribunda							14	7		23	28	15		4	2
Dillwynia retorta								21							
Dillwynia rudis	5			5	20		4	17	3						
Dillwynia spp.							10								
Drosera binata	17	29			1	23	7	2	6						
Drosera peltata															3
Drosera spatulata	1	27	21			7		1	1	1				9	
Empodisma minus	13	3	1	30	30	29	29	18	26	8	1	21	18		
Entolasia stricta				1	9	9	1	1		26	20	11	14	20	16
Epacris microphylla															
Epacris obtusifolia	8	30	21		24	28	1	7	9				1	18	
Epacris paludosa				11											
Eucalyptus sieberi							1								
Eucalyptus spp.							2	1		2	6	1			
Schoenus paludosus		18	19		1	3			6						
Genoplesium sp.															
Gleichenia dicarpa	7						6	26	12						
Gleichenia microphylla	8			27			26	21	19						
Gompholobium grandiflorum							1								
Gompholobium minus										2					
Gonocarpus micranthus ssp. micranthus	9						3	20	5						1
Gonocarpus tetragynus	23	30	29		22	21	10		11	9	17	5	2		
Gonocarpus teucrioides							1								

Species	Swamp 11			Swamp 15A			Swamp 15B			Donalds Castle Swamp A			Donalds Castle Swamp B		
Scientific Name	11A	11B	11C	15AV1	15AV2	15AV3	15BV1	15BV2	15BV3	DCSAV1	DCSAV2	DCSAV3	DCSBV1	DCSBV2	DCSBV3
Goodenia dimorpha var. dimorpha	4	30	19						1	26	7				
Goodenia hederacea							1						2		
Goodenia stelligera		30	22		21	18	2		21			11		30	17
Grevillea sericea ssp. sericea		1								10	9	5	5	8	12
Grevillea speciosa		1											1		
Grevillea sp.															2
Gymnoschoenus sphaerocephalus			18		22	18	1		14		7				
Haemodorum planifolium							1	1	1	3	2			8	
Haemodorum sp.		7					2								1
Hakea dactyloides										2	2				
Hakea teretifolia ssp. teretifolia	5	1				2		1	3	1			5		
Hemarthria uncinata var. uncinata	30	1		6	20	15	25	29	7		22	28	9	2	30
Hemigenia purpurea												8			
Hibbertia riparia										1	4	5			
Hypericum japonicum										1			1		
Isopogon anemonifolius															
Lepidosperma forsythii									11						
Lepidosperma laterale								1	17						
Lepidosperma limicola	30		11		23	30	30	13	22			6	15	2	14
Lepidosperma longitudinale															
Lepidosperma neesii		2	1					2		23	17	15	15	17	13
Lepidosperma spp.							5								
Leptocarpus tenax	30	29	17		15	27	2	24	11	2	22	30	29	29	30
Leptospermum juniperinum	9			15	2		2	15	8						1
Leptospermum lanigerum															
Leptospermum polygalifolium ssp. polygalifolium							2	6		6					2
Leptospermum spp.															
Leptospermum squarrosum										20	11	6			
Leptospermum trinervium															
Lepyrodia anarthria			13		2		2	17				22	25		18

Species	Swamp 11			Swamp 15A			Swamp 15B			Donalds Castle Swamp A			Donalds Castle Swamp B		
Scientific Name	**11A**	**11B**	**11C**	**15AV1**	**15AV2**	**15AV3**	**15BV1**	**15BV2**	**15BV3**	**DCSAV1**	**DCSAV2**	**DCSAV3**	**DCSBV1**	**DCSBV2**	**DCSBV3**
Lepyrodia muelleri	4	3	1			0				5		1		2	
Lepyrodia scariosa	6	23	15		10	25	11	2	26	28	14	13		14	6
Lepyrodia spp.		11	7					13							
Lindsaea linearis		2						5		15	5	2			6
Lomandra cylindrica										3		14			4
Lomandra micrantha										2	8	1			
Lomandra sp.												1			
Lycopodiella spp.						2									
Lycopodiella lateralis?						3									
Lycopodium spp.	2	4							3						
Melaleuca thymifolia	1									7	17	14			
Mirbelia speciosa ssp. speciosa					8			8	1						
Mitrasacme paludosa															
Mitrasacme pilosa var. pilosa					2		1	10		5	14	8	1	5	6
Mitrasacme polymorpha							1	3							
Monotaxis linifolia					5			9				3		1	
Opercularia diphylla								3	1	14	5				
Opercularia spp.															
Panicum simile															
Patersonia sericea					2					6				1	1
Persoonia lanceolata								2							
Persoonia levis								1							
Petrophile pulchella							1	1							
Pimelea linifolia															
Platysace linearifolia							3	7		2	2	11			
Pteridium esculentum								2							
Ptilothrix deusta	1	30	16		14	2			2	30	30	22	25	30	22
Schizaea bifida		6			1	0			2						
Schoenus brevifolius	22	27	27		22	29	14	3	3	16	8	27	29	28	29
Schoenus sp.														18	

Species	Swamp 11			Swamp 15A			Swamp 15B			Donalds Castle Swamp A			Donalds Castle Swamp B		
Scientific Name	**11A**	**11B**	**11C**	**15AV1**	**15AV2**	**15AV3**	**15BV1**	**15BV2**	**15BV3**	**DCSAV1**	**DCSAV2**	**DCSAV3**	**DCSBV1**	**DCSBV2**	**DCSBV3**
Schoenus paludosus						5									
Selaginella uliginosa	3	1			7	3	5	1	2			1	5	28	2
Sowerbaea juncea					6	4				2		5		27	
Sphaerolobium minus	6	2					7		5	13	16	5			
Sphaerolobium spp.	5		2						1						
Sphaerolobium vimineum	2		1	3	2	9	1	6	2			4	1	5	16
Sprengelia incarnata	9	28	9		13	6		3	7					15	
Stockhousia nudum															
Stylidium lineare		13	1		3									14	5
Tetraria capillaris	10	11	8				7	4	4						
Thelymitra spp.		5	3		6	0	2		2	6	2			19	2
Utricularia uniflora			5												
Viminaria juncea															
Viola hederacea										3	6	3			
Xanthorrhoea minor ssp. minor															
Xanthorrhoea resinosa													18		
Xanthosia dissecta							9	5							
Xanthosia tridentata							8	3							
Xyris complanata			11												
Xyris gracilis	1	23	18		15	26		4	22	2			1	27	
Xyris juncea		26	24												
Xyris operculata	11	6	23		14	12	4	2	21				19		
Xyris sp.	2														

Key: 1: <5% - 3 or less individuals; 2: <5% - more than 3 sparsely scattered; 3: <5% - common throughout plot; 4: 5% - 25%; 5: 25% - 50%; 6: 50% - 75%; 7: 75% - 100%

