Illawarra Coal

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resourcing the future

Appin Area 9

Appin Area 9 Longwalls 901 to 904 Extraction Plan
Annex D - Biodiversity Management Plan, 2 September 2014

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Review History

Revision	Description of Changes	Date	Approved
A	New Document	12 September 2011	GB
B	Revised Draft	6 December 2011	GB
C	Final (updated with BHPBIC comments)	18 January 2012	GB
D	Final – Updated with new Mine Plan	6 June 2012	GB
E	Final – Updated with Agency Comments	31 October 2013	GB
F	Final – Updated with additional Agency Comments	1 August 2014	GB
G	Final – Updated with additional Agency Comments	2 September 2014	GB

Persons involved in the development of this document include:

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Daniel Thompson	Environmental Planner	Cardno
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1 INTRODUCTION

1.1 PROJECT BACKGROUND

BHP Billiton Illawarra Coal (BHPBIC) operates the Bulli Seam Operations (BSO) (Appin and West Cliff Collieries) extracting hard coking coal used for steel production.

On 22 December 2011 the Planning and Assessment Commission (PAC), under delegation of the Minister for Planning, approved the BSO Project (MP 08_0150) under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to continue mining operations until 31 December 2041.

This Biodiversity Management Plan (BMP) supports the Longwalls 901 to 904 Extraction Plan for Appin Area 9 (AA9). The relationship between this BMP and the other components of the Extraction Plan is shown in Figure 1 of the Extraction Plan.

1.2 SCOPE

This BMP has been prepared by Cardno on behalf of BHPBIC in accordance with the BSO Approval *Condition 5 (I), Schedule 3* as follows:

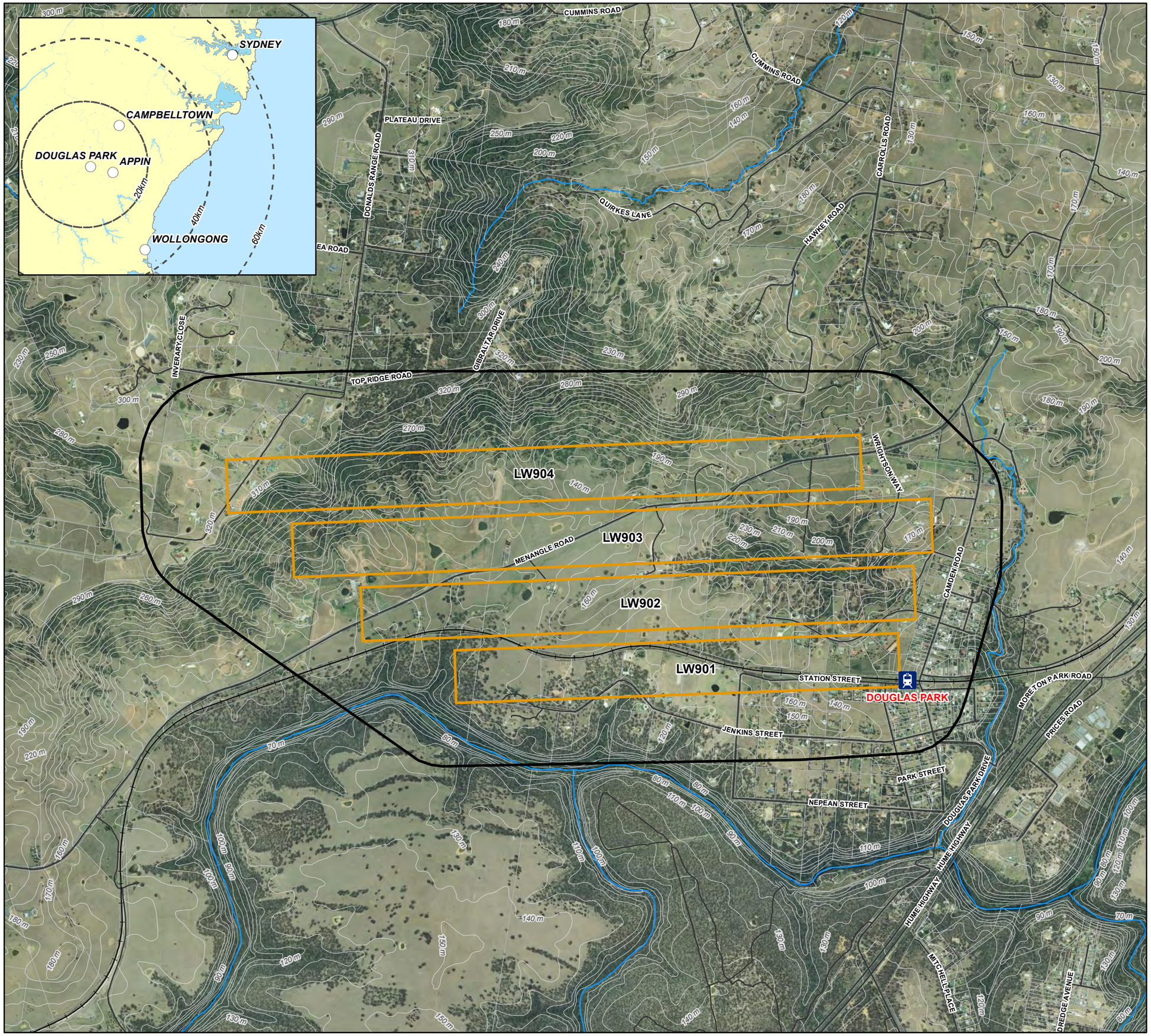
> *5. The Proponent shall prepare and implement an Extraction Plan for first and second workings within each longwall mining domain to the satisfaction of the Director-General. Each extraction plan must:...*
>
> *(i) include a Biodiversity Management Plan, which has been prepared in consultation with OEH and DPI (Fisheries), which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on aquatic and terrestrial flora and fauna, with a specific focus on threatened species, populations and their habitats; endangered ecological communities; and water dependent ecosystems, including (for Appin Areas 7, 8 and 9):*
>
> - *Additional targeted surveys for threatened species, sufficient to identify any actions required to protect any significant populations from potential impacts.*

The Study Area for the Extraction Plan (refer to **Figure 1**) is defined in accordance with MSEC (2012) as *the surface area predicted to be affected by the proposed mining of Longwalls 901 to 904 and encompasses the areas bounded by the following limits:-*

- *A 35^{o} Angle of Draw line from the maximum depth of cover, which equates to a horizontal distance varying between 345 metres and 510 metres around the limits of the proposed extraction areas proposed for Longwalls 901 to 904, and*
- *The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, resulting from the extraction of the proposed Longwalls 901 to 904.*

Additionally, features potentially sensitive to far field movements, which includes horizontal, valley closure and upsidence movements that may be outside the 20 mm subsidence zone or 35^{o} Angle of Draw line have been assessed including:

- Watercourses (including the Nepean River), within the predicted limits of 20 mm total upsidence and closure
- Steep slopes
- Cliffs.



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Appin Area 9 (LW 901- 904) Study Area

Legend

- Railway Stations (LPI)
- Local Roads (LPI)
- Railway (LPI)
- 10m Contours (LPI)
- Watercourses (LPI)
- Cadastre (LPI)
- AA9 Longwall Layout
- Longwalls 901-904 Study Area

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FIGURE 1

Scale 1:20,000 (at A3)

Kilometres
0 0.25 0.5 0.75 1

Cardno

Map Produced by Cardno Wollongong
Date: 31/10/2013
Coordinate System: GDA 1994 MGA Zone 56
Project: 109012-03
Map: 1801_AppinArea9_LW_StudyArea.mxd 07

Aerial imagery supplied by BHPBIC (2009)

1.3 OBJECTIVES

The objectives of this BMP are to identify the biodiversity within the Longwalls 901 to 904 Study Area and to manage the potential impact and/or environmental consequences of the proposed mining to terrestrial and aquatic biodiversity.

Specific focus will be on threatened species, populations and their habitats; endangered ecological communities; and groundwater dependent ecological communities.

1.4 DISTRIBUTION

This BMP has been developed in consultation with the Office of Environment and Heritage (OEH) and Department of Primary Industries (DPI Fisheries), and relevant stakeholders for terrestrial and aquatic biodiversity. The finalised BMP will be distributed to:

- Department of Planning and Environment (DoPE)
- Division of Resources and Energy (DRE)
- OEH
- DPI Fisheries.

Although listed in the Project Approval the Sydney Catchment Authority (SCA) are not a relevant Stakeholder for biodiversity for the Longwalls 901 to 904 Study Area.

BHPBIC will make the BMP and other relevant documentation publicly available on the BHPBIC website (*Condition 11, Schedule 6 of the BSO approval*).

2 STATUTORY REQUIREMENTS

Extraction of coal from Longwalls 901 to 904 will be in accordance with the conditions set out in the BSO Approval, applicable legislation as detailed in **Section 2.2** and the requirements of relevant licenses and permits (including conditions attached to mining leases).

2.1 BSO APPROVAL

Condition 5 (i), Schedule 3 of the BSO Approval requires the preparation of a BMP to manage the potential impacts and/or environmental consequences of the proposed mining on aquatic and terrestrial flora and fauna (refer **Section 1.2**).

This BMP also addresses the requirements detailed in *Condition 6, Schedule 3* and *Condition 2, Schedule 6* of the BSO Approval as shown in **Table 2.1**.

Table 2.1 – Management Plan Requirements

Project Approval Condition	***Relevant BMP Section***
Condition 6 – Schedule 3 The Proponent shall ensure that the management plans required under *Condition 6 (g)-(l)* above include: (a) an assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval; and (b) a detailed description of the measures that would be implemented to remediate predicted impacts.	Section 4 Section 7
Condition 2 – Schedule 6 The Proponent shall ensure that the management plans required	

Project Approval Condition	***Relevant BMP Section***
under this approval are prepared in accordance with any relevant guidelines, and include:	
(a) detailed baseline data;	Section 3
(b) a description of:	
- the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 2
- any relevant limits or performance measures/criteria;	Section 5
- the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;	Sections 5 to 8
(c) a description of the measures that would be implemented to comply with the relevant statutory, limits, requirements or performance measures/criteria;	Sections 5 to 8
(d) a program to monitor and report on the:	Section 6
- impacts and environmental performance of the project;	
- effectiveness of any management measures (see c above);	
(e) a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	Section 8
(f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Section 10
(g) a protocol for managing and reporting any:	
- incidents;	Section 9
- complaints;	
- non-compliances with statutory requirements; and	
- exceedances of the impact assessment criteria and/or performance criteria; and	
(h) a protocol for periodic review of the plan.	Section 10

Due consideration has been given to all the BSO Approval Conditions in the preparation of this BMP, including those relating to auditing, rehabilitation and environmental management.

2.2 LEGISLATION AND GUIDELINES

This BMP has been developed taking due account of the requirements of the following legislation and associated guidelines:

- *Environment Protection and Biodiversity Conservation Act, 1999 (*EPBC Act)
- *Threatened Species Conservation Act, 1995 (*TSC Act*)*
- *Fisheries Management Act, 1994 (*FM Act*).*

2.3 RELEVANT LEASES AND LICENCES

The following licences or permits may be applicable to BHPBIC's operations in AA9:

- Mining Leases as per **Table 2.2**.

- Environmental Protection Licence (EPL) 2504 which applies to BSO, including Appin and West Cliff Mines. A copy of the licence can be accessed at the EPA website via the following link http://www.epa.nsw.gov.au/prpoeo/index.htm
- BSO Mining Operation Plan (MOP) 1/10/2012 to 30/09/2019
- All relevant OH&S and HSEC approvals
- Any additional leases, licences and approvals resulting from the BSO Approval.

Table 2.2 – Appin Mine Leases, Licences and Other Reference Documents

Mining Lease - Document Number	Issue Date	Expiry Date/ Anniversary Date
CCL 767	29/10/1991	08/07/2029
CL 388	22/1/1992	21/01/2013 Renewal Pending
ML 1382	20/12/1995	19/12/2016
ML 1433	24/7/1998	23/07/2019
ML 1678	26/06/2014	26/06/2035

3 BASELINE ASSESSMENT

A baseline Aquatic Biodiversity Assessment (Bioanalysis, 2009) and Terrestrial Flora and Fauna Assessment (Flora Search, 2009; Biosphere 2009) were undertaken in support of the BSO Environmental Assessment (EA). The Study Area for these assessments included the Longwalls 901 to 904 Study Area.

Supplementary field surveys for Aquatic Biodiversity (Cardno Ecology Lab, 2012 - **Attachment A**) and Terrestrial Biodiversity (Biosis, 2012 - **Attachment B**) were undertaken for the purposes of this Extraction Plan.

3.1 TERRESTRIAL BIODIVERSITY

AA9 is known to support four Threatened Ecological Communities (TECs), known habitat for three threatened fauna species, and provides potential habitat for eight threatened flora species as well as 24 threatened fauna species.

3.1.1 Vegetation Communities

The natural environment of the Longwalls 901 to 904 Study Area contains flora and fauna habitats, which include remnant stands of open woodland, riparian scrub in drainage lines, closed grassland and fringing aquatic vegetation near constructed dams in grazed paddocks (**Figure 2**).

Several TECs were also identified in the Longwalls 901 to 904 Study Area. **Table 3.1** describes the communities present and their conservation status. Further descriptions of the vegetation communities are detailed in Biosis (2012).