APPENDIX 5

FAUNA RECORDED IN THE STUDY AREA

Table 22: Animal species recorded in the Study Area

Scientific Name	Common Name	EPBC Act	TSC Act	Dendrobium Area 3 (current surveys)				Monitoring Surveys			Other Relevant Reports										Biosis Inci-dental	Birds Aus
				Gully	Ridge	Upland Swamp	Rainforest	Gully	Ridge	Upland Swamp	1. 3434	2. 3465	3. 3580	4. 3600	5. 3838	6. 3910	7. 4226	8. 4289	9. 4299	10. 4439		
Amphibians																						
Crinia signifera	Common Eastern Froglet			OW	OW	W	W	X	-	X	X	X	-	-	W	W	W	W	W	W	-	-
Heleioporus australiacus	Giant Burrowing Frog	V	V	W	W	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	W	-
Limnodynastes dumerilii	Eastern Banjo Frog			-	-	W	-	X	-	X	X	X	-	O	-	-	-	-	-	-	-	-
Limnodynastes peronii	Striped Marsh Frog			-	-	-	-	X	-	X	-	-	-	-	-	-	-	W	-	-	-	-
Litoria citropa	Blue Mountains Tree Frog			OW	O	-	W	X	X	X	X	X	-	-	-	-	-	-	-	-	-	-
Litoria dentata	Bleating Tree Frog			-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Litoria ewingii	Brown Tree Frog			W	-	-	-	X	-	X	-	-	X	-	-	-	-	-	-	W	-	-
Litoria freycineti	Freycinet's Frog			-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Litoria jervisiensis	Jervis Bay Tree Frog			-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Litoria lesueuri	Lesueur's Frog			OW	-	-	-	X	-	X	-	X	-	-	-	-	-	-	-	O	-	-
Litoria littlejohni	Littlejohn's Tree Frog	V	V	OW	-	W	-	X	-	X	-	-	-	-	-	-	-	-	-	-	W	-
Litoria nudidigita	Leaf Green Tree Frog (Southern Call Race)			-	-	-	W	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Litoria peronii	Peron's Tree Frog			W	-	-		X	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Litoria phyllochroa	Leaf Green Tree Frog (Northern Call Race)			OW	-	-	W	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Litoria phyllochroa/ nudidigita	Leaf Green Tree Frog complex			O	-	-	O	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Scientific Name	Common Name	EPBC Act	TSC Act	Dendrobium Area 3 (current surveys)				Monitoring Surveys			Other Relevant Reports										Biosis Inci-dental	Birds Aus
				Gully	Ridge	Upland Swamp	Rainforest	Gully	Ridge	Upland Swamp	1. 3434	2. 3465	3. 3580	4. 3600	5. 3838	6. 3910	7. 4226	8. 4289	9. 4299	10. 4439		
Litoria verreauxii	Verreaux's Tree Frog			OW	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Litoria sp	Unidentified Tree Frog			W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-
Paracrinia haswelli	Haswell's Frog			-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	W	-	-
Pseudophryne australis	Red-crowned Toadlet		V	W	W	W	-	-	-	-	X	X	-	-	-	-	-	-	-	-	O/W	-
	Unidentified tadpole			O	-	O	-	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-
Birds																						
Acanthiza lineata	Striated Thornbill			OW	OW	W	W	X	X	X	-	-	-	-	-	-	W	-	O	OW	-	X
Acanthiza nana	Yellow Thornbill			-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	O	-	-	-
Acanthiza pusilla	Brown Thornbill			W	OW	-	-	X	X	X	-	X	-	OW	-	-	W	O	-	OW	-	X
Acanthiza reguloides	Buff-rumped Thornbill			W	OW	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Acanthiza sp.	Unidentified Thornbill			W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthorhynchus tenuirostris	Eastern Spinebill			OW	OW	W	W	X	X	X	-	X	-	W	O	O	W	OW	O	OW	-	X
Accipiter fasciatus	Brown Goshawk			-	-	-	-	X	-	-	-	-	-	-	-	-	W	-	-	-	-	X
Accipiter novaehollandiae	Grey Goshawk			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Aegotheles cristatus	Australian Owlet-nightjar			W	W	W	-	W	-	W	-	X	-	-	-	-	-	-	-	-	-	X
Ailuroedus crassirostris	Green Catbird			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Alcedo azurea	Azure Kingfisher			-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alisterus scapularis	Australian King-Parrot			W	W	-	-	X	X	X	-	-	-	OW	-	-	-	O	-	-	-	X
Anthochaera carnunculata	Red Wattlebird			OW	OW	W	-	X	X	X	-	X	-	W	-	-	W	OW	W	OW	-	X
Anthochaera chrysoptera	Little Wattlebird			OW	W	-	W	X	X	X	-	X	-	-	-	-	O	-	-	OW	-	X

Scientific Name	Common Name	EPBC Act	TSC Act	Dendrobium Area 3 (current surveys)				Monitoring Surveys			Other Relevant Reports										Biosis Inci-dental	Birds Aus
				Gully	Ridge	Upland Swamp	Rainforest	Gully	Ridge	Upland Swamp	1. 3434	2. 3465	3. 3580	4. 3600	5. 3838	6. 3910	7. 4226	8. 4289	9. 4299	10. 4439		
Anthochaera sp.	Unidentified Wattlebird			-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aquila audax	Wedge-tailed Eagle			O	-	-	-	-	X	X	-	X	-	-	-	-	-	-	O	-	-	X
Artamus cyanopterus	Dusky Woodswallow			-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Artamus superciliosus	White-browed Woodswallow			-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Cacatua galerita	Sulphur-crested Cockatoo			-	-	-	-	X	X	X	-	-	-	-	-	-	W	W	-	-	-	X
Cacatua roseicapilla	Galah			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Cacomantis flabelliformis	Fan-tailed Cuckoo			W	W	W	W	X	X	X	-	X	-	W	-	-	-	-	-	-	-	X
Cacomantis variolosus	Brush Cuckoo			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Callocephalon fimbriatum	Gang-gang Cockatoo		V	OW	OW	W	-	X	X	X	-	-	-	-	-	-	-	-	-	OW	OW	X
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo			W	-	-	-	X	X	X	X	X	-	-	-	O	-	-	-	OW	-	X
Calyptorhynchus lathami	Glossy Black-cockatoo		V	OW	OW	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	W	-
Cecropis ariel	Fairy Martin			-	-	-	-	X	-	X	-	X	-	-	-	-	-	-	-	-	-	-
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo			-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X
Chrysococcyx lucidus	Shining Bronze-Cuckoo			-	-	-	-	X	X	X	-	-	-	-	-	-	-	-	O	-	-	X
Cinclosoma punctatum	Spotted Quail-thrush			-	OW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Climacteris erythrops	Red-browed Treecreeper			OW	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	X