Table 3.1 – Longwall 901 to 904 Study Area Vegetation Communities

Cumberland Plain mapping (NPWS 2002a)	TSC Act status	EPBC Act status
Shale Sandstone Transition Forest (Low Sandstone Influence)	Shale Sandstone Transition Forest (High Sandstone	Shale Sandstone Transition Forest (Endangered)

Cumberland Plain mapping (NPWS 2002a)	TSC Act status	EPBC Act status
Shale Sandstone Transition Forest (High Sandstone Influence)	Influence)	
Shale Hills Woodland	Cumberland Plain Woodland (Critically Endangered Ecological Community [CEEC])	Cumberland Plain Shale Woodland (CEEC)
Shale Plains Woodland		
Moist Shale Woodland	Moist Shale Woodland (Endangered Ecological Community [EEC])	-
Western Sydney Dry Rainforest	Western Sydney Dry Rainforest (EEC)	-
Upper Georges River Sandstone Woodland	-	-
Western Sandstone Gully Forest	-	-
Riparian Scrub	-	-

3.1.2 Threatened Flora

No threatened flora species were recorded in the BSO EA surveys or supplementary surveys (Biosis, 2012). **Figure 3** shows known occurrences of threatened species previously recorded in the locality.

Twenty-one threatened flora species (or their potential habitats) appear on database searches of the locality (Biosis, 2012). Eight of these species have a medium likelihood of occurring in the Longwalls 901 to 904 Study Area, namely:

- *Cynanchum elegans*
- *Epacris purpurascens var. Purpurascens*
- *Grevillea parviflora* ssp. *Parviflora*
- *Persoonia bargoensis*
- *Persoonia hirsute*
- *Pomaderris brunnea*
- *Pterostylis saxicola*
- *Pultenaea pedunculata.*

A detailed list of threatened flora species with a likelihood of occurring within the Longwall 901 to 904 Study Area is provided in Biosis (2012).

3.1.3 Threatened Fauna

Three threatened fauna species (Cumberland Plain Land Snail, Brown Treecreeper and Koala) were recorded in the Longwall 901 to 904 Study Area and immediate surrounds within Open Woodland, Open Forest or Scrub habitat. **Figure 3** shows known occurrences of threatened species in the locality.

Forty-seven threatened fauna species (or their potential habitats) appear on database searches of the locality (Biosis, 2012). Eighteen of these species have a medium likelihood

of occurring in the Longwall 901 to 904 Study Area, with 11 of these having a high likelihood (shown in bold):

- *Circus assimilis* (Spotted Harrier)
- *Haliaeetus leucogaster* (White-bellied Sea-eagle)**
- *Hieraaetus morphnoides* (Little Eagle)
- *Ardea ibis* (Cattle Egret)**
- *Callocephalon fimbriatum* (Gang-gang Cockatoo)
- *Calyptorhynchus lathami* (Glossy Black-cockatoo)
- ***Climacteris picumnus victoriae* (Brown Treecreeper (eastern subspecies))**
- *Melithreptus gularis gularis* (Black-chinned Honeyeater (eastern subspecies))
- *Merops ornatus* (Rainbow Bee-eater)**
- ***Daphoenositta chrysoptera* (Varied Sittella)**
- *Chthonicola sagittata* (Speckled Warbler)
- *Stagonopleura guttata* (Diamond Firetail)
- ***Melanodryas cucullata cucullata* (Hooded Robin (south-eastern form))**
- ***Petroica boodang* (Scarlet Robin)**
- ***Glossopsitta pusilla* (Little Lorikeet)**
- *Lathamus discolor* (Swift Parrot)
- *Rostratula australis* (Australian Painted Snipe)**
- *Gallinago hardwickii* (Latham's Snipe)**
- *Ninox connivens* (Barking Owl)
- *Ninox strenua* (Powerful Owl)
- ***Meridolum corneovirens* (Cumberland Plain Land Snail)**
- *Dasyurus maculatus maculates* (Spotted-tailed Quoll (south-eastern mainland))
- ***Mormopterus norfolkensis* (Eastern Freetail Bat)**
- ***Pseudomys novaehollandiae* (New Holland Mouse)**
- ***Phascolarctos cinereus* (Koala)**
- ***Pteropus poliocephalus* (Grey-headed Flying-fox)**
- *Chalinolobus dwyeri* (Large-eared Pied Bat)
- *Miniopterus schreibersii* oceanensis(Eastern Bentwing-bat)
- ***Myotis macropus* (Southern Myotis).**

*** Migratory Species*

3.1.4 Migratory Species

Australia is a signatory to international agreements aimed at protecting migratory species. Migratory species are considered to be matters of National Environmental Significance and as such are protected under the EPBC Act.

Twelve species listed under the migratory provisions of the EPBC Act have been predicted to occur within the locality. Five migratory bird species are considered likely to occur in the Longwall 901 to 904 Study Area on occasion (Biosis, 2012) and are marked with a double asterisk in the above list.

No migratory bird species were recorded during the Biosis (2012) supplementary surveys.

REMEMBRANCE DRIVEWAY

LW904

LW903

LW902

LW901

MENANGLE ROAD

DOUGLAS PARK

HUME HIGHWAY

HUME HIGHWAY

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Vegetation Communities

APPIN AREA 9
LW 901-904

Legend

- Railway Stations (LPI)
- Railway (LPI)
- Major Roads (LPI)
- Watercourses (LPI)
- AA9 Longwall Layout
- Longwalls 901-904 Study Area

Vegetation Communities

- Alluvial Woodland
- Moist Shale Woodland
- Riparian Forest
- Riparian Scrub
- Shale Hills Woodland
- Shale Plains Woodland
- Shale Sandstone Transition Forest (HSI*)
- Shale Sandstone Transition Forest (LSI*)
- Upper Georges River Sandstone Woodland
- Western Sandstone Gully Forest
- Western Sydney Dry Rainforest

** HSI - High Sandstone Influence*
** LSI - Low Sandstone Influence*

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FIGURE 2

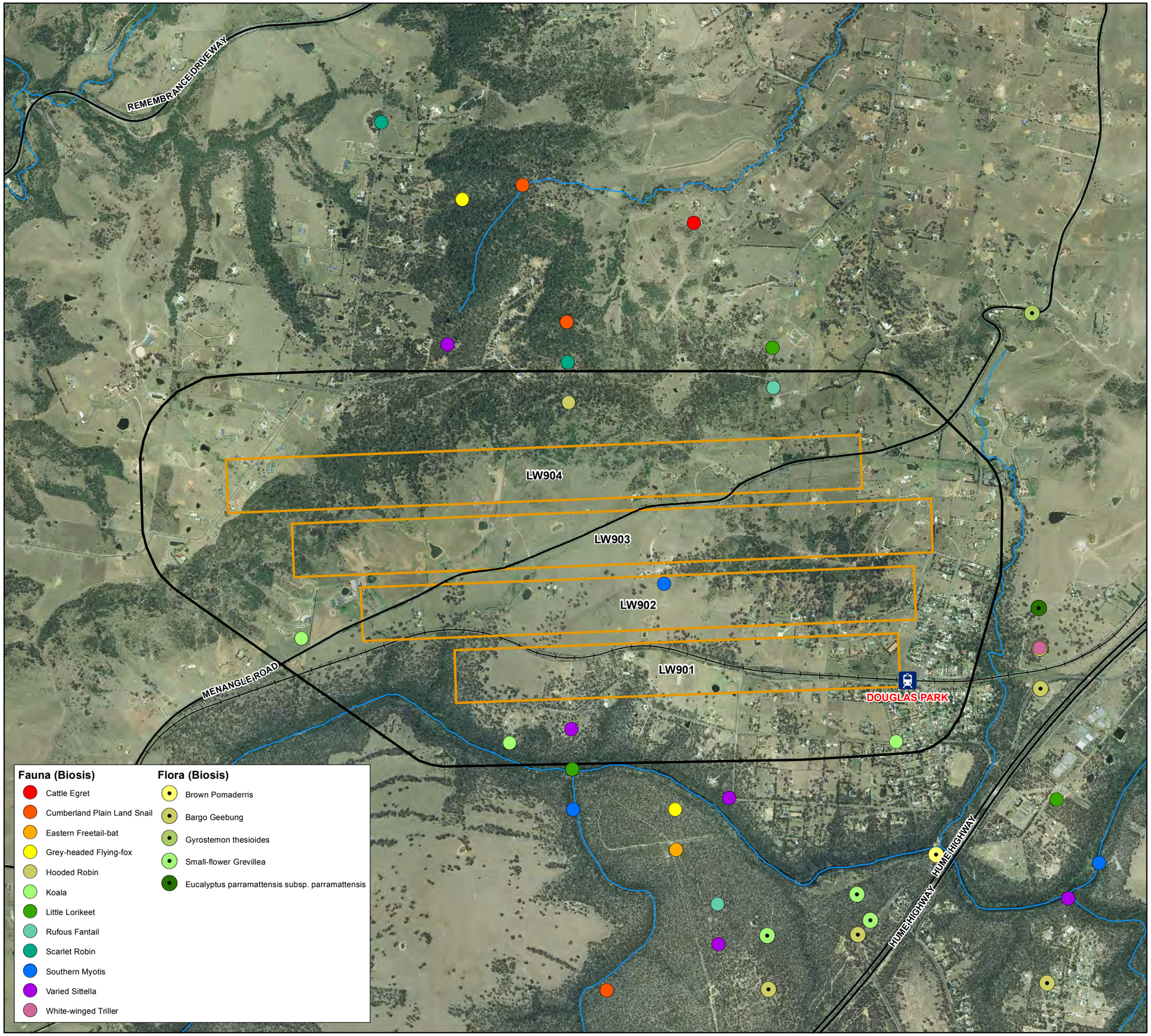
Scale 1:20,000 (at A3)

Kilometres
0 0.25 0.5 0.75 1

Cardno

Map Produced by Cardno Wollongong
Date: 31/10/2013
Coordinate System: GDA 1994 MGA Zone 56
Project: 109012-03
Map: 1804_VegetationTypes.mxd 04

Aerial imagery supplied by BHPBIC (2009)



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Threatened Flora and Fauna Occurrences

APPIN AREA 9
LW 901-904

Legend

- Railway Stations (LPI)
- Railway (LPI)
- Major Roads (LPI)
- Watercourses (LPI)
- AA9 Longwall Layout
- Longwalls 901-904 Study Area

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FIGURE 3

Scale 1:20,000 (at A3)

Kilometres
0 0.25 0.5 0.75 1

Cardno

Map Produced by Cardno Wollongong
Date: 1/11/2013
Coordinate System: GDA 1994 MGA Zone 56
Project: 109012-03
Map: 1803_FloraFaunaSites.mxd 05

Aerial imagery supplied by BHPBIC (2009)

3.1.6 State Environmental Planning Policy 44 - Koala Habitat Protection

The *State Environmental Planning Policy 44 – Koala Habitat Protection* (SEPP 44) is applicable to the Wollondilly LGA. The Longwall 901 to 904 Study Area contains two species of Koala feed tree (Grey Gum *Eucalyptus punctata* and Forest Red Gum *Eucalyptus teriticornus*) which are core Koala habitat within the open woodland and forest habitats.

Koala scats were also identified during the supplementary surveys. Consequently Biosis (2012) consider that the Longwall 901 to 904 Study Area supports a local population of Koala.

3.2 AQUATIC BIODIVERSITY

3.2.1 The Nepean River

The Nepean River (within the Longwall 901 to 904 Study Area) can be characterised into two sections; the upstream reaches, where the surface water flows are controlled by stream features including boulder fields and rockbars and, the downstream section, where the river is a flooded valley controlled by the Douglas Park Weir (MSEC 2012). Both of these sections of the Nepean River would provide permanent aquatic habitat for biota including aquatic macroinvertebrates, aquatic macrophytes and fish.

Significant information exists on the aquatic ecology of the Nepean River near Douglas Park as a result of extensive surveys for mining operations in the area. This information has been used to develop a comprehensive baseline monitoring program for the Study Area which will be initiated prior to mining. A general description of the local environment is provided in the following sections. A full description of the Study Area can be found in **Attachment A.**

The location of all relevant monitoring sites is shown in **Figure 4**.

3.2.2 Other Creeks and Drainage Lines

The Study Area is also traversed by several drainage lines, which flow into the Nepean River after rainfall events. The two largest drainage lines are the Nepean Tributary No. 1 situated above proposed Longwalls 902 to 904 and Harris Creek located to the east of the longwalls and approximately 400m away from the nearest longwall, which is Longwall 903 (MSEC 2012). Neither of these systems or the smaller watercourses contain significant aquatic habitat.

3.2.3 Aquatic Vegetation

The 28 species of aquatic macrophytes that have been recorded in the upper reaches of the Nepean River adjacent to AA9 and AA7 are listed in **Attachment A**.

The distribution of submerged macrophytes has been mapped on a number of occasions since September 2003. The following species were found to occur in dense, mixed beds and were considered to be in good health:

- Hydrilla *(Hydrilla verticillata)*
- Elodea Water Weed *(Elodea sp.)*
- Clasped Pondweed *(Potamogeton perfoliatus)*
- Floating Pondweed *(Potamogeton tricarinatus)*
- Ribbonweed *(Vallisneria sp.)*
- Blunt Pondweed *(Potamogeton ochreatus)*
- Curly Pondweed *(Potamogeton crispus).*

During the most recent survey undertaken in December 2010, Hydrilla, Blunt Pondweed and Elodea were found at all the sites surveyed and floating pondweed at all but one site (Cardno Ecology Lab 2012). Macrophytes were generally found in narrow bands adjacent to the river banks, but extended out into the deep, faster flowing sections of the channel at a few sites.

In May 2008, extensive beds of submerged macrophytes, composed mostly of *Elodea canadensis*, an introduced species, and *Hydrilla verticillata* plus a few plants of the floating attached species, *Triglochin procerum*, were observed at Site NP1 (Bioanalysis 2009). *Elodea canadensis* was also common at Site NP2. A few plants of *Triglochin microtuberosum* were also observed at this site.

3.2.4 Aquatic Macroinvertebrates

Macroinvertebrate abundance is used as an indication of stream health. Monitoring undertaken during the course of the previous extraction of AA7 found a total of 76 taxa of macroinvertebrates have been recorded in the section of the Nepean River adjacent to AA7, with 52 of these being found at the sites in the upper reach beyond Douglas Park Weir. These taxa are listed in **Attachment A**. The recording of taxa at each site during each field study has been summarised in **Table 3.2**.

Table 3.2 – Aquatic Macroinvertebrates within Study Area (between Douglas Park Weir and Maldon Weir)

Date	Site	Taxa Observed	AUSRIVAS Condition
May 2008 (Sites associated with edge habitats only)*	NP1*	14 and 20 per site Lacking 24% of taxa expected at one site 52% at the other.	Significantly impaired
	NP2*	4 and 12 per site Lacking 64% of taxa expected at one site and 52% at the other	Severely Impaired
September 2003	AA7	36% to 48% of expected families with a 50% probability of occurrence absent.	Significantly impaired
November 2008	Four most upstream sites	-	Equivalent
	Downstream sites	Lacked between 24% and 36% of the expected taxa	Impaired
November/December 2010	Two most upstream sites	-	Equivalent
	Three other upstream sites	Lacked between 18% and 24% of the expected taxa	Impaired
	Most downstream site	Lacked 53% of the expected taxa	Severely impaired

** Note: NP1 is approximately 400 m downstream of Maldon Weir and NP2 is situated upstream of the confluence with Allen's Creek.*

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Aquatic Ecology Locations

APPIN AREA 9
LW 901-904

Legend

- Railway Stations (LPI)
- Nepean River Tributary 1
- Watercourses (LPI)
- Local Roads (LPI)
- Railway (LPI)
- Cadastre (LPI)
- AA9 Longwall Layout
- Aquatic Monitoring Locations
- Longwalls 901-904 Study Area

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FIGURE 4

Scale 1:20,000 (at A3)

Kilometres
0 0.25 0.5 0.75 1

Cardno

Map Produced by Cardno Wollongong
Date: 31/10/2013
Coordinate System: GDA 1994 MGA Zone 56
Project: 109012-03
Map: 1805_AquaticEcologyMonitoring.mxd 06

Aerial imagery supplied by BHPBIC (2009)

3.2.5 Fish

A summary of the fish that have been observed within the Nepean River system upstream and downstream of the Study Area is listed below. The fish data in the upper Nepean River system was collected prior to the installation of the fishways.

- Australian bass (*Macquaria novemaculeata*)
- Freshwater catfish (*Tandanus tandanus*)
- Cox's gudgeon (*Gobiomorphus coxii*)
- Flat head gudgeon (*Philypnodon grandiceps*)
- Dwarf flathead gudgeon (*Philypnodon* sp.)
- Fire-tail gudgeon (*Hypseleotris galii*)
- Empire gudgeon (*Hypseleotris compressa*)
- Australian smelt (*Retropinna semoni*)
- Eastern gambusia (*Gambusia holbrooki*)
- Long-finned eel (*Anguilla reinhardtii*)
- Goldfish (*Carrasius auratus*)
- Carp (*Cyprinus carpio*).

Several species of fish, including striped gudgeon, bully mullet, freshwater mullet, bullrout and freshwater herring that have been recorded further downstream in the section of the Nepean River upstream of Penrith Weir (Baumgartner and Reynoldson (2007) could potentially colonise the Study Area now that fishways have been installed on the intervening weirs.

Movement of fish into the upstream reaches of the Nepean River is restricted by Maldon Weir. Maldon Weir is the upstream limit of migration for Australian bass and other species that require estuarine areas to spawn (Sammut and Erskine, 1995). Further detail about where each of these fish species has been observed is provided in **Attachment A**.

3.2.6 Threatened Species

In desktop searches four threatened species were found to be present in the locality of, or have potential habitat within the Study Area. **Table 3.3** provides a summary of the likelihood of identified threatened species to be present in the Study Area.

Table 3.3 – Threatened Species Likely to Occur in the Longwall 901 - 904 Study Area (adapted from CEL, 2012)

Species	Listing	Likelihood of Occurrence in Study Area
Adams emerald dragonfly (*Archaeophya adamsi*)	Endangered under the *FM Act.*	There are no records of the Adams emerald dragonfly south of Sydney despite active collecting in the Georges and Nepean River catchments (NSW Fisheries, undated). The larvae of Adam's emerald dragonfly have been found in riffle and/or cascade habitats in small to moderate sized creeks within a well vegetated catchment. ***The section of the Nepean River within the Study Area does not contain appropriate habitat for this species.***
Sydney hawk dragonfly (*Austrocordulia leonardi*)	Endangered under the *FM Act.*	The large, deep, permanent pools within the downstream reach of the Nepean River that flows through the Study Area and the relative stability in water level and flow rate, resulting from flow regulation by Douglas Park Weir, appear to provide suitable habitat for the larva of Sydney hawk dragonfly. ***Therefore it may be possible that a viable local population exists within the Study Area.***
Giant dragonfly	Endangered	The Giant dragonfly has been recorded in permanent coastal and

(*Petalura gigantea*)	under Schedule 1 of the *TSC Act.*	upland wetlands stretching from Moss Vale to southern Queensland, but has not been recorded in most areas for many years. The species is known or predicted to occur in the Bungonia, Burragorang, Kanangra, Moss Vale and Wollemi sub-regions of the Hawkesbury/Nepean Catchment Management Region, but has not been found in the sub-region encompassing the Study Area. This species is found in permanent swamps and bogs with some free water and open vegetation (NSW OEH, 2011). **Due to the lifestyle of the Giant Dragonfly *it is highly unlikely that the species is likely to occur in permanent aquatic habitats of the Study Area.***
Macquarie perch (*Macquaria australasica*)	Vulnerable under the *FM Act* Endangered under the *EPBC Act.*	Recent records indicate that Macquarie perch occurs in the Nepean River upstream and downstream of Pheasant's Nest Weir (Baumgartner and Reynoldson 2007). The weir structure is believed to block the downstream passage of this species (Gehrke and Harris 1996). The presence of this weir and another significant barrier to fish passage further downstream at Maldon Weir and the absence of any records from the downstream reaches of the Nepean River suggest that **it *is highly unlikely that the Study Area supports a population of Macquarie perch.***

4 PREDICTED IMPACTS

In accordance with the findings of the Southern Coalfield Inquiry:

- **Subsidence effects** are defined as the deformation of ground mass such as horizontal and vertical movement, curvature and strains.
- **Subsidence impacts** are the physical changes to the ground that are caused by subsidence effects, such as tensile and sheer cracking and buckling of strata.
- **Environmental consequences** are then identified, for example, as a loss of surface water flows and standing pools.

4.1 TERRESTRIAL BIODIVERSITY

4.1.1 Subsidence Effects

Terrestrial ecological features will be subject to the full range of subsidence effects depending on their location in the Longwalls 901 to 904 Study Area.

4.1.2 Subsidence Impacts

Predicted subsidence impacts for natural features within the Longwalls 901 to 904 Study Area are outlined in MSEC (2012). A summary of the predictions that could have environmental consequences for terrestrial biodiversity are provided in **Table 4.1**.

Table 4.1 – Predicted Impacts to Natural Surface Features as a Result of Subsidence for Longwalls 901 to 904 (MSEC, 2012)

Natural Surface Feature	Predicted Impacts Due to Subsidence
Nepean River	• Minor and isolated fracturing of the stream bed • Low to negligible potential for diversion of surface water flows • Gas emissions likely to occur • Localised iron staining resulting in potential changes to water quality
Drainage Lines	• Changes in grade of drainage lines are considered small in comparison to natural grades. This is unlikely to result in significant increases in ponding flooding or scouring, although some localised impacts may occur • Fracturing of uppermost bedrock in drainage lines located directly above longwalls. Where the creek bed consists of alluvial deposits fractures will

Natural Surface Feature	Predicted Impacts Due to Subsidence
	be filled over time. Where the creek bed consists of bedrock the diversion of surface water flows may occur during low flow events. These flows will be forced to the surface once a fracture network is no longer available for this flow
Cliffs	• Possible rock falls from cliffs, extremely low risk of cliff falls
Rocky Outcrops	• Fracturing of a small percentage of rock outcrops in discrete locations
Steep Slopes	• Tension cracks at the top of slopes due to down slope movements

4.1.3 Environmental Consequences

Table 4.2 compares the potential consequences as determined in the BSO EA to the residual risk determined by Biosis (2012) for the Longwalls 901 to 904 Study Area. Where residual risk differs from that within the BSO EA the reason for the difference is provided.

Potential impacts as assessed by Biosis (2012) are largely consistent with those outlined within the BSO EA. Generally the risks are lower in the Longwall 901 to 904 Study Area when compared to the broader BSO EA area as there are fewer sensitive vegetation communities in the locality and substantial areas of cleared vegetation. The proposed extraction also does not require significant vegetation clearing.

Table 4.2 – Potential Subsidence Impacts on Terrestrial Flora and Fauna Habitat

Potential impact assessed	Level of impact according to FloraSearch (2009), Biosphere (2009) and BSO EA	Level of impacts based on Current Survey
Vegetation	Slope and ridge-top vegetation: • Small, isolated impacts to vegetation due to cracking Riparian vegetation: • Small, localised impacts to vegetation due to ponding, flooding, scouring or gas release Gently undulating lands • Negligible impacts due to surface cracking	As for BSO EA, negligible residual risk
Fauna habitats	Slope and ridge-top habitats: • Potential for small animals to become trapped in cracks. Impacts expected to be minor • Rare impacts to fauna due to rockfall Riparian habitats: • Negligible impacts to fauna and fauna habitat Gently undulating lands: • Minor impacts due to surface cracking Water habitats: • Impacts to water habitat unlikely to result in impacts to fauna	As for BSO EA, negligible residual risk
Threatened flora	No significant impacts on threatened flora species predicted	As for BSO EA, negligible residual risk
Threatened fauna	No significant impacts on threatened fauna species predicted	As for BSO EA, negligible residual risk
Koala habitat	As described above for other fauna habitats, the predicted effects of subsidence on Koala habitat are likely to be minimal and are not considered to have any real effect on the species	As for BSO EA, negligible residual risk

Potential impact assessed	Level of impact according to FloraSearch (2009), Biosphere (2009) and BSO EA	Level of impacts based on Current Survey
Spread of amphibian Chytrid Fungus and impacts on frog species	Collection and handling of frogs or the inadvertent transport of the infected material between frog habitat by persons, vehicles or equipment may promote the spread of the disease	Provided mitigation measures outlined in the BSO EA are implemented residual risk is negligible
Infection of Native Plants by *Phytophthora cinnamomi*	Project-related activities have the potential to introduce or spread the infection of native plants by *P. cinnamomi*	Provided mitigation measures outlined in the BSO EA are implemented residual risk is negligible
Weeds	The Project has the potential to increase the spread of weeds through vegetation clearing activities, dispersal of seed or soil material containing seed via continued movement of vehicles across the Project area and through rehabilitation or restoration activities	Low residual risk remains due to potential for spread of weeds through vehicle movement and movement of monitoring teams. Mitigation measures to reduce the risk if spread of weeds is managed

4.2 AQUATIC BIODIVERSITY

4.2.1 Subsidence Effects

MSEC (2009) undertook an initial assessment of predicted subsidence in the Longwalls 901 to 904 Study Area to support the BSO EA. These predictions were revised by MSEC (2012) to account for the revised Mine Plan for Longwalls 901 to 904. The maximum predicted subsidence, upsidence and closure are outlined in **Table 4.3**.

Table 4.3 – Subsidence, Upsidence and Closure Predictions for the Nepean River (MSEC, 2012)

Site	Subsidence (mm)	Upsidence (mm)	Closure (mm)	Tilt (mm/m)
Nepean River Upstream	30	110	200	0.22
Nepean River Downstream	<20	<20	<20	0.22
Nepean River Tributary 1	1175	575	625	5
Harris Creek	<20	<20	<20	<0.5

The "*upstream*" section of the Nepean River is defined as '*the section of the River as it enters the AA9 domain to the point where it passes through the boulder field at the confluence of the Nepean River and Allens Creek*' (**Figure 4**). '*The section of the river downstream of this confluence*' is defined as '*downstream*'.

4.2.2 Subsidence Impacts

The proposed longwalls do not mine directly beneath the Nepean River. The closest longwall finishes 125 m from the closest bank of the River (**Figure 1**). The Nepean River Tributary No. 1 is situated above proposed Longwalls 902 to 904 and Harris Creek is located to the east of the longwalls and approximately 400 m away from mining (Longwall 903).

A summary of the impact predictions that may have environmental consequences for terrestrial biodiversity are provided in **Table 4.4**. The predictions indicate that impacts on the physico-chemical features of the Nepean River will be no more than negligible and are thus consistent with the Subsidence Impact Performance Measures for the Nepean River specified in the Project Approval for the BSO EA. Fracturing of the river bed may occur and result in both gas emissions and iron staining. These impacts, however, are expected to be

localised, minor in extent and transient and are thus also unlikely to represent more than negligible impacts.