Scientific Name	Common Name	EPBC Act	TSC Act	Dendrobium Area 3 (current surveys)				Monitoring Surveys			Other Relevant Reports										Biosis Inci-dental	Birds Aus
				Gully	Ridge	Upland Swamp	Rainforest	Gully	Ridge	Upland Swamp	1. 3434	2. 3465	3. 3580	4. 3600	5. 3838	6. 3910	7. 4226	8. 4289	9. 4299	10. 4439		
Colluricincla harmonica	Grey Shrike-thrush			W	OW	W	W	X	X	X	-	X	-	-	W	O	W	OW	O	OW	-	X
Colluricincla megarhyncha	Little Shrike-thrush			-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Columba leucomela	White-headed Pigeon			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Coracina tenuirostris	Cicadabird			-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Coracina novaehollandiae	Black-faced Cuckoo-shrike			OW	W	-	-	X	X	X	-	X	-	O	-	-	-	O	O	-	-	X
Cormobates leucophaeus	White-throated Treecreeper			OW	OW	W	W	X	X	X	-	X	-	OW	-	-	W	OW	O	OW	-	X
Corvus coronoides	Australian Raven			-	W	-	-	X	X	X	-	X	-	-	-	-	W	OW	W	OW	-	X
Corvus mellori	Little Raven			W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cracticus torquatus	Grey Butcherbird			W	W	W	-	X	X	X	-	X	-	-	-	-	-	-	-	W	-	X
Cuculus pallidus	Pallid Cuckoo			-	-	W	-	X	X	X	-	-	-	W	-	-	-	-	-	-	-	-
Cygnus atratus	Black Swan			-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dacelo novaeguineae	Laughing Kookaburra			W	W	-	W	X	X	X	-	-	-	W	W	-	-	W	-	W	-	X
Daphoenositta chrysoptera	Varied Sittella			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-
Dicaeum hirundinaceum	Mistletoebird			W	-	W	W	X	X	X	-	-	-	-	-	-	-	-	-	W	-	X
Dicrurus bracteatus	Spangled Drongo			O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eopsaltria australis	Eastern Yellow Robin			OW	W	W	OW	X	X	X	-	X	-	W	-	-	W	-	-	W	-	X
Eurystomus orientalis	Dollarbird			O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Falco longipennis	Australian Hobby	M		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X

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				Gully	Ridge	Upland Swamp	Rainforest	Gully	Ridge	Upland Swamp	1. 3434	2. 3465	3. 3580	4. 3600	5. 3838	6. 3910	7. 4226	8. 4289	9. 4299	10. 4439		
Falco peregrinus	Peregrine Falcon	M		-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	X
Falcunculus frontatus	Crested Shrike-tit			-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	X
Gerygone mouki	Brown Gerygone			W	W	-	W	X	X	X	-	-	-	-	-	-	W	-	W	OW	-	X
Gerygone olivacea	White-throated Gerygone			-	-	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	X
Grallina cyanoleuca	Magpie-lark			-	-	-	-	-	-	-	-	-	-	O	-	-	-	O	-	-	-	X
Gymnorhina tibicen	Australian Magpie			-	-	-	-	X	-	-	-	-	-	O	O	O	-	-	-	-	-	X
Haliaeetus leucogaster	White-bellied Sea-eagle	M		-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Hirundo neoxena	Welcome Swallow			OW	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	X
Hirundo nigricans	Tree Martin			-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	X
Leucosarcia melanoleuca	Wonga Pigeon			-	W	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	X
Lichenostomus chrysops	Yellow-faced Honeyeater			OW	OW	OW	W	X	X	X	-	-	-	-	-	-	W	-	W	OW	-	X
Licenostomus fuscus	Fuscous Honeyeater			-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lichenostomus leucotis	White-eared Honeyeater			W	W	W	W	X	-	X	-	-	-	O	-	-	-	O	-	OW	-	X
Lichenostomus melanops	Yellow-tufted Honeyeater			-	-	-	W	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lichenostomus penicillatus	White-plumed Honeyeater			-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lichmera indistincta	Brown Honeyeater			-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-
Lopholaimus antarcticus	Topknot Pigeon			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Macropygia amboinensis	Brown Cuckoo-Dove			W	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	X

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Malurus cyaneus	Superb Fairy-wren			OW	W	-	-	X	-	X	-	-	-	-	-	-	-	-	O	W	-	X
Malurus lamberti	Variegated Fairy-wren			W	W	-	W	X	X	X	-	X	-	-	-	-	W	-	O	OW	-	X
Malurus sp.	Unidentified Fairy-wren			-	W	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Manorina melanocephala	Noisy Miner			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Manorina melanophrys	Bell Miner			-	-	-	-	-	-	-	-	-	-	-	-	W	-	-	-	-	-	-
Meliphaga lewinii	Lewin's Honeyeater			-	-	-	W	X	X	-	-	-	-	-	-	O	W	OW	-	-	-	X
Melithreptus brevirostris	Brown-headed Honeyeater			OW	-	-	-	X	X	X	-	-	-	-	-	-	-	-	-	W	-	X
Melithreptus lunatus	White-naped Honeyeater			OW	OW	-	-	X	X	X	-	-	-	-	-	-	W	-	-	OW	-	X
Menura novaehollandiae	Superb Lyrebird			OW	W	W	W	X	X	X	-	-	-	-	-	-	W	-	-	O	-	X
Monarcha melanopsis	Black-faced Monarch	M		-	-	-	-	X	X	X	-	X	-	-	-	-	-	-	-	-	-	X
Myiagra cyanoleuca	Satin Flycatcher	M		-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Myiagra inquieta	Restless Flycatcher			W	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myiagra rubecula	Leaden Flycatcher	M		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Myzomela sanguinolenta	Scarlet Honeyeater			-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Neochmia temporalis	Red-browed Finch			-	-	-	-	X	-	-	-	-	-	O	-	-	O	-	-	-	-	X
Ninox connivens	Barking Owl		V	-	OW	-	-	W	-	-	-	-	-	-	-	-	-	-	-	-	W	-
Ninox novaeseelandiae	Southern Boobook			W	O/W	W	W	X	X	X	-	X	-	-	-	-	-	-	-	-	-	X