From these predictions it can be concluded that extraction of Longwalls 901 to 904 will result in negligible diversion of flows, negligible changes in the natural drainage behaviour of pools, negligible iron staining and negligible gas releases in the Nepean River and that impacts on the physico-chemical attributes of the other watercourses will also be negligible.

Table 4.4 – Predicted Impacts on Physico-chemical Attributes of the Major Watercourses Under the Extraction Plan Layout

Watercourse	Attribute	Predicted Impacts
Nepean River	Surface water level	No measurable impact expected from subsidence in the upstream reach and it is unlikely that there would be any significant change in the downstream reach
	Change in levels of the river bed and banks	Small changes in levels may occur in the downstream reach, but these are not expected to result in any measurable impact
	Ponding, flooding and scouring of stream banks	Unlikely to be any significant change
	Change in stream alignment.	Unlikely to be any significant change
	River bed	Minor, localised fracturing may occur, but the likelihood of this is low beyond the predicted limit of subsidence.
	Surface water flows	Potential for loss or diversion is very low in the downstream reach. Minor, localised fracturing of rock bars and diversion of flows may occur in the upstream reach but this impact is expected to be no more than negligible
	Groundwater inflows	Possible that mining-induced springs could develop
	Gas emissions	Transient, localised emissions are likely to occur
	Water quality	Localised iron staining may occur
Nepean River Tributary No.1 and Harris Creek	Ponding, flooding and scouring of stream banks	Significant increases are unlikely, but there could be minor localised increases in ponding and flooding
	Creek beds and bedrock	Fracturing of the uppermost bedrock may occur, but the incidence is expected to be low. In creeks with alluvial deposits, fractures are likely to be in-filled over time. Some surface water flows may be diverted into underlying strata and drainage of pools may occur. Water is likely to re-emerge downstream, so net loss of water from the catchments is unlikely
	Water quality	Localised iron staining may occur

4.2.3 Environmental Consequences

Table 4.5 compares the potential consequences as determined in the BSO EA to the residual risk determined by Cardno Ecology Lab (2012) for the Longwall 901 to 904 Study Area. Where residual risk differs from that within the BSO EA the reason for the difference is provided.

The assessment of the consequences for aquatic ecology of subsidence that occurs during extraction of Longwalls 901 to 904 based on the AA9 Extraction Plan layout is concluded to be similar to that based on the BSO EA layout.

Table 4.5 – Comparison of Potential Environmental Consequences of Subsidence on Aquatic Ecology between the Longwall 901 to 904 Layout and the Approved BSO EA layout

Component of Aquatic Ecology	Potential Impacts predicted from BSO EA	Revised Potential Impacts from Extraction
Aquatic Habitat	Nepean River - Impacts on flow and pool depth are not expected in the Douglas Park Weir pool	Same as for BSO EA layout There are unlikely to be any measurable impacts on surface water level, availability or connectivity of aquatic habitats in the downstream reach of the river due to its flooded nature and very low gradient In the upstream reach, any fracturing that occurs is expected to be isolated and negligible in nature, so the potential for impacts on surface flow is limited In the downstream reach, subsidence and upsidence may result in small changes in the levels of the river bed and banks. This could lead to minor increases and decreases, respectively in the availability of aquatic habitat, but may be difficult to detect Dilation of the bedrock in the base of the river could result in a one-off minor decrease in water volume and availability of aquatic habitat
	Some fracturing of bed rock is expected, as well as mobilisation of iron and other minerals and transient gas emissions in the weir pool	There is a low probability of minor, localised fractures of the river bed occurring. The fractures would be filled by water and/or sediment. The likelihood of any diversion of surface flows and loss of aquatic habitat is consequently very low Isolated, transient gas emissions may occur. If these lead to a substantial reduction in dissolved oxygen levels, there could be a short-term decrease in quality of aquatic habitat Negligible iron staining may occur, but is unlikely to lead to changes in water quality and should not therefore affect the quality of aquatic habitat Significant changes in the levels of ponding, flooding or scouring of the river banks and stream alignment are not expected in either reach. There is consequently not expected to be any detectable impacts on the longitudinal connectivity of aquatic habitats
	Harris Creek and Tributary No. 1 of the Nepean River - potential impacts include isolated incidents of iron staining, short-term spikes in water quality parameters such as iron, gas emissions, reduced pool levels in dry weather and localised underflow and a reduction in the frequency and persistence of inter-pool flow. If diversion of surface water occurs, drainage of pools may result in a temporary loss of small areas of aquatic habitat	The incidence of fracturing is expected to be low and unlikely to result in significant loss in surface water flows. Diversion of water into sub-surface layers during low flow periods could result in changes in quality and quantity of water. This is unlikely to have a detectable effect on the availability of aquatic habitats Minor, localised increases in ponding, flooding or scouring may occur. These would have negligible impacts on the availability and quality of aquatic habitats
Riparian vegetation	Changes in the level of water in streams and gas emissions are unlikely to disturb riparian vegetation to the extent that its ecological role would be significantly adversely impacted	A small increase in the level of the bank or bed of the Nepean River could reduce the wetted perimeter and lead to desiccation of some of the riparian vegetation along the edge of the river. This may lead to minor changes in the composition and extent of the vegetation

Component of Aquatic Ecology	Potential Impacts predicted from BSO EA	Revised Potential Impacts from Extraction
		Gas emissions could result in localised die-back of riparian vegetation. Such impacts are considered unlikely and would be transient Localised, fracturing of bedrock and cracking of surface soils along the river banks could have a minor, localised impact on riparian vegetation
Aquatic macrophytes	Nepean River - no detectable changes in composition or distribution due to mining	A small increase in the level of the bank or bed of the Nepean River could reduce the wetted perimeter and lead to stranding and desiccation of aquatic vegetation along the edge of the river. This may lead to negligible changes in the composition and extent of macrophyte beds, but these are unlikely to be detected, because of the natural variability of these beds
	Harris Creek - reduced water levels in the downstream reach could lead to exposure and desiccation of macrophytes. These impacts would be short-term and localised and would not persist once water levels are restored	Impacts on the aquatic flora that may inhabit these ephemeral watercourses are unlikely to be detectable, because of the large variability in natural flows
Aquatic macroinvertebrates	Nepean River - potential impacts would be similar in scale to those observed during mining of Appin Area 7 (i.e. none). Impacts on the western side of the Nepean River would be hard to detect, because of the degraded nature of the existing aquatic habitat	In the Nepean River, changes in riparian and aquatic vegetation could lead to the loss of edge habitat and reduction in the abundance of aquatic macroinvertebrates living therein. Losses would be negligible relative to the amount of habitat available within the downstream reach of the river
	Harris Creek - if diversion of surface water leads to temporary loss of small areas of pool habitat, macroinvertebrates dependent upon this habitat that are unable to relocate to other aquatic habitat are likely to perish as a result of desiccation and/or predation. Drainage of pools after river bed or rock bar fracturing may prevent downstream drift of macroinvertebrates. If effects are isolated, macroinvertebrates in remaining pools could facilitate re-colonisation of impacted pools when water levels return. Significant adverse impacts are unlikely given that changes in water quality are expected to be short-lived and localised and macroinvertebrates should recover quickly once water levels return	Impacts on the aquatic macroinvertebrates that may periodically inhabit these watercourses due to diversion of flows are unlikely to be detectable, because of the large variability in natural flows Minor, localised changes in ponding, flooding or scouring would have minimal impacts on aquatic macroinvertebrates that periodically inhabit this watercourse
Fish	Nepean River - potential impacts would be similar in scale to those observed during mining of Appin Area 7 (i.e. none). Reductions in dissolved oxygen associated with gas emissions are likely to be short-lived and localised and unlikely to have a significant effect, because fish populations are highly mobile	Same as for BSO EA layout
	Harris Creek and tributaries – if fracturing of bedrock leads to loss of habitat, a few species (e.g. eels) may be able to relocate to nearby pools, but most would perish due to desiccation and/or predation. As losses would be	Same as for BSO EA layout

Component of Aquatic Ecology	Potential Impacts predicted from BSO EA	Revised Potential Impacts from Extraction
	restricted to small, localised areas of habitat, this is unlikely to have a significant effect on fish assemblages within the Study Area	
Threatened Species	Macquarie perch - it is highly unlikely that a viable population is present in this section of the Nepean River, because of a lack of suitable habitat (including natural riffle habitat required for spawning and numerous barriers to fish passage from downstream	Same as for BSO EA layout, however, it should be noted potential spawning habitat does occur in the upstream reach of the river

5 PERFORMANCE MEASURES AND INDICATORS

The BSO Approval provides Subsidence Impact Performance Measures (*Condition 1, Schedule 3).* **Table 5.1** details the Approval Conditions relevant to Biodiversity.

In relation to the subsidence impact performance measure for Biodiversity the term "*negligible*" is defined within the Project Approval as "*small and unimportant, such as not to be worth considering*".

Table 5.1 – Subsidence Impact Performance Measures (Biodiversity)

Biodiversity (Condition 1, Schedule 3)	
Threatened species, threatened populations, or endangered ecological communities.	Negligible environmental consequences.

A number of other Performance Measures from this section of the BSO Approval relevant to the BMP are outlined in **Table 5.2**.

Table 5.2 – Subsidence Impact Performance Measures (Other)

Watercourses (Condition 1, Schedule 3)	
Nepean River	Negligible environmental consequences including: - *negligible* diversion of flows or changes in the natural drainage behaviour of pools; - *negligible* gas releases and iron staining; and - *negligible* increase in water cloudiness
Other watercourses	No greater subsidence impact or environmental consequences than predicted in the EA and PPR
Land (Condition 1, Schedule 3)	
Cliffs of "special significance" (i.e. cliffs longer than 200 m and/or higher than 40 m; and cliff-like rock faces higher than 5 m that constitute waterfalls)	Negligible impact (that is occasional rock falls displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 0.5% of the total face area of such cliffs) within any longwall mining domain
Other cliffs flanking the Nepean River	Negligible environmental consequences (that is occasional rock falls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 0.5% of the total face area of such cliffs) within any longwall mining domain

Other cliffs	Minor impacts (that is occasional rock falls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 3% of the total face area of such cliffs within any longwall mining domain)

**Note. Not all of the above mentioned features are present in the Longwall901 to 904 Study Area as the subsidence impact performance measures in Schedule 3 relate to the entire BSO Area.*

In order to mitigate the potential subsidence impacts and environmental consequences from Longwalls 901 to 904, monitoring will be undertaken prior to mining, throughout the extraction process and at the completion of subsidence (refer **Section 6**).

In the event that any subsidence impact is recorded, consideration would be given to implementing appropriate management, remediation and/or mitigation measures in consultation with relevant landholders, OEH and other relevant stakeholders (**Section 7**).

If the subsidence impact performance measures are exceeded, BHPBIC will notify OEH and other stakeholders and implement the Contingency Plan (**Section 8**).

6 MONITORING AND REPORTING

6.1 MONITORING PROGRAM

Subsidence parameters (i.e. subsidence, tilt, tensile strain, compressive strain, valley closure and closure strain) will be measured in accordance with the Longwalls 901 to 904 Subsidence Monitoring Program located at Annex B of the Extraction Plan.

The monitoring program outlined below will be implemented to monitor the impacts of subsidence effects to Biodiversity within the Longwall 901 to 904 Study Area. As subsidence effects are predicted to be small in magnitude the monitoring program outlined below reflects the magnitude of these expected impacts.

6.1.1 Aquatic Biodiversity

Monitoring for aquatic biodiversity would address biota and measure relevant water quality variables at appropriate spatial and temporal scales. This will enable changes to water quality, aquatic habitats and biota resulting from mining related subsidence to be distinguished from natural variability and other catchment influences.

Monitoring will occur along the Nepean River and build on the current monitoring program in place for Appin Longwalls 701 to 710, as discussed in Annex B of the Extraction Plan. Two additional sets of Nepean River monitoring sites will be included in the program, one within (Sites X3 and X4) and one upstream (Sites X5 and X6) of the Longwalls 901 to 904 Extraction Area (**Figure 4**). The existing downstream Appin Area 7 sites (1 and 2) will continue to be monitored.

Sampling will be conducted twice in spring for two years prior to the commencement of mining in order to establish a baseline condition and once every two years during and after mining to detect any changes to the aquatic environment and its biota that could be attributed to mining activities. Monitoring at each site would employ a range of techniques including:

- Water quality sampling
- Aquatic macrophyte observations
- AUSRIVAS sampling
- Fish sampling.

Detailed recommendations for monitoring including laboratory methods and data analysis are provided by Cardno Ecology Lab (2012).

Cardno Ecology Lab (2008) assessed the suitability of aquatic habitats within the smaller watercourses traversing the Study Area and found that permanent aquatic habitat was limited in these watercourses and as such no monitoring was required.

Additional aquatic ecology studies would be triggered by events such as significant changes in water quality and availability of aquatic habitats. Trigger values for aquatic ecology monitoring parameters are outlined in **Table 7.1**.

6.1.2 Terrestrial Biodiversity

The monitoring program for mining related subsidence effects on terrestrial biodiversity reflects the predicted small magnitude of subsidence effects on biodiversity values for the Longwall 901 to 904 Study Area.

Monitoring will focus on detecting changes to vegetation communities and fauna habitats present within the Longwall 901 to 904 Study Area and will have coverage across the Study Area.

Subsidence effects are more likely to result in impacts to natural features through loss of surface water flows and the impacts to groundwater dependant ecological features (PAC, 2010). Groundwater dependant vegetation communities present within the BMP Study Area, as shown in **Figure 2**, include Riparian Scrub, Western Sandstone Gully Forest and Western Sydney Dry Rainforest. Other vegetation communities are less likely to be impacted as a result of subsidence effects, hence less monitoring of these communities will be undertaken.