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Ninox strenua	Powerful Owl		V	-	-	-		-	-	X	-	-	-	-	-	-	-	-	-	-	W	X
Ocyphaps lophotes	Crested Pigeon			-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Origma solitaria	Rockwarbler			-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Oriolus sagittatus	Olive-backed Oriole			-	W	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	X
Orthonyx temminckii	Logrunner			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Pachycephala olivacea	Olive Whistler		V	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	W	-
Pachycephala pectoralis	Golden Whistler			W	W	W	W	X	X	X	-	X	-	-	OW	-	W	-	O	OW	-	X
Pachycephala rufiventris	Rufous Whistler			-	-	-	-	X	X	X	-	X	-	-	-	O	-	-	-	-	-	X
Pardalotus punctatus	Spotted Pardalote			W	W	-	W	X	X	X	-	-	-	-	-	-	W	-	W	W	-	X
Pardalotus striatus	Striated Pardalote			O	-	-	-	X	X	X	-	-	-	-	-	-	-	-	-	W	-	-
Petroica boodang	Scarlet Robin			W	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Petroica rosea	Rose Robin			-	-	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	X
Phaps chalcoptera	Common Bronzewing			-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Philemon corniculatus	Noisy Friarbird			-	W	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	X
Philemon citreogularis	Little Friarbird			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Phylidonyris nigra	White-cheeked Honeyeater			-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	X
Phylidonyris novaehollandiae	New Holland Honeyeater			OW	OW	W	W	X	X	X	-	X	-	-	-	-	O	-	-	OW	-	X
Philemon citreogularis	Crescent Honeyeater			-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X
Platycercus elegans	Crimson Rosella			OW	OW	W	W	X	X	X	-	X	-	O	O	-	W	OW	W	OW	-	X
Platycercus eximius	Eastern Rosella			-	-	-	-	-	-	X	-	-	-	-	-	-	-	O	-	-	-	X

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Podargus strigoides	Tawny Frogmouth			-	O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	X
Psophodes olivaceus	Eastern Whipbird			W	W	-	W	X	X	X	-	X	-	-	-	-	-	W	W	-	-	X
Ptilonorhynchus violaceus	Satin Bowerbird			W	-	-	W	X	X	X	-	-	-	-	-	-	-	-	-	-	-	X
Pycnoptilus floccosus	Pilotbird			-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Rhipidura albiscapa	Grey Fantail			OW	OW	W	W	X	X	X	-	X	-	O	O	O	W	O	O	OW	-	X
Rhipidura rufifrons	Rufous Fantail	M		-	-	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	X
Scythrops novaehollandiae	Channel-billed Cuckoo			-	-	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	X
Sericornis citreogularis	Yellow-throated Scrubwren			-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Sericornis frontalis	White-browed Scrubwren			W	W	W	W	X	X	X	-	-	-	O	-	-	O	-	O	OW	-	X
Sericornis magnirostris	Large-billed Scrubwren			-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X
Stagonopleura bella	Beautiful Firetail			-	-	-	-	X	-	X	-	-	-	-	O	-	-	-	-	-	-	-
Stipiturus malachurus	Southern Emu-wren			-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	OW	-	-
Strepera graculina	Pied Currawong			T/OW	W	W	W	X	X	X	-	X	-	W	-	-	W	-	W	-	-	X
Strepera versicolor	Grey Currawong			W	W	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	X
Todiramphus sanctus	Sacred Kingfisher			W	W	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	X
Trichoglossus haematodus	Rainbow Lorikeet			-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	X
Tyto tenebricosa	Sooty Owl		V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Vanellus miles	Masked Lapwing			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Zosterops lateralis	Silvereye			OW	OW	W	-	X	X	X	-	-	-	-	-	-	W	-	O	OW	-	X
Zoothera lunulata	Bassian Thrush			-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X
	Unidentified			O	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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	Treecreeper																					
Mammals																						
Canis familiaris	Dingo			-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canis familiaris	Feral Dog or Dingo			I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cercartetus nanus	Eastern Pygmy Possum		V	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	O	-
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	-	-	AD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chalinolobus gouldii	Gould's Wattled Bat			AD	-	AD	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Chalinolobus morio	Chocolate Wattled Bat			AD	-	AD	AP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Falsistrellus tasmaniensis	Eastern False Pipistrelle		V	AP	-	AP	AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Felis catus	Cat (feral)		U	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kerivoula papuensis	Golden-tipped Bat		V	AM	-	AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macropod sp.	Unidentified macropod			I/W	O/W	I/W	-	W	-	W	-	-	-	-	-	-	-	-	-	-	-	-
Macropus rufogriseus	Red-necked Wallaby			IP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Miniopterus australis	Little Bentwing-bat		V	-	-	AP	-	-	-		-	-		-	-	-	-	-	-	-	-	-
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat		V	AD	-	AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mormopterus norfolkensis	Eastern Freetail Bat		V	AD	-	AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mormopterus sp	Unidentified Freetail Bat			AP	-	AP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Mus musculus	House Mouse		U	-	-	HP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myotis macropus	Southern Myotis		V	AD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyctophilus geoffroyi	Lesser Long-eared Bat			T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyctophilus sp.	Unidentified Long-eared Bat			AD	-	AD	AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petaurus breviceps	Sugar Glider			OW	OW	W	W	X	X	X	-	X	-	-	-	-	-	-	-	-	-	-
Petauroides volans	Greater Glider			O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petaurus / Petauroides sp.	Unidentified Glider			-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phascolarctos cinereus	Koala		V	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	W	-
Pseudocheirus peregrinus	Common Ringtail Possum			-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	-	O	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	W	-
Rhinolophus megaphyllus	Eastern Horseshoe-bat			AD	-	AD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat		V	AP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scoteanax rueppellii	Greater Broad-nosed Bat		V	AP	-	AP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scotorepens orion	Eastern Broad-nosed Bat			AM	-	AM	AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tachyglossus aculeatus	Short-beaked Echidna			-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-
Tadarida australis	White-striped Freetail Bat			W/AD	W	W/AD	-	X	X	X	-	X	-	-	-	-	-	-	-	-	-	-

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Trichosurus sp.	Unidentified Brushtail Possum			I	-	I	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vespadelus darlingtoni	Large Forest Bat			T/AD	-	AD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vespadelus pumilus	Eastern Forest Bat			-	AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vespadelus regulus	Southern Forest Bat			AD	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Vespadelus troughtoni	Eastern Cave Bat		V	AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vespadelus vulturnus	Little Forest Bat			AD	-	AD	AD	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Vombatus ursinus	Common Wombat			I	O/I	I	-	O/I	O/I	I	-	X	I	I	I	I	I	I	I	I	-	-
Vulpes vulpes	Fox		U	O/I	I	O	-	O	-	O	-	X	-	-	-	-	-	O/I	-	-	-	-
Wallabia bicolor	Swamp Wallaby			I/W	O/I	I	-	O/I	O/I	I/W	X	X	-	I	O	-	O	O	I	O	-	-
	Unidentified microbat			O	O	O	-	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-
Reptiles																						
Amphibolurus muricatus	Jacky Lizard			-	-	-	-	-	O	-	-	-	-	-	-	-	-	O	-	-	-	-
Acritoscincus platynota	Red-throated Skink			-	O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Carlia folorium	Tree-base Skink			-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cryptophis nigrescens	Eastern Small-eyed Snake			-	O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Ctenotus robustus	Striped Skink			-	-	-	-	-	-	-	O	O	-	O	-	-	-	-	-	-	-	-
Ctenotus taeniolatus	Copper-tailed Skink			O	O	-	-	-	O	-	-	O	-	O	-	-	-	-	-	O	-	-
Egernia whitii	White's Skink			-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Eulamprus quoyii	Eastern Water Skink			-	O	-	-	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Eulamprus tenuis	Bar-sided Skink			-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-
Hoplocephalus bungaroides	Broad Headed Snake	V	E1	-	-	-		-	O	-	-	-	-	-	-	-	-	-	-	-	O	-
Lampropholis delicata	Dark-flecked Garden Sunskink			-	O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Lampropholis guichenoti	Pale-flecked Garden Sunskink			-	O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Lampropholis sp.	Unidentified Grass Skink			-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Morelia spilota spilota	Diamond Python			-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Oedura lesueurii	Lesueur's Velvet Gecko			-	O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Phyllurus platurus	Southern Leaf-tailed Gecko			O	O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Physignathus lesueurii	Eastern Water Dragon			O	-	-	-	O	-	-	-	O	-	-	-	-	-	O	-	-	-	-
Pseudechis porphyriacus	Red-bellied Black Snake			O	-	-	-	O	O	-	-	-	O	-	-	-	-	O	I	-	-	-
Pseudonaja textilis	Eastern Brown Snake			-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Ramphotyphlops nigrescens	Blackish Blind Snake			-	O	-	-	-	O	-	O	O	-	-	-	-	-	-	-	-	-	-
Ramphotyphlops sp.	Unidentified Blind Snake			-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rankinia diemensis	Mountain Heath Dragon			-	O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Saiphos equalis	Three-toed Skink			-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-

Scientific Name	Common Name	EPBC Act	TSC Act	Dendrobium Area 3 (current surveys)				Monitoring Surveys			Other Relevant Reports										Biosis Inci-dental	Birds Aus
				Gully	Ridge	Upland Swamp	Rainforest	Gully	Ridge	Upland Swamp	1. 3434	2. 3465	3. 3580	4. 3600	5. 3838	6. 3910	7. 4226	8. 4289	9. 4299	10. 4439		
Tiliqua scincoides	Eastern Blue-tongued Lizard			-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Varanus rosenbergi	Rosenberg's Goanna		V	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	O	-
Varanus varius	Lace Monitor			-	-	-	-	-	-	-	O	O	-	-	-	-	-	-	-	-	-	-
	Unidentified Snake			-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
	Unidentified Skink			O	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-

Key: **EPBC Act**: E – Endangered; V – Vulnerable; M – Migratory
TSC Act: E1 – Endangered; V – Vulnerable; U – Introduced Species

Observation Type:
O – Seen; W – Heard; OW – Observed and Heard; X – Recorded but specific observation type unknown; F – Fly-over only; T – Trapped; AD – Anabat Recording Definite Identification; AP – Anabat Recording Probable Identification; AM – Anabat Recording Possible Identification; HP – Hair Sample Probable Identification; I – Indirect Evidence (e.g. hair, scats, tracks, scratches); IP – Scat Sample Probable Identification.

Other relevant reports:
1 - *Dendrobium Coal Project: Terrestrial and Aquatic Habitat Assessment* (Biosis Research 2001e);
2 - *Dendrobium Coal Project Species Impact Statement* (Biosis Research 2001d);
3 - *Habitat Assessment of Swamp 18* (Biosis Research 2001f);
4 - *Swamp 17 – Post Fire Flora and Fauna Habitat Assessment* (Biosis Research 2003b);
5 - *Upland Swamp Ground Water Monitoring Bore - Terrestrial Flora and Fauna Habitat Assessment*. (Biosis Research 2003c);
6 - *Elouera Colliery LW 9 and 10 Terrestrial Flora and Fauna Habitat Assessment* (Biosis Research 2003a);
7 - *Elouera Colliery Longwall 14 Impacts of Subsidence on Terrestrial Flora and Fauna* (Biosis Research 2005b);
8 - *Terrestrial Flora and Fauna Habitat Assessment: Dendrobium Colliery Area 3 Seismic and Borehole Survey Investigations* (Biosis Research 2005d);
9 - *Delta Colliery Longwall 17 Impacts of Subsidence on Terrestrial Flora and Fauna* (Biosis Research 2006b);
10 - *Delta Colliery Longwall 11A, 11B, 12, 15, 16, 18 and 19 Impacts of Subsidence on Terrestrial Flora and Fauna* (Biosis Research 2006a).

APPENDIX 6

CURRICULUM VITAE

Matthew B.G. Richardson

Position:
Senior Botanist, Biosis Research Pty. Ltd.

Professional Affiliations and Memberships:
Ecological Society of Australia

Australian Network for Plant Conservation

Qualifications:
Bachelor of Science (Hons I) (Plant Ecology/Population Genetics) University of Wollongong

Employment Profile:

1998-	Botanist, Biosis Research Pty. Ltd.
1998	Research Assistant, Australian Museum Business Services (AMBS)
1997-98	Field Botanist, Gary Leonard and Associates Botanical and Horticultural Consultants
1997-98	Research Assistant, Ecological Genetics Laboratory; University of Wollongong

Fields of Competence:
- ✓ flora survey and identification
- ✓ native vegetation classification and mapping
- ✓ habitat and biodiversity assessment
- ✓ rare or threatened species assessment
- ✓ environmental impact statement – natural environment
- ✓ impact minimisation (mitigation) guidelines
- ✓ project management and report preparation
- ✓ expert evidence
- ✓ plant mating system research
- ✓ plant population genetics and gene flow research
- ✓ field and laboratory experimental techniques

Professional Experience:

Matthew has over seven years experience in applied conservation biology and consulting. A list of Mathew's key projectsconsultancy reports and professional experience is available upon request.

Rhidian Harrington

Position:

Senior Ecologist, Biosis Research Pty. Ltd. / Sydney Group Resource Manager

Professional Affiliations and Memberships:

Birds Australia
Ecological Society of Australia

Qualifications:

BACHELOR OF SCIENCE (HONS), JAMES COOK UNIVERSITY
MASTER OF SCIENCE (ZOOLOGY), UNIVERSITY OF THE WITWATERSRAND
DOCTOR OF PHILOSOPHY (ZOOLOGY), UNIVERSITY OF MELBOURNE

Employment Profile:

2003-present	Senior Ecologist, Biosis Research Pty. Ltd.
2002-03	Project Officer, Black-eared Miner Recovery Team, La Trobe University, Melbourne
2002	Scientific writer, Institute of Land and Food Resources (ILFR), University of Melbourne
1998-01	Research coordinator/demonstrator, Melbourne University
1998-02	Research Assistant, Puckapunyal Army Reserve, Victoria
1995-96	Research assistant, Botswana National Parks
1993-95	Lecturer/Demonstrator, University of the Witwatersrand, South Africa
1992	Research assistant for OTC and National Parks Queensland, Australia
1992	Research assistant, Australian Centre for Tropical and Freshwater Research, Queensland
1987	Volunteer research assistant, National Park and Wildlife Service, Zimbabwe

Fields of Competence:

- ✓ Terrestrial ecology
- ✓ Zoology
- ✓ Flora and fauna survey and identification
- ✓ Identification of Australian vertebrates
- ✓ Native vegetation classification and mapping
- ✓ Literature reviews
- ✓ Experimental design
- ✓ Expert evidence
- ✓ Statistical data analysis
- ✓ Environmental impact assessment
- ✓ Impact minimisation (mitigation) guidelines
- ✓ GIS mapping
- ✓ Project management

Professional Experience:

Rhidian has over 12 years experience in applied conservation biology and consulting. A list of Rhidian's key projects, consultancy reports and professional experience is available upon request.