Visual inspections of vegetation communities within the Longwall 901 to 904 Study Area will be undertaken as part of routine landscape and water monitoring programs. Targeted inspection by a qualified ecologist will follow should changes to vegetation health be observed.

Inspections of vegetation condition will assess the following:

- Vegetation health and appearance
- Visible impacts such as canopy thinning, thinning of shrub layer, loss of ground cover, dead branches present.

All areas of impact or any subsidence effects will be mapped and documented using digital photography. Where an impact is detected a qualified ecologist will be engaged to document the following:

- The total area of impact mapped using GPS and aerial photo interpretation
- The Foliage Percentage Cover (FPC)
- Modified Braun-Blanquet cover abundance scores for each species.

This information will be used to objectively assess the extent and degree of impact. Assessment of similar vegetation communities or fauna habitat within the broader locality will be undertaken to determine if the detected changes are within normal variation or represent a possible impact of mining. Additional studies (e.g. gas release measurements) will be undertaken in response to an observed mining impact to understand the mechanism involved and consider any Corrective Management Actions (CMAs) that may be required.

Impact assessment reports will be prepared and provided to relevant Government Agencies. The reports will:

- Detail any impact detected
- Provide a proposed assessment methodology for further study
- Consultation with OEH in relation to assessment methodology.

BHPBIC will implement remediation measures (**Section 7.2**) where impacts to vegetation communities or fauna habitat are caused by subsidence effects.

6.2 REPORTING

Results from the monitoring program will be reported annually in the Annual Environmental Management Report (AEMR). This report will:

- Detail the outcomes of monitoring undertaken
- Provide results of visual inspections
- Determine whether performance indicators have been exceeded
- Make recommendations in relation to any CMAs required.

Monitoring results will be reviewed monthly by the BHPBIC Subsidence Management Committee. However, if the findings of monitoring are deemed to warrant an immediate response the Manager Approvals will initiate the requirements of the Trigger Action Response Plan (TARP) (**Table 7.1**).

Monitoring results will be made publicly available in accordance with BSO Approval *Condition 8 & 11, Schedule 6* and will also be included in the Annual Reporting *Condition 4, Schedule 6.*

7 MANAGEMENT AND MITIGATION STRATEGIES

7.1 TERRESTRIAL BIODIVERSITY

7.1.1 Mitigation Strategies

Where BHPBIC staff and contractors are required to access surface areas as a part of monitoring programs, implement CMAs or undertake other activities, the following mitigation measures shall be adhered to:

- Mitigation measures within Sections 5.8.3 and 5.9.3 of the BSO EA
- Implementation of monitoring program (Section 6.1)
- Implementation of offset measures (Sections 7.3 and 8.1)
- Prepare and implement TARPs (Section 7.3)
- Vegetation clearance mitigation measures (if applicable)
- Implementation of weed control measures
- Implementation of measures for the management of Chytrid/Phytophthora e.g. restricting vehicle movements and access, limiting soil disturbance, encouraging natural regeneration, hygiene of staff and equipment
- Manage fire (if applicable)
- Manage dust (if applicable)
- Minimise fauna traps e.g. mitigate any cracking
- Implement speed limits on fire roads and tracks
- Manage noise (if applicable)
- Manage artificial lighting (if applicable)
- Not introduced fauna e.g. no pets
- Report pest species and include pest awareness in induction/awareness sessions
- Destroy rabbit burrows (if applicable)
- Any remediation works will take appropriate measures to minimise other impacts

- Implement measures to reduce the spread of Chytrid Fungus by following the NPWS guidelines
- Implement measures to prevent the spread of weed species such as inspections and cleaning to ensure vehicles, equipment and clothing are free of weed species
- Vehicular access will be restricted to recognised tracks and disturbed areas where possible to avoid and minimise impacts to native vegetation and fauna habitat
- Should access to areas of native vegetation be required access on foot will be preferred to vehicular access
- If vegetation clearing is required a suitably qualified ecologist will be engaged to determine the vegetation/fauna habitat characteristics of the area to determine the potential impacts and recommended measures to reduce these impacts
- Implement measures to prevent and manage the infection of native plants by *Phytopthora cinnamomi* and other relevant pathogens.

7.1.2 Management Measures

As detailed in **Section 6.1.2** where significant impacts are observed and are a result of subsidence effects, BHPBIC will implement a remediation program.

Initially management measures shall be targeted at reducing the subsidence impacts (if possible). If this is not possible CMAs, such as assisted regeneration will be implemented. These actions will be implemented to address any ecological impacts.

These management measures are aimed at ensuring long term viability of impacted biodiversity values through assisted regeneration and replanting, as well as measures to continue to address subsidence effects that are causing impacts.

Assisted regeneration will include weed management measures, as well as fencing off affected areas to prevent grazing (where agreed with the landowner and the relevant statutory authority). Where assisted regeneration is not meeting expected outcomes, replanting of ground cover, shrubs species and trees will be implemented. All replanting will be undertaken using species characteristic of the vegetation community, with planting undertaken in accordance with the OEH requirements for local provenance species as identified in the Florabank guidelines (Mortlock, 1999).

7.2 AQUATIC BIODIVERSITY

7.2.1 Mitigation Strategies

The potential impacts of Longwalls 901 to 904 on aquatic habitats and biota in the Nepean River would be minimised by:

- Adopting a mine layout that does not involve mining under the river and setting the nearest longwall, which is Longwall 901 at least 125 m back from the bank of the Nepean River
- Identifying triggers that would prompt surveys to assess any impacts on aquatic habitats and their biota identified during and after extraction of the Longwalls
- Identifying physical and water quality impacts that occur during the extraction of Longwalls 901 to 904 through ongoing monitoring and timely implementation of appropriate CMAs.

7.2.2 Management Measures

Standard management measures will be implemented for negligible impacts to aquatic biodiversity where those impacts occur as a result of mining. Standard management measures include photographic records, continuation of the approved monitoring program and reporting.

Intensive management measures for aquatic biodiversity will be employed where more than negligible impacts resulting from subsidence occur. Intensive management measures include implementation of the standard management measures as well as the involvement of relevant stakeholders, agencies and specialists to investigate and report on the changes that are identified.

Water quality samples and targeted fish and aquatic vertebrate sampling would be undertaken once an impact is confirmed. Additional monitoring would be undertaken with specialists providing updates on the investigation process and the relevant stakeholders and agencies would be provided with investigation results. In the event that the impacts of mine subsidence on aquatic habitats are greater than predicted the following mitigation measures would also be considered, in consultation with key stakeholders:

- Should significant impacts on aquatic biodiversity occur which are considered to be outside of the Performance Measures of the BSO Approval, BHPBIC would review future longwalls. The review would consider measures including decreases in longwall width and length
- Implementing stream remediation measures, such as backfilling or grouting in areas where fracturing of controlling rock bars and/or stream bed leads to diversion of stream flow and drainage of pools
- Implementing appropriate control measures, such as installation of sediment fences down slope of areas where subsidence has led to erosion and stabilisation of areas prone to erosion and soil slumping using rock, brush matting or vegetation, to limit the potential for deposition of eroded sediment into the Nepean River.

If these management measures prove ineffectual, appropriate offset and compensatory measures would be implemented.

7.3 TARPS

The AA9 Biodiversity TARP is shown in **Table 7.1**.

Table 7.1 – AA9 Trigger Action Response Plan (TARP)

Monitoring	Trigger	Action
Aquatic Ecology		
Nepean River • Sites 1 and 2 (downstream) • Sites X3 and X4 (adjacent to Longwalls 901 and 902)	***Level 1**** • Reduction in aquatic habitat resulting from the mining over 1 season	• Continue monitoring program • Submit an Impact Report to OEH, DoPI, DPI and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2* Reduction in aquatic habitat resulting from the mining over 2 seasons	• *Actions stated for Level 1* • Report trigger to key stakeholders • Review monitoring program • Notify relevant specialists and develop and implement any CMA required. • Implement agreed CMA's as approved *<u>Note:</u> CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. impacts to aquatic habitat with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*

Monitoring	Trigger	Action
	Level 3* • Reduction in aquatic habitat resulting from the mining for >2 consecutive seasons or complete loss of habitat	• *Actions stated for Level 2* • Notify OEH, DoPE, DPI, NoW, DRE, relevant resource managers and technical specialists and seek advice on any CMA required. • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include: – Grouting of fractures which result in flow diversion – Completion of works following approvals • Completion of works following approvals, including monitoring and reporting on success • Review the TARP and Management Plan in consultation with key stakeholders *<u>Note:</u> CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. impacts to aquatic ecology with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Exceeding Performance Measures • Mining results in more than negligible environmental consequences for a threatened species, threatened population or endangered ecological communities	• *Actions stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful
Terrestrial Ecology		
Visual inspections as part of landscape and water monitoring programs in active mining areas	***Level 1**** • Impacts detectable via observational monitoring (e.g. canopy thinning, thinning of shrub layer, minor loss of ground cover) to a single vegetation strata • Subsidence impacts (such as surface cracking, rock falls) resulting in small areas of disturbance that will mitigate without CMA	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, DPI and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2* • Impacts detectable via observational monitoring (e.g. canopy thinning with dead branches present, thinning of the shrub layer with dead branches, loss of	• *Actions stated for Level 1* • Report trigger to key stakeholders • Review monitoring program • Notify relevant specialists and develop and implement any CMA required • Implement agreed CMA's as

Monitoring	Trigger	Action
	ground cover in multiple areas) to multiple vegetation strata - Subsidence impacts (such as surface cracking, rock falls) resulting in small areas of disturbance that will not mitigate without CMA	approved *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. impacts to terrestrial with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Level 3* • Impacts (e.g. canopy thinning with dead branches present, thinning of the shrub layer with dead branches, loss of ground cover in multiple areas) to multiple vegetation strata caused by subsidence effects • Subsidence impacts (such as surface cracking, rock falls) resulting in large areas of disturbance that will not mitigate without CMA • Negligible environmental consequences to threatened species, populations or EEC	• *Actions stated for Level 2* • Notify OEH, DoPE, DPI, NoW, DRE, relevant resource managers and technical specialists and seek advice on any CMA required • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include: – Erosion prevention works – Establishment of vegetation • Completion of works following approvals, including monitoring and reporting on success • Review the TARP and Management Plan in consultation with key stakeholders *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. impacts to terrestrial ecology with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Exceeding Performance Measures • Mining results in more than negligible environmental consequences on threatened species, threatened populations, or endangered ecological communities	• *Actions stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful

** These may be revised in consultation with DoPI and DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.*

8 CONTINGENCY AND RESPONSE PLANS

8.1 CONTINGENCY PLAN

In the event the Performance Measures detailed in **Section 2** of this BMP are exceeded, or are likely to be exceeded, BHPBIC will implement a Contingency Plan to manage any unpredicted impacts and their consequences.

This would involve:

- Capture photographic record

- Notify relevant stakeholders soon as practicable
- Notify relevant agencies and specialists as soon as practicable
- Offer site visits with stakeholders
- Contract specialists to investigate and report on changes identified
- Provide incident report to relevant agencies
- Weekly monitoring until stabilised
- Updates from specialists on investigation process
- Inform relevant agencies and stakeholders of results of investigation
- Develop site CMA in consultation with key stakeholders if required, (pending stakeholder availability) and seek approvals
- Implement CMA as agreed with stakeholders following approvals
- Conduct initial follow up monitoring and reporting of CMA completion
- Review Management Plan
- Report in regular reporting and AEMR.

BHPBIC will consult with appropriate specialists and relevant agencies in order to devise an appropriate response in respect to any identified exceedance.

The development and implementation of contingency measures will be designed to address the specific circumstances of the exceedance and assessment of environmental consequences.

If the contingency measures implemented by BHPBIC fail to remediate or mitigate the impact or the Director-General determines that it is not reasonable or feasible to remediate the impact BHPBIC will provide a suitable offset to compensate for the impact to the satisfaction of the Director-General of DoPE in accordance with the BSO Approval *Condition 2, Schedule 3*.

All incidents will be reported internally through BHPBIC's Incident Procedure and related records will be maintained in accordance with the Records Management Procedure (**Section 10.4**).

9 INCIDENTS, COMPLAINTS, EXCEEDANCES AND NON-CONFORMANCES

9.1 INCIDENTS

BHPBIC will notify DoPE and any other relevant agencies of any incident associated with AA9 as soon as practicable after BHPBIC becomes aware of the incident. BHPBIC will provide DoPE and any relevant agencies with a detailed report on the incident within seven days of the date of the occurrence.

9.2 COMPLAINTS HANDLING

BHPBIC will:

- Provide a readily accessible contact point through a 24 hour toll-free Community Call Line (1800 102 210). The number will be displayed prominently on BHPBIC sites in a position visible by the public as well as on publications provided to the local community
- Respond to complaints in accordance with the BHPBIC Community Complaints and Enquiry Procedure

- Maintain good relations and communication lines between community members and BHPBIC
- Keep a register of any complaints, including the details of the complaint with information such as:
    - Time and date
    - Person receiving the complaint
    - Complainant's contact name and phone number
    - Description of the complaint
    - Work area where complaint relates to
    - Details of any verbal response
    - Details of any written response where appropriate
    - Details of any corrective actions.