Glenn W Muir

Position:

Ecologist, Biosis Research Pty. Ltd.
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Professional Affiliations and Memberships:

Society of Australian Systematic Biologists
Frog and Tadpole Study Group of NSW
Royal Zoological Society of NSW

Qualifications:

BACHELOR OF SCIENCE, MACQUARIE UNIVERSITY

Employment Profile:

April 2005 – September 2007	Ecologist / Project Manager, Biosis Research
1996 - 2005	Ecologist / Project Manager, Australian Museum Business Services
1994 to 1996	Administrative Assistant, Australia Council for the Arts

Fields of Competence:

- ✓ Green and Golden Bell Frog habitat design
- ✓ Fauna survey and identification
- ✓ Habitat assessment
- ✓ Flora and fauna impact assessment
- ✓ Threatened species management plans
- ✓ Biodiversity assessment
- ✓ Expert evidence
- ✓ Project management

Professional Experience:

Glenn has 10 years experience in ecological consulting. He is an expert on the Green and Golden Bell Frog and has worked with the population at Sydney Olympic Park for many years. A list of Glenn's key projects, consultancy reports and professional experience is available upon request.

Sian Wilkins

Position:
Botanist, Biosis Research Pty. Ltd.

Qualifications:

Bachelor of Environmental Science (Hons I) (Terrestrial Biology) University of New South Wales
Statement of Attainment in Bushland Weed Control – Padstow TAFE

Employment Profile:

2004-present	Botanist, Biosis Research Pty. Ltd.
2002-2004	Botanist, Anne Clements and Associates Pty. Ltd.

Fields of Competence:

- ✓ Flora survey and identification
- ✓ Native vegetation classification and mapping
- ✓ Rare or threatened species and ecological communities assessment
- ✓ Environmental impact statement – natural environment
- ✓ Impact minimisation (mitigation) guidelines
- ✓ Project management, research, data analysis and report preparation
- ✓ Monitoring rehabilitation of vegetation

Sian has experience conducting vegetation surveys in a range of different environments across NSW, including identification and assessment of endangered ecological communities (such as Cumberland Plain Woodland, Shale Sandstone Transition Forest, River-flat Eucalypt Forest, Swamp Oak Floodplain Forest, Shale Gravel Transition Forest, Freshwater Wetlands, Hunter Lowland Redgum Forest, Lower Hunter Spotted Gum - Ironbark Forest and Lowland Rainforest); and targeted surveys for threatened flora species (such as Acacia chrysotricha, A. pubescens, Callistemon linearifolius, Epacris purpurescens, Eucalyptus parramattensis ssp. decadens, Grevillea juniperina ssp. juniperina, G. parvilfora spp. parviflora, Melaleuca biconvexa, Pimelea spicata, Tetratheca juncea and Tetratheca glandulosa).

Professional Experience:

Sian has over five years experience in applied conservation biology and consulting. A list of Sian's key projects, consultancy reports and professional experience is available upon request.

Nathan Smith

Position:

Botanist, Biosis Research Pty. Ltd.

Qualifications:

Bachelor of Science (Resource & Environmental Management), School of Earth Sciences, Macquarie University, Sydney.
Certificate II & IV Bushland Regeneration, School of Horticulture, Northern Sydney Institute of Technology and Further Education, Ryde.
Statement of Attainment in Spatial Information Systems, School of Surveying, Sydney Institute of Technology, Ultimo.

Employment Profile:

2003-present	Botanist, Biosis Research Pty. Ltd.
2001-2003	Toolijooa Environmental Restoration Pty Ltd, Native Plant Seed Collector and Bush Regeneration Project Manager
2000-2003	North Sydney Council, Bushcare Supervisor
1998-2003	Australian Bushland Restoration Pty Ltd, Bushland Management Supervisor
1996-1997	Agserv Pty Ltd, Weed Control Operator & Bush Regeneration Supervisor

Fields of Competence:

- ✓ Bushland management & site assessment
- ✓ Native plant and weed identification
- ✓ Threatened species assessment (including EECs)
- ✓ Native vegetation classification
- ✓ Habitat restoration and mine site rehabilitation

Professional Experience:

Nathan has over 11 years experience in environmental restoration and consulting. A list of Nathans's key projects, consultancy reports and professional experience is available upon request.

Jennifer Charlton

Position:

Zoologist, Biosis Research Pty. Ltd.

Professional Affiliations and Memberships:

Birds Australia.
Waterfall Springs Conservation Association, NSW, Australia.

Qualifications:

Bachelor of Science in Zoology, University of New South Wales, Sydney.

Other:

Senior First Aid Certificate – St John Ambulance, January 2005.
Basic Height Safety & Tree Access – Total Height Safety, November 2006.
OHS Construction Induction – Work Cover NSW, December 2006.

Employment Profile:

2004-present	Zoologist, Biosis Research Pty. Ltd.
2003-2004	Technical Officer, Australian Museum Business Services.
2003-2004	Mammal & Bird Keeper Assistant, The Australian Reptile Park, Somersby.
2003-2004	Records Officer, Waterfall Springs Sanctuary, Kulnura.
2001-2004	Database Co-ordinator, Wildlife ARC, Central Coast, NSW.

Fields of Competence:

- ✓ Zoology
- ✓ Fauna survey and identification (amphibians, birds, reptiles, mammals)
- ✓ Radio-tracking
- ✓ Habitat assessment
- ✓ Rare and threatened species survey and assessment
- ✓ Terrestrial fauna monitoring
- ✓ Experimental design
- ✓ Database design and management
- ✓ Project Management

Professional Experience:

Jennifer has four years experience as a zoologist. A list of Jennifer's key projects, consultancy reports and professional experience is available upon request.

Brendan J Smith

Position:

Botanist, Biosis Research Pty. Ltd.

Qualifications:

B.Sc. Environmental Biology (Distinction Average). 2005
University of Technology, Sydney.
AUSRIVAS Certificate (Australian River Assessment System). 2005
DEH Accreditation, University of Technology, Sydney.
Associate Diploma of Applied Science, Horticulture. 1996
Ryde TAFE College.
Certificate In Horticulture 1992
Padstow TAFE

Employment Profile:

2006-present	Botanist, Biosis Research
2004 – 2006	Project Officer, Total Earth Care Pty Ltd
2004 – 2005	Interpretive Ranger (Part time), Kur-ring-gai Council
2004 – 2004	Bush Regenerator / Seed Collection Officer, Total Earth Care Pty Ltd
2001 – 2003	Interpretive Hiking Guide – Blue Mountains, Wildframe Ecotours
2000 – 2000	Contracts Administration Clerk, Warner Bros. London
1998 – 1999	TAFE Teacher, Native Plant Propagation, Ryde TAFE College
1995 – 1999	Nursery team leader, Kur-ring-gai Council Community Nursery
1995 - 1999	Native Seed Collection Workshops, Facilitator, Various Councils

Fields of Competence:

- ✓ Flora survey and identification
- ✓ Bushland management & site assessment
- ✓ Native plant and weed identification
- ✓ Threatened species assessment (including EECs)
- ✓ Native vegetation classification
- ✓ Habitat restoration
- ✓ Weed density mapping and assessment
- ✓ Indigenous plant collection and production
- ✓ Project management and report preparation
- ✓ Monitoring rehabilitation of vegetation
- ✓ Options and constraints assessment

Professional Experience:

Brendan is a botanist with Biosis Research, Sydney office. Brendan has 9 years experience working with indigenous plant species in flora surveys, natural area restoration and weed management. A list of Brendan's key projects, consultancy reports and professional experience is available upon request.

Terri-Ann English

Position:

Zoologist, Biosis Research Pty. Ltd.

Qualifications:

Bachelor of Applied Science (Environmental Science) Charles Sturt University, Wagga Wagga
Currently undertaking Masters in Environmental Science at University of Western Sydney

Employment Profile:

2001 - Current	Zoologist, Biosis Research Pty. Ltd.
1999 - 01	Zoologist/Technical Assistant, Biosis Research Pty. Ltd.
1996	Technical Officer Scientific NSW NPWS

Fields of Competence:

- ✓ fauna survey
- ✓ mammalian fauna research
- ✓ frog surveys
- ✓ bird surveys
- ✓ habitat and biodiversity assessment
- ✓ rare and threatened species assessment

Professional Experience:

Terri has 5 years experience as a Zoologist. A list of Terri's key projects, consultancy reports and professional experience is available upon request.

Katie Cartner

Position:
Zoologist, Biosis Research Pty. Ltd.

Professional Affiliations and Memberships:
Waikato Botanical Society, New Zealand.

Qualifications:
Bachelor of Science (Biological Sciences) University of Waikato, New Zealand.

Other:
Senior First Aid Certificate – St John Ambulance, June 2004.
Cardiopulmonary Resuscitation – St John Ambulance, June 2006.
OHS General Induction for Construction Work in NSW (Green Card) – June 2006.
OHS Workplace Consultation – National Safety Council of Australia, January 2006.

Employment Profile:
2006-	Zoologist, Biosis Research Pty. Ltd.
2005-2006	Research Assistant, Biosis Research Pty. Ltd.
2004-2005	Technical Assistant, Biosis Research Pty. Ltd.
2003-2004	Administration Assistant, Omnilab Pty Ltd.
2003	Volunteer, Department of Conservation (Mercury Islands, NZ).
2003	Volunteer, Department of Conservation (Tiri tiri Matangi Island, NZ)
2001-2003	Field and Laboratory Technician, Landcare Research, NZ.
2000-2001	Laboratory Technician, AgResearch, NZ.

Professional Experience:
Katie has over four years experience working in an assistant role in various natural heritage assessments, surveys and research. A list of Katie's key projects, consultancy reports and professional experience is available upon request.

Rachel V. Blakely

Position:
Research Assistant, Biosis Research Pty. Ltd.

Professional Affiliations and Memberships:
Birds Australia
Australasian Wader Study Group

Qualifications:
BSc (Honours) University of Queensland, St Lucia, QLD.
BSc (Dean's scholarship) Zoology, Monash University, Clayton, VIC.

Other:
PADI Divemaster qualification (includes PADI Rescue Diver and Dive Medic training).
Senior First Aid Certificate – St John Ambulance, expires 14/12/2008.
NSW General Boat license #01129768, expires 31/10/09.

Employment Profile:

2006-present	Research Assistant, Biosis Research Pty. Ltd.
2005-2006	Technical Assistant, Biosis Research Pty. Ltd.
2004-2005	Executive Assistant, Giaconda Limited
2004	Volunteer Research Assistant, Marine and Estuarine Ecology Unit, University of Queensland
2003-2004	Science Tutor, Moreton Bay Research Centre, Stradbroke Island, QLD
2002-2004	Divemaster Village Dive, Exmouth, WA & Dive Victoria, Portsea, Vic & Bluezone Scuba, Brisbane, QLD.

Fields of Competence:
- ✓ Field and laboratory experimental techniques
- ✓ Shorebird surveys
- ✓ Bat surveys
- ✓ Terrestrial and Aquatic field survey techniques

Professional Experience:
A list of Rachel's key projects, consultancy reports and professional experience is available upon request.

Melissa J. Starling

Position:
Research Assistant, Biosis Research Pty. Ltd.

Qualifications:
BSc (Honours) Australian National University

Other:
Senior First Aid (Remote) Certificate – Parasol EMT, expires 30/7/2007
OHS General Induction for Construction Work in NSW (Green Card) – 2007

Employment Profile:
2007	Research Assistant, Biosis Research Pty. Ltd.
2007	Consultant, Landscope, NSW.
2007	Ecological Consultant, LesryK Environmental Consulting, NSW.
2006	Research Assistant, Centre for Tropical Research, Los Angeles.
2005-2006	Research Assistant, bird behavioural ecology research group, ANU, ACT.
2005	Research Assistant, vertebrate physiology lab, ANU, ACT.
2004	Research Assistant, ANU Green, ACT.
2003-2004	Volunteer Field Assistant, Pheasant Coucal Project, ANU, NT.

Fields of Competence:
- ✓ Terrestrial ecology
- ✓ Zoology
- ✓ Flora and fauna survey and identification
- ✓ Identification of Australian vertebrates
- ✓ Literature reviews
- ✓ Experimental design
- ✓ Laboratory experimental techniques

Professional Experience:
Details of Melissa’s key professional experience is available upon request.

Theresa Pizzuto

Position:

Research Assistant, Biosis Research Pty. Ltd.

Professional Affiliations and Memberships:

Royal Zoological Society of New South Wales.

Qualifications:

Master of Applied Science (Wildlife Health and Population Management), The University of Sydney NSW
Bachelor of Science (Biology), The University of Sydney, NSW
Certificate III in Animal Studies (Veterinary Nursing), TAFE NSW, Richmond
Four Wheel Drive Off-road Driver Training and Hazard Awareness. National Driver Education, 2005
Basic Four Wheel Drive course, Level 1, Off Road Driver Training, 2005.