9.3 NON CONFORMANCE PROTOCOL

The requirement to comply with all approvals, plans and procedures is the responsibility of all personnel (staff and contractors) employed on or in association with the BSO Project. Regular inspections, internal audits and initiation of any remediation/rectification work in relation to the Extraction Plan will be undertaken by the Manager Approvals.

Non-conformities, corrective actions and preventative actions are managed in accordance with the BHPBIC *Non-Conformance, Preventative and Corrective Action Procedure (ICHP0107)*. This procedure details the processes to be utilised with respect to the identification of non-conformances, the application of appropriate corrective actions(s) to address non-conformances and the establishment of preventative actions to avoid non-conformances. The key elements of the process include:

- Identification of non-conformance and/or non-compliances
- Recording of non-conformance and/or non-compliance
- Evaluation of the non-conformance and/or non-compliance to determine specific corrective and preventative actions
- Corrective and preventative actions to be assigned to the responsible person
- Management review of corrective actions to ensure the status and effectiveness of the actions.

An Annual Review will be undertaken to assess BHPBIC's compliance with all conditions of the BSO Approval, mining leases and all other approvals and licences.

An independent environmental audit will also be undertaken (*Condition 9, Schedule 6*) to review the adequacy of strategies, plans or programs under these approvals and if appropriate, recommend actions to improve the environmental performance of the BSO. The independent environmental audit will be undertaken by a suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Director-General of DoPE.

10 PLAN ADMINISTRATION

This BMP will be administered in accordance with the requirements of the AA9 Environmental Management System (EMS) and the BSO Approval Conditions. A summary of the administrative requirements is provided below.

10.1 ROLES AND RESPONSIBILITIES

All statutory obligations applicable to the AA9 operations are identified and managed via an online compliance management system (TICKIT). The online system can be accessed by appropriate BHPBIC managers at the link below.

https://illawarracoal.tod.net.au/login.

The overall responsibility for the implementation of this BMP resides with the Manager Approvals who shall be the BMP's authorising officer.

Parties responsible for environmental management in AA9 and the implementation of the BMP include:

Head of External Affairs

- Ensure that the requisite personnel and equipment are provided to enable this BMP to be implemented effectively

Manager Approvals

- Authorise the BMP and any amendments thereto
- Delegate to an appropriately qualified person the responsibility to document any changes to the BMP, recognising the potential for those changes to affect other aspects of the BMP
- Provide regular updates to BHPBIC on the results of the BMP
- Arrange information forums for key stakeholders as required
- Prepare any report and maintain records in accordance with the BMP
- Organise and participate in assessment meetings called to review mining impacts
- Within 24 hours, respond to any queries or complaints made by members of the public in relation to aspects of the BMP
- Organise audits and reviews of the BMP
- Address any identified non-conformances and implement improvement opportunities
- Implement any agreed actions, responses or remedial measures
- Ensure surveys required by this BMP are conducted and record details of instances where circumstances prevent these from taking place

Environmental Field Team Coordinator

- Instruct suitable person(s) in the required standards for inspections, recording and reporting and be satisfied that these standards are maintained
- Investigate significant subsidence impacts
- Identify and report any non-conformances with the BMP
- Participate in any assessment meetings called to review subsidence impacts in the area affected by mining

Survey Coordinator

- Collate survey data and present in an acceptable form for review at assessment meetings

- Bring to the attention of the Manager Approvals any findings indicating an immediate response may be warranted
- Bring to the attention of the Manager Approvals any non-conformances identified with the Plan or ideas aimed at improving the BMP

Technical Experts

- Conduct the roles assigned to them in a competent and timely manner to the satisfaction of the Manager Approvals and formally provide expert opinion as requested

Person(s) Performing Inspections

- Formally bring to the attention of the Environment Field Team Coordinator any non-conformances identified with the Plan, or ideas aimed at improving the Plan
- Conduct inspections in a safe manner.

10.2 RESOURCES REQUIRED

The Head of External Affairs provides resources sufficient to support this BMP.

Equipment will be needed for the TARPs provisions of this BMP. Where this equipment is of a specialised nature, it will be provided by the supplier of the relevant service. All equipment is to be appropriately maintained, calibrated and serviced as required in operation manuals.

It is the responsibility of the Manager Approvals to ensure that personnel and equipment are provided as required to allow the provisions of this Plan to be implemented.

10.3 TRAINING

All staff and contractors working on BHPBIC sites are required to complete the BHPBIC training program which includes:

- An initial site induction, including all relevant aspects of environment, safety and community
- Safe Work Methods Statements and Job Safety Analyses, Toolbox Talks and Pre-shift communications
- On-going job specific training and re-training where required.

All training records are maintained by the BHPBIC Safety and Training Department (STAX database system), which can be accessed by BHPBIC staff via the online information system iPick.

It shall be the responsibility of the Manager Approvals to ensure that all persons and organisations having responsibilities under this BMP are trained and understand their responsibilities.

The person(s) performing regular inspections shall be under the supervision of the Environment Field Team Coordinator and be trained in observation and reporting. The Environment Field Team Coordinator shall be satisfied that the person(s) performing the inspections are capable of meeting and maintaining this standard.

10.4 RECORD KEEPING AND CONTROL

Environmental Records are maintained in accordance with the BHPBIC procedure *Records Management (ICHP0108)*.

10.5 DOCUMENT CONTROL

The BHPBIC *Document Control procedure (ICHP0103)* outlines the method for control of defined 'business critical' documentation for all BHPBIC operations. The system has been designed in such a manner to ensure that:

- Documents are approved for adequacy by authorised personnel prior to use
- Obsolete documents are promptly removed from circulation
- Documents are reissued, or made available, to relevant persons in a timely fashion after changes have been made and the authorisation process is complete.

The BMP and other relevant documentation will be made available on the BHPBIC website (*Condition 11, Schedule 6).*

10.6 MANAGEMENT PLAN REVIEW

A comprehensive review of the objectives and targets associated with the BSO is undertaken on an annual basis via the BHPBIC Balanced Planning (1 year outlook) and Balanced Strategy (5 year outlook) processes. These reviews, which include involvement from senior management and other key personnel, assess the performance of BSO over the previous year and develop goals and targets for the following period.

An annual review of the environmental performance of BSO will also be undertaken in accordance with *Condition 4 Schedule* 6.

More specifically this BMP will be subject to review and revision if necessary, to the satisfaction of the Director-General within three months of:

- The submission of an annual review under *Condition 4, Schedule 6*
- The submission of an incident report under *Condition 7, Schedule 6*
- The submission of an audit report under *Condition 9, Schedule 6*
- Any modification to the conditions of this approval.

If deficiencies in the EMS and/or BMP are identified in the interim period, the plans will be modified and approvals for these modifications sought as required. This process has been designed to ensure that all environmental documentation continues to meet current environmental requirements, including changes in technology and operational practice, and the expectations of stakeholders.

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Attachment A – Appin Area 9 Longwalls 901 to 904 Aquatic Ecology Impact Assessment (Cardno Ecology Lab, 2012)

Cardno Ecology Lab

Shaping the Future

Marine and Freshwater Studies

Appin Area 9
Longwalls 901-904
Aquatic Ecology Assessment

Job Number: EL0809013

Prepared for BHP Billiton Illawarra Coal

May 2012

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Cover Image: Upstream reach of the Nepean River within the Appin Area 9 Study Area.

Photographer Matt Harper, Cardno Ecology Lab

Document Control

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Executive Summary

BHP Billiton Illawarra Coal (BHPBIC) is seeking approval to extract Longwalls 901 to 904 in Appin Area 9, located to the west of their current longwall mining operations in Appin Area 7. This Aquatic Ecology Assessment (AEA) has been prepared to support the Biodiversity Management Plan (BMP) component of the Appin Area 9 Longwalls 901 to 904, Extraction Plan. The AEA focuses on the aquatic habitats, flora and fauna that occur in the watercourses that flow through the area that could potentially be affected by the mining of Longwalls 901 to 904. The following watercourses are the focus of the study: Nepean River, a perennial river system situated to the south of the Appin Area 9 Study Area, the Nepean Tributary No. 1 situated above the proposed Longwalls 902 to 904 and Harris Creek located to the east of the longwalls and approximately 400m away from mining (Longwall 903). The AEA includes:

- A review of existing information on the aquatic ecology of these watercourses;
- Assessment of potential impacts on aquatic habitats and biota arising from the extraction of the longwalls;
- Recommendations on minimisation and monitoring of potential impacts on aquatic ecology and contingent measures.

The stretch of the Nepean River that flows through the Study Area comprises an upstream reach with moderate surface flow controlled by boulder fields, rockbars and a small weir, and a downstream reach with a large continuous pool with no observable flow, controlled by Douglas Park Weir. Both reaches contain permanent aquatic habitat for aquatic macroinvertebrates, aquatic macrophytes and fish. Twenty-eight aquatic plant species have been recorded in the upper reaches of the Nepean River.

The regulation of flows along this river has had a profound effect on the aquatic fauna. A total of 76 macroinvertebrate taxa and 12 species of fish have been recorded in the pool edge habitat in the river adjacent to Appin Areas 7 and 9. The "health" of the macroinvertebrate fauna at sites along the river has ranged from equivalent to severely impaired relative to the AUSRIVAS reference condition. The recent installation of fishways on 13 weirs along the Nepean River could enable more species to frequent the reaches of the river within the Study Area.

Three threatened species of invertebrates, Adams emerald dragonfly (*Archaeophya adamsi*), Sydney hawk dragonfly (*Austrocordulia leonardi*) and Giant dragonfly (*Petalura gigantea*), and one threatened species of fish, Macquarie perch (*Macquaria australasica*), or suitable habitat from them is known or likely to occur in the Study Area. The distribution records indicate that there could be a viable population of Adams emerald dragonfly within the Study Area, but not for the other species.

The assessment of potential impacts on aquatic ecology arising from the extraction of Longwalls 901-904 is based on the maximum predicted subsidence parameters and their predicted impacts on the physico-chemical characteristics of the three significant watercourses that flow through Appin Area 9.

The predicted changes in surface water levels, ponding, flooding and scouring of river banks and surface flows would have negligible effects on aquatic habitats or biota in the Nepean River. The effects on aquatic ecology of changes in the level of river banks and fracturing of the river bed plus any gas emissions and iron staining would also be negligible. The diversion of water into sub-surface layers during low flow periods and changes in surface water level in Harris Creek and Nepean Tributary No. 1 are unlikely to have detectable effects on the availability of aquatic habitats or aquatic biota. If minor localised changes in ponding, flooding or scouring do occur in these watercourses, the impact on the availability and quality of aquatic habitats and associated biota would be minimal. The assessment of the consequences for aquatic ecology of any subsidence that occurs during extraction of Longwalls 901-904 based on the Extraction Plan layout is thus similar to that based on the Part 3A Application layout.

Potential impacts on aquatic ecology within the Study Area would be managed by:

- Impact minimisation, including setback of longwalls from the river and identification of triggers that would prompt surveys to assess any impacts on aquatic habitats and their biota identified during and after extraction of the longwalls;
- Aquatic ecology monitoring during and after mining and any remediation works to determine the nature and extent of any subsidence-induced impacts on aquatic ecology and responses of aquatic ecosystems to any remediation or management works implemented;
- Undertaking additional aquatic ecology studies in response to specific impacts on water quality and availability of aquatic habitats within the watercourses; and
- Implementation of contingent measures such as review of mine layout and appropriate offset distances from the Nepean River, stream remediation measures, appropriate control measures to limit deposition of any eroded sediment into the river, and appropriate offset and compensatory measures.

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1 Introduction

BHP Billiton Illawarra Coal (BHPBIC) commissioned Cardno Ecology Lab to prepare an Aquatic Ecology Assessment to support the Biodiversity Management Plan (BMP) component of the Appin Area 9, Longwalls 901 to 904, Extraction Plan.

1.1 Project Background

Appin Colliery is located in the Southern Coalfields of New South Wales (NSW), approximately 25 km west of Wollongong, in the Wollondilly Local Government Area (LGA) (Figure 1). At the colliery, longwall mining techniques are used to extract premium quality, hard coking coal (used for steel production) and some energy coal from the Bulli Seam.

In December 2007, BHPBIC sought approval under Part 3A of the Environmental Planning and Assessment Act 1979 (*EP & A Act*) to expand its underground coal mining operations at Appin Colliery to extract coal in Areas 5, 7, 8, and 9. These areas form part of the Bulli Seam Operations (BSO). On 22 December 2011, approval for the BSO Project was granted by the Minister for Planning under the *EP & A Act*. The approval for this project allows BHPBIC to continue mining operations for a further 30 years.

BHPBIC is now seeking approval to extract Longwalls 901 to 904 in Appin Area 9, which is located to the west of the current longwall mining operations in Appin Area 7. The layout of the proposed longwalls in Appin Area 9 has been modified from that of the EA Base Plan presented in the BSO Part 3A Application. The modifications include:

- Setback from the Nepean River and the cliffs within the valley in order to minimise potential impacts on these sensitive features, and
- Minimisation of the volume of sterilised coal which could be efficiently extracted while meeting the stream impact minimisation criteria from the BSO EA and the requirements of the Project Approval.

The Study Area for the Aquatic Ecology Assessment (AEA) is defined as the surface area that is likely to be affected by the proposed mining of Longwalls 901 to 904. The Study Area encompasses the area bounded by the following limits:-

- The 35 degree angle of draw line from the proposed extents of Longwalls 901 to 904;
- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour resulting from extraction of the proposed Longwalls 901 to 904, and
- Surface features outside the above areas that are sensitive to either far-field movements or valley-related movements (MSEC 2011).

1.2 Objectives

The objectives of this assessment are to:

- Describe the aquatic ecology of the Study Area using data presented in the Aquatic Ecology Assessment prepared for the BSO EA (Bioanalysis 2009) and additional data collected during site investigations and assessments for Appin longwalls 701-710 (The Ecology Lab 2004, 2006, 2008a and b, 2009; Cardno Ecology Lab 2009 and 2011);

- Identify potential impacts on aquatic habitats and biota resulting from the subsidence predictions presented in MSEC (2011);
- Determine whether the predicted impacts to aquatic habitats and biota differ from those presented within the BSO EA (BHPBIC 2009);
- Recommend ways to avoid, minimise and mitigate impacts to aquatic habitats and biota; and
- Report on residual impacts to aquatic habitats and biota and ensure they are consistent with the Conditions of Approval for the BSO Project (see Section 2.2).

This AEA will be used to derive the aquatic ecology management recommendations contained within the Appin Area 9 Extraction Plan.

1.3 Statutory Requirements

The statutory obligations with regard to Appin Area 9 are:

- The relevant conditions of Project Approval for the BSO Project, as outlined below; and
- Legislation which has provisions for the protection of aquatic flora and fauna, including the Fisheries Management Act 1994 (*FM Act*), Threatened Species Conservation Act 1995 (*TSC Act*), Environmental Planning and Assessment Act 1979 *(EP&A Act)* and Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act*);

The conditions specified in the BSO Project Approval that are relevant to aquatic ecology include:

- Subsidence Impact Performance Measures for Natural Features (see Table 1 for summary);
- Preparation of an Extraction Plan incorporating a Biodiversity Management Plan that provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on aquatic flora and fauna, particularly threatened species, populations and their habitats; endangered ecological communities; and water dependent ecosystems;
- Additional targeted surveys for threatened species, sufficient to identify any actions required to protect significant populations from potential impacts.

The term negligible, used in Table 1, is defined in the BSO Project Approval as small and unimportant, such as to be not worth considering.

Table 1: Subsidence Impact Performance Measures Pertinent to Aquatic Ecology in the Appin Area 9 Study Area.

Natural Feature	Performance Measure
Nepean River	Negligible environmental consequences (that is, negligible diversion of flows, negligible change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases).
Other watercourses	No greater subsidence impact or environmental consequences than predicted in the EA and PPR.
Threatened species, threatened populations, or endangered ecological communities	Negligible environmental consequences

2 Existing Aquatic Environment and Biota

The description of existing aquatic ecology presented in this section draws upon the following studies:

- Appin Colliery – Longwalls 901 to 904 - Subsidence Predictions and Impact Assessments for the Natural Features and Surface Infrastructure in Support of the Extraction Plan (MSEC 2011);
- Site inspections undertaken by Cardno Ecology Lab in September 2008 and May 2010;
- Aquatic Ecology Assessment undertaken at location NP1, situated approximately 400 m downstream of Maldon Weir, and NP2, situated within the Study Area on the reach of the Nepean River upstream of the confluence with Allens Creek, for the BSO EA (Bioanalysis 2009);
- Stream Risk Assessment for the BSO EA (BHPBIC 2009);
- Surface Water Assessment for the BSO EA (Gilbert and Associates 2009);
- Monitoring of aquatic ecology and assessment of the effects of mine subsidence on aquatic habitat and biota in Appin (formerly Douglas) Area 7 Longwalls 701-704 (The Ecology Lab 2004, 2006, 2009; Cardno Ecology Lab 2011); and
- Monitoring of aquatic ecology and assessment of the effects of mine subsidence on aquatic habitat and biota for Appin Longwalls 705-710 (The Ecology Lab, 2004 and 2008a).

It should be noted that the aquatic ecology studies undertaken in relation to Appin Area 7 focus on the area to the east of the Appin Area 9 Study Area and that the Aquatic Ecology Assessment prepared for the BSO EA was conducted across a broad area which included the Study Area for Appin Area 9. Data from the two most upstream sites on the Nepean River in the Appin Area 7 monitoring programme are pertinent to the Appin Area 9 Study Area, as they are situated upstream of the confluence with Harris Creek and to the south of Longwall 901.

2.1 Physical Setting

The Nepean River is a perennial river system that originates in the uplands west of Wollongong and flows northward past Camden to its junction with the Warragamba River near Wallacia, where it becomes part of the main Hawkesbury River (MSEC 2011). The Appin Area 9 Study Area is situated adjacent to the Nepean River, just upstream of the Douglas Park Weir on the northern bank. The water in the section of the river that flows through the Study Area is derived from the licensed discharges of the Cataract, Cordeaux, Avon and Nepean Dams. The flow in this section is controlled by Maldon Weir, which is situated approximately 5 kilometres south-west of the proposed longwalls. The section of the river within the Study Area is set in a deep rocky gorge surrounded by steep sandstone cliffs and talus slopes (MSEC 2011).

The Study Area is also traversed by several ephemeral drainage lines which flow into the Nepean River after rainfall events. The two largest drainage lines are the Nepean Tributary No. 1 situated above the proposed Longwalls 902 to 904 and Harris Creek located to the east of the longwalls and approximately 400m away from the nearest longwall (903) (MSEC 2011). Neither of these systems or the smaller watercourses contain significant aquatic habitat.

2.2 Aquatic Habitat

2.2.1 Nepean River

The Study Area is traversed by an approximately 2.6 km long section of the Nepean River, with 1.1 km of this being located within the area defined by a 35 degree angle of draw from the proposed extents of Longwalls 901 to 904 and the predicted total 20 mm subsidence contour. The section of the Nepean River within the Study Area consists of an upstream reach in which the surface flow is controlled by boulder fields, rockbars and a small weir, and a flooded downstream reach, in which surface water level is controlled by Douglas Park Weir (MSEC 2011). The boulder field at the confluence of the Nepean River and Allens Creek marks the boundary between the two reaches. Most of the downstream reach is situated beyond the area defined by the 35 degree angle of draw line and the predicted total 20 mm subsidence contour. The river bed is composed of Hawkesbury Sandstone overlain by fluvial sediment (MSEC 2011).

The downstream reach of the Nepean River is interrupted by the 1 m high causeway at Douglas Park. The channel above and below this causeway consists of a continuous pool, approximately 50 m wide and 3.5 m deep, with no observable flow (The Ecology Lab 2004). There are several sand bars along the channel, particularly near the mouth of the Cataract River. The riverbanks support a mixture of native and exotic trees and shrubs, including *Casuarina*, *Eucalyptus* and *Lantana*. There are extensive beds of submerged macrophytes in the shallower reaches and snags and boulders along the channel edge.

The site inspection undertaken in August 2008 by Cardno Ecology Lab indicates moderate, continuous flow of water in the upstream reach. The aquatic habitat is more varied in this reach, comprising pools containing aquatic macrophytes interspersed by riffles composed of gravel and/or boulders. The riparian zone in the section upstream of the boulder field is continuous and dominated by native species. The substratum in the upper reach includes bedrock, boulders, gravel and sand. Both reaches contain permanent aquatic habitat for aquatic macroinvertebrates, aquatic macrophytes and fish.

The aquatic habitat occurring at Site NP1 consists of a series of pools 15 to 75 m wide with a depth of approximately 5 m, punctuated by chokes of large boulders (Bioanalysis 2009). The substratum of the pools includes bedrock, boulders and sand. The edge of the channel is comprised of boulder habitat and sandbars supporting riparian vegetation. There are extensive macrophyte beds within the pools and evidence of disturbance of the river bank. The 15 m high Maldon weir is likely to pose a significant barrier to the passage of fish. The habitat at location NP2 consists of a continuous pool varying in width from 3 to 10 m with a depth of approximately 3 m (Bioanalysis 2009). The substratum of the pool is composed of bedrock and boulders, with occasional pockets of coarse sediment. Aquatic macrophytes are present. The stream bank has not been disturbed.

2.2.2 Harris Creek

Harris Creek is a relatively small (< 3 km long), ephemeral, 3rd order stream that flows through steep valleys in its lower reaches as it approaches the Nepean River. The Stream Risk Assessment for the BSO EA (Appendix P) indicates that the dominant physical features are boulder fields, pools, rock bars, sediment and a vegetated drainage line (BHPBIC 2009). The

most notable feature is a prominent rock bar and pool located upstream of a bend in the stream (Gilbert and Associates 2009).

The channel of the creek in the lower reaches is 3-5 metres wide and comprises bedrock, scattered boulders and a continuous band of riparian vegetation (The Ecology Lab 2004). There are also a pools in the lower reaches containing moderate aquatic habitat. The rest of the creek is dry, with the upper reaches consisting of a gully surrounded by pasture, indicating that it is likely to provide minimal aquatic habitat. There are also a number of farm dams along the channel that would interrupt downstream flows. Access of the upper reaches by livestock has resulted in extensive erosion of the bank and channel. There is some connectivity of flows across the pools in the lower reach of the creek, but this is unlikely to be maintained in extended dry periods (The Ecology Lab 2008a). The steep lower reach of the creek situated within the Nepean River gorge poses a substantial barrier to the passage of many species of fish.

2.2.3 Other watercourses

Two unnamed tributaries of the Nepean River also cross part of the Study Area. Tributaries 1 and 2, as they are referred to in the BSO EA, are 3rd order streams that are approximately 1.4 km and 0.2 km long, respectively and have stream gradients ≥ 50 m/km (BHPBIC 2009). The catchments of these tributaries are relatively small, with minimal aquatic habitat (mostly dry creek bed in September 2003) (The Ecology Lab 2004). The steep gradient at the confluence of Tributary 1 and the Nepean River is considered to be a significant barrier to fish passage.

2.3 Water Quality

The quality of the water in the section of the Nepean River that flows through the Study Area is described in the BSO EA where water quality data is compared with the ANZECC/ARMCANZ (2000) guidelines for lowland rivers (Bioanalysis 2008).

Considerable information is available on the quality of water in the Nepean River between Douglas Park Weir and Menangle Weir, which has been monitored bi-monthly by BHPB since May 2002. Geoterra (2006) noted that the average pH, salinity, phosphorus and nitrogen levels in this reach were outside the ANZECC/ARMCANZ (2000) guidelines for protection of aquatic ecosystems in south-eastern Australia and that dissolved zinc and aluminium concentrations exceeded the 95% species conservation level in some areas. The water in the pools has been found to be stratified, with deeper layers being colder and having low to very low dissolved oxygen levels during the summer and low flow periods. This stratification is due to the low re-aeration co-efficient of the Nepean River between Maldon Weir and Menangle Weir, resulting from the absence of cascades or rapids that would facilitate exchange of oxygen (EcoEngineers, 2008).

2.4 Riparian Vegetation

In May 2008, pouched coral fern (*Gleichenia dicarpa*), *Gahnia* sp., *Lomandra longifolia*, *Potamogeton sulcatus*, *Hemarthria uncinata*, *Isolepis cernua*, *Juncus prismatocarpus* and *Viola* sp. and a variety of weed species, including common couch (*Cynodon dactylon*), *Ageratina riparia* and *Nasturtium officinale* were found at NP2 (Bioanalysis 2009). Scattered plants of *Lomandra fluviatilis*, a species considered to be of national significance, according to Rare or Threatened Australian Plants (ROTAP) classification (Briggs and Leigh, 1992), were also observed.

2.5 Aquatic Vegetation

The aquatic macrophytes that have been recorded in the upper reaches of the Nepean River adjacent to Appin Areas 7 and 9 are listed in Appendix 2. Twenty-eight species have been recorded. It should be noted that the studies undertaken by The Ecology Lab (2004, 2006 and 2008a) and subsequently Cardno Ecology Lab (2009 and 2011) focused on in-stream macrophytes and that identification of these was hampered by poor visibility during the first two surveys. Bioanalysis (2009) recorded aquatic macrophytes observed in stream and the riparian zone and thus provide a more comprehensive picture of aquatic flora.

The distribution of submerged macrophytes within the large pools in the reaches of the Nepean River upstream, within and downstream of Appin Area 7 has been mapped on several occasions since September 2003 (The Ecology Lab 2004, 2006 and 2008a; Cardno Ecology Lab 2011). The distribution of seven species of submerged aquatic plants, hydrilla (*Hydrilla verticillata*), elodea water weed (*Elodea* sp), clasped pondweed (*Potamogeton perfoliatus*), floating pondweed (*Potamogeton tricarinatus*), ribbonweed (*Vallisneria* sp.), blunt pondweed (*Potamogeton ochreatus*) and curly pondweed (*Potamogeton crispus*) has been mapped in this section of the river. These species occurred in dense, mixed beds and were considered to be in good health. The surveys undertaken prior to mining showed that there was considerable natural variation in the distribution, extent and composition of these beds. This indicates that large-scale changes in the extent of macrophyte beds may occur regardless of mining and suggests that changes in macrophyte beds related to mine subsidence may be difficult to distinguish from temporal variation due to other factors, including natural variability. During the most recent survey undertaken in December 2010, hydrilla, blunt pondweed and elodea were found at all the sites surveyed and floating pondweed at all but one site (Cardno Ecology Lab 2011). Macrophytes were generally found in narrow bands adjacent to the river banks, but extended out into the deep, faster flowing sections of the channel at a few sites. Three species of emergent macrophytes, tall spikerush (*Eleocharis sphacelata*), cumbungi (*Typha* sp.) and alligator weed (*Alternanthera philoxeroides*), were found at some of the sites surveyed in December 2010.