Employment Profile:

2007-	Research Assistant, Biosis Research Pty. Ltd.
2005-2006	Kangaroo Management Officer, Cumberland Ecology
2006	Volunteer Field Assistant, African Wild Dog Conservation Zambia, Zambia
2005-2006	Volunteer, Veterinary and Quarantine Centre (VQC), Taronga Park Zoo, Sydney, Zoological Parks Board of New South Wales .

Fields of Competence:

- ✓ fauna survey and identification (mammals, birds, amphibians, reptiles)
- ✓ mammalian fauna research, including rare and threatened species research and monitoring
- ✓ radio-tracking
- ✓ habitat assessment and assessment of faunal habitat use
- ✓ experimental design, research and report production
- ✓ feral pest control and monitoring

Professional Experience:

Details Theresa's key professional experience is available upon request.

Anne Rutlidge

Position:
Technical Assistant, Biosis Research Pty. Ltd

Qualifications:
BSc (Honours) Environmental Science – University of Technology, Sydney.
Other:
OHS consultation course, AMH OH&S Services 2005
Senior First Aid Certificate – Medixcare 2005

Employment Profile:

April 2007-	Technical Assistant, Biosis Research Pty Ltd, Sydney
2006-2007	Demonstrator, Earth Science, University of Technology Sydney
2003-2007	Sailmaker, Creative Canvas
2002-2003	Office Assistant, Occupational Therapy Helping Children

Fields of Competence:

- ✓ Hydrological fieldwork
- ✓ Preparation and organisation of field surveys
- ✓ Laboratory wet chemistry techniques
- ✓ Administrative tasks

Professional Experience:
Details of Anne's key professional experience is available upon request.

Daniel Gilmore

Position:
Zoologist

Professional Affiliations and Memberships:
Field Naturalists Club of Victoria
Victorian Frog Group
Birds Australia (formerly Royal Australian Ornithologists Union)

Qualifications:
Bachelor of Conservation Ecology. Deakin University, Victoria

Employment Profile:

2003	Executive Research Assistant, Biosis Research Pty Ltd, Victoria
2001	Zoologist, Biosis Research Pty. Ltd., Victoria
2001	Ecological Consultant (self employed)
1999	Librarian,Deakin University, Victoria
1996	Wildlife Keeper, Gondwana Wildlife Sanctuary, Queensland
1995	Revegetation Training Officer, Greening Australia, Victoria
1995	Team Leader (Zoologist) (voluntary), Flora and Fauna Survey Group, Trust for Nature, Victoria

Fields of Competence:
- ✓ fauna survey
- ✓ habitat assessment
- ✓ rare and threatened species/communities assessment
- ✓ rare and threatened species/communities management
- ✓ revegetation/rehabilitation guidelines
- ✓ natural area conservation and management
- ✓ pest plant and animal management
- ✓ fire ecology
- ✓ conservation significance/issues assessment
- ✓ sites of significance studies
- ✓ environmental impact assessment - natural environment
- ✓ impact minimisation (mitigation) guidelines
- ✓ environmental design guidelines

Professional Experience:

Daniel has over ten years experience as an ecologist and zoologist. Details of David's key professional experience is available upon request.

Mark H. Venosta

Position:

Zoologist

Professional Affiliations and Memberships:

Australian Mammal Society
Australasian Bat Society
Ecological Society of Australia
Field Naturalists Club of Victoria Inc.
Victorian Frog Group

Qualifications:

Bachelor of Science (Hons), Deakin University
Bachelor of Conservation Ecology, Deakin University
Diploma in Natural Resource Management, Northern Melbourne Institute of TAFE

Employment Profile:

Nov 01 Executive Research Assistant, Biosis Research Pty. Ltd.
2001 Casual Zoologist, Biosis Research Pty. Ltd.
2001 Sessional Lecturer in Animal Identification, Holmesglen TAFE.
2000- 01 Education Officer/ Nest Box Design, La Trobe University Wildlife Reserves.
1998 & 01 Field Worker on annual Baw Baw Frog, *Philoria frosti* survey, Department of Natural Resources and Environment.

Fields of Competence:

- ✓ Australian Vertebrate Identification
- ✓ Habitat assessment
- ✓ Field survey for species of zoological significance
- ✓ Conservation planning and management
- ✓ Forestry Coupe Auditing

Professional Experience:

Mark has 5 years experience as a Conservation Ecologist and Natural Resource Manager. Details of Mark's key professional experience is available upon request.

Ruth Marr

Position:
Zoologist

Qualifications:
Bachelor of Science Honours (Zoology) – Monash University
Master of Environment – The University of Melbourne (In Progress)

Employment Profile:
Feb 2007 – Present: Zoologist, Biosis Research Pty Ltd, Victoria
June 2006 – Feb 2007: Technical Assistant, Biosis Research Pty Ltd, Victoria
2005 – 2006: Research Assistant, Parks Australia North, Christmas Island, Western Australia
2004: Research Assistant, Monash University, Victoria

Fields of Competence:
- ✓ fauna survey
- ✓ aquatic survey
- ✓ habitat assessment
- ✓ conservation planning and management
- ✓ field survey for species of zoological significance
- ✓ communication

Professional Experience:
Details of Ruth's key professional experience is available upon request.

Naomi O'Brien

Position:

Technical Assistant

Professional Affiliations* and Memberships:

Membership: Friends of the Zoo (FOTZ)

Qualifications:

Bachelor of Science with Honours (majors in Zoology and Conservation Biology) - The University of Melbourne, Victoria.

Employment Profile:

2005-present Technical Assistant, Biosis Research Pty Ltd, Victoria

2004-2005 Research Assistant, The University of Melbourne, Victoria

Professional Experience:

During her career, Naomi has conducted and assisted with fieldwork on the following projects:

Honours Research: The effects of cross-fostering on the growth and development of tammar (Macropus eugenii) and Pademelon (Thylogale billardierii) pouch young (2004)

Research Assistant: Behaviour and techniques for controlling common wombats (*Vombatus ursinus*) at Wilson's Promontory (with The University of Melbourne and Parks Victoria; Wilson's Promontory; 2004)

Research Assistant: Scotia Sanctuary Recovery Project (with Scotia Sanctuary; 2005)

Research Assistant: Assisted reproduction and captive management of Macropod species (for The University of Melbourne; 2004-2005)

Research Assistant: Behaviour of mountain brush-tailed possums (*Trichosurus caninus*) within roadside and forest vegetation (with The University of Melbourne; Strathbogie Ranges 2004)

Publications:

O'Brien, N.E Menzies, B. Fletcher, T. Shaw, G. Renfree, M.B (In draft) Abnormal Growth and Development of Reciprocally Cross-fostered tammar (*Macropus eugenii*) and pademelon (*Thylogale billardierii*) pouch young.

Menzies, B**.** O'Brien, N., E Fletcher, T. Shaw, G. Renfree, M.B (In draft) Retarded growth of parma (*Macropus parma*) but not tammar (*Macropus eugenii*) wallaby pouch young after reciprocal age matched interspecies cross fostering.

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