In May 2008, extensive beds of submerged macrophytes, composed mostly of *Elodea canadensis*, an introduced species, and *Hydrilla verticillata* plus a few plants of the floating attached species, *Triglochin procerum*, were observed at Site NP1 (Bioanalysis 2009). *Elodea canadensis* was also common at NP2. A few plants of *Triglochin microtuberosum* were also observed at this site.

2.6 Aquatic Macroinvertebrates

The regulated flows from the upstream storages (e.g. Avon, Nepean and Cordeaux Dams) and some of the weirs (e.g. Pheasants Nest and Broughtons Pass) on the Hawkesbury-Nepean system has been shown to have a profound impact on macroinvertebrates associated with riffle and pool-rock habitats, but no effect on those associated with edge habitats within the river (Growns and Growns 2001). The construction of weirs favours species that prefer low velocity environments (Williams 1994). Despite this, a total of 76 taxa have been recorded in the section of the Nepean River adjacent to Appin Area 7, with 52 of these being found at the sites in the upper reach beyond Douglas Park Weir, during surveys undertaken in September 2003, November 2008 and November/December 2010 (The Ecology Lab 2004, Cardno Ecology Lab 2009 and 2011). These taxa are listed in Appendix 3.

Considerably fewer taxa have been recorded per site, with the numbers varying from 13 to 16, 25 to 32 and 15 to 31 in September 2003, November 2008 and November/December 2010,

respectively (The Ecology Lab 2004, Cardno Ecology Lab 2009 and 2011) (Appendix 4). In spring 2003, the fauna at the Appin Area 7 monitoring sites was found to be significantly impaired relative to the AUSRIVAS reference condition, with between 36% and 48% of the expected families with a 50% probability of occurrence absent (The Ecology Lab 2004). In November 2008, the fauna at the four most upstream sites was equivalent to AUSRIVAS reference condition, but at the downstream sites was impaired and lacked between 24% and 36% of the expected taxa (Cardno Ecology Lab 2009). In December 2010, the fauna at the two most upstream sites was found to be equivalent to the AUSRIVAS reference condition, but at three of the other sites was impaired, lacking between 18% and 24% of the expected taxa. The fauna at the most downstream site was found to be severely impaired, with 53% of the expected taxa absent.

The sampling undertaken upstream of Douglas Park Weir yielded 13 and 14, 30 and 32 and 27 and 30 taxa per site in September 2003, November 2008 and November/December 2010, respectively (The Ecology Lab 2004, Cardno Ecology Lab 2009 and 2011) (Appendix 2). The fauna at these sites was assessed as significantly impaired relative to the AUSRIVAS reference condition in September 2003, but as equivalent to reference condition in the two subsequent surveys.

In May 2008, the aquatic macroinvertebrates occurring in association with the edge habitat at two sites at locations NP1, situated approximately 400m downstream of Maldon Weir, and NP2, situated upstream of the confluence with Allens Creek, were sampled using the AUSRIVAS protocol and timed dip net sweeps of edge, macrophytes, riffle, pools and rocks (Bioanalysis 2009). The sampling undertaken at NP3 has not been described, because this location is situated just upstream of Menangle Weir, which is beyond the Appin Area 9 Study Area. The AUSRIVAS sampling yielded 14 and 20 taxa per site at NP1 and 4 and 12 taxa per site at NP2. The fauna at NP1 was significantly impaired relative to the AUSRIVAS reference condition, lacking 24% of the expected taxa at one site and 52% at the other. The fauna at NP2 was severely impaired, lacking 64% of the expected taxa at one site and 78% at the other. In general, fewer taxa were collected in the timed sweeps across a variety of habitats than in the AUSRIVAS samples, with numbers per replicate varying from 9-11 and 11-14 at the sites in NP1 and from 8-14 and 5-12 at the sites in NP2.

2.7 Fish

The regulated flows from the three dams in the upper reaches of the Nepean River system and the 13 weirs that have been constructed along the main channel of the river are likely to have had a major impact on the fish fauna (Baumgartner and Reynoldson 2007). These weirs are substantial barriers to the passage of fish and have probably resulted in fragmentation of populations, reduced opportunities for genetic exchange and prevented the larvae of species that migrate to the estuary/sea to spawn from making recolonising migrations (Gehrke *et al.* 2000). The recent installation of vertical slot fishways at the barriers along the river from Penrith Weir up to Douglas Park weir will enable some species to increase their upstream distribution (Rourke and Baumgartner 2011). The Appin Area 9 Study Area is situated adjacent to the 12 km section of the Nepean River between Douglas Park Weir and Maldon Weir and is therefore likely to show an increase in fish diversity now that species in a large section of the downstream reach of the river are able to move upstream via the fishways. The movement of fish into the Study Area from the upper reaches of the Nepean River is restricted by the 15 m high x 40 m wide fixed crest weir at Maldon, which restricts fish passage during all flow

conditions due to excessive head loss and by Pheasants Nest Weir (Mallen-Cooper and Smit 2005; NSW DPI 2006). Maldon Weir is the upstream limit of migration for Australian bass and other species that require estuarine areas to spawn (Sammut and Erskine 1995).

The information that is available about the fish in the upper Nepean River system was collected prior to the installation of these fishways. Studies have been undertaken by NSW Fisheries (Harris *et al.* 1996; Gehrke *et al.* 1996), The Ecology Lab (2004, 2006 and 2008a), Cardno Ecology Lab (2009 and 2011), Bioanalysis (2009) and NSW DPI (Baumgartner and Reynoldson 2007). The species of fish recorded during these studies are listed in Appendix 5.

The NSW government records on the BioNet database indicated that eleven native and three alien species of fish have been recorded in the Nepean River and its tributaries within the Campbelltown LGA (The Ecology Lab 2008).

The gill netting operations undertaken by NSW Fisheries at Douglas Park yielded two species, Australian bass (*Macquaria novemaculeata*) and freshwater catfish (*Tandanus tandanus*), in 1985-1986 (Harris *et al.* 1996) and one species, Cox's gudgeon (*Gobiomorphus coxii*), in spring 1995 (Gehrke *et al.* 1996).

Five native fish species, flat head gudgeon (*Philypnodon grandiceps*), dwarf flathead gudgeon (*Philypnodon* sp.), fire-tail gudgeon (*Hypseleotris galii*), empire gudgeon (*Hypseleotris compressa*), Australian smelt (*Retropinna semoni*), and one alien species, eastern gambusia (*Gambusia holbrooki*) have been caught in the section of the river that flows through the SMP Areas for the Appin Area 7 longwalls (The Ecology Lab 2004 and 2006; Cardno Ecology Lab 2009 and 2011). Glass shrimp and freshwater prawns also occur in this section of the river (Cardno Ecology Lab 2011). All of the fish species have been caught at some stage at the two upstream sites (i.e. those closest to Appin Area 9). Additional sampling was carried out at the monitoring sites adjacent to Longwalls 701 and 702 after their extraction was completed (The Ecology Lab 2008b; Cardno Ecology Lab 2009). Australian smelt and firetail gudgeon were caught at the sites sampled in April 2008 and June 2009. Flathead gudgeon and gambusia were also caught during the April 2008 study.

Bioanalysis (2009) captured flathead gudgeon, striped gudgeon, dwarf flathead gudgeon, Australian smelt, gambusia and Australian bass at Site NP1, located approximately 400m downstream of Maldon Weir, but only caught flathead gudgeon, dwarf flathead gudgeon, Australian smelt and gambusia at Site NP2, which is located in the upstream reach of the Nepean River that flows through the Appin Area 9 Study Area.

It should be noted that the surveys undertaken adjacent to Appin Areas 7 and 9 were based on a combination of back-pack electrofishing, baited traps and dip netting and were consequently limited to relatively shallow (< 1m) areas. An additional five species, long-finned eel, (*Anguilla reinhardtii*), goldfish (*Carrasius auratus*), carp (*Cyprinus carpio*), Cox's gudgeon and Australian bass, were recorded during a boat-based electrofishing survey of the sections of the river upstream of the Douglas Park and Menangle weirs (Baumgartner and Reynoldson 2007). The survey at the latter site also yielded a sixth species, eel-tailed catfish. Flat-head gudgeon, gambusia and firetail gudgeon were also caught during the survey of these reaches.

Several species of fish, including striped gudgeon, bully mullet, freshwater mullet, bullrout and freshwater herring that have been recorded further downstream in the section of the Nepean River upstream of Penrith Weir (Baumgartner and Reynoldson (2007) could potentially colonise the Study Area now that fishways have been installed on the intervening weirs. There is

evidence that some species have already increased their distribution in the Nepean River (Rourke and Baumgartner 2011).

2.8 Threatened Species

A search of relevant databases indicates that the following threatened aquatic species or their habitats are known or likely to occur in the Study Area:

- Adams emerald dragonfly (*Archaeophya adamsi*) – listed as Endangered under the *Fisheries Management, 1994 Act* (*FM Act*);
- Sydney hawk dragonfly (*Austrocordulia leonardi*) – listed as Endangered under the *FM Act*;
- Giant dragonfly (*Petalura gigantea*) – listed as Endangered under Schedule 1 of the NSW Threatened Species Conservation Act, 1995 (*TSC Act*);
- Macquarie perch (*Macquaria australasica*) – listed as Vulnerable under the *FM Act* and as Endangered under the Environment Protection and Biodiversity Conservation Act, 1999 (*EPBC Act).*

Sydney hawk dragonfly is extremely rare, having been collected in small numbers at three locations in a small area south of Sydney, from Audley to Picton (NSW Fisheries, 2004). There are no records for this species within the SMP Area, however, it has been recorded upstream in the Nepean River, at the Maldon Bridge near Wilton (NSW Fisheries, 2004). The larvae have specific habitat requirements, including deep, cool, slow-flowing water in rocky rivers with steep sides (NSW Fisheries, 2004). The large, deep, permanent pools within the downstream reach of the Nepean River that flows through the SMP Area and relative stability in water level and flow rate, resulting from flow regulation by Douglas Park Weir, appear to provide suitable habitat for the larva of Sydney hawk dragonfly. It is consequently possible that a viable local population exists within the Study Area.

Adam's emerald dragonfly is also extremely rare, having been collected only in small numbers at a few locations despite widespread and consistent efforts since the 1960's (NSW Fisheries, undated). There are no records for Adams emerald dragonfly south of Sydney despite active collecting in the Georges and Nepean River catchments (NSW Fisheries, undated). The larvae of Adam's emerald dragonfly have been found in riffle and/or cascade habitats in small to moderate sized creeks within a well vegetated catchment. The section of the Nepean River within the Study Area does not contain appropriate habitat for this species.

The giant dragonfly is an extremely large, and unusual species of dragonfly, which has a largely terrestrial life cycle (NSW OEH, 2011). The giant dragonfly has been recorded in permanent coastal and upland wetlands stretching from Moss Vale to southern Queensland, but has not been recorded in most areas for many years. The species is known or predicted to occur in the Bungonia, Burragorang (Part A), Kanangra, Moss Vale and Wollemi sub-regions of the Hawkesbury/Nepean Catchment Management Region, but has not been found in the sub-region encompassing the Study Area. This species is found in permanent swamps and bogs with some free water and open vegetation (NSW OEH, 2011). Adult giant dragonflies are short-lived, surviving for one summer after emergence and therefore difficult to find. They spend most of their time on low vegetation on or adjacent to the swamp. The females deposit eggs into moss, under other soft ground layer vegetation, and into moist litter and humic soils, often associated with groundwater seepage areas within appropriate swamp and bog habitats. The

larval life stage is long, lasting from ten to thirty years. The larvae live in permanent, long-chambered burrows built under swamps that have terrestrial entrances. They emerge from their burrows at night, and in wet weather, to feed on insects and other arthropods (NSW OEH, 2011). Larvae are not known to swim and avoid open water. Given this lifestyle, it is highly unlikely that this species occurs in the permanent aquatic habitats within the Study Area.

The records from the Australian Museum indicate that Macquarie perch were present in the upper Nepean River between 1894 and 1905. Recent records indicate that Macquarie perch occurs in the Nepean River upstream and downstream of Pheasant's Nest Weir (Baumgartner and Reynoldson 2007). This structure is believed to block the downstream passage of this species (Gehrke and Harris 1996). The presence of this weir and another significant barrier to fish passage further downstream at Maldon Weir and absence of any records from the downstream reaches of the Nepean River suggest that it is highly unlikely that the Study Area supports a population of Macquarie perch.

2.9 Conclusion

Significant information exists on the aquatic ecology of the Nepean River near Douglas Park as a result of extensive surveys for mining operations in the area. This information has been used to develop a comprehensive baseline monitoring program for the Study Area which will be initiated prior to mining (see Section 4.1). Given the changes that are likely to occur in the distribution, abundance and diversity of fish along the Nepean River, due to the installation of fishways, it is recommended that the monitoring includes a comprehensive survey of fish.

3 Assessment of Potential Impacts

3.1 Introduction

The extraction of coal from the proposed longwalls will result in vertical and horizontal movements of the rock and soil mass above the extracted coal seam, which may, in turn, affect natural and man-made features on and below the land surface. Subsidence movements that occur at surface watercourses may cause fracturing of the stream bed and banks, movements of joint and bedding plains in the stream bed, uplift and buckling of strata in the stream bed (DoP 2008). These physical impacts can cause diversions of surface and sub-surface flows, drainage of pools and increases in groundwater inflows. Ground movements can also lead to tilting of stream beds which can, in turn, lead to erosion of the stream bed and banks and increased instream sediment load, changes in flow rates and migration of stream channels. Subsidence may also allow the release of gas from sub-surface strata which could reduce water quality and in some cases lead to dieback of riparian vegetation. These physical impacts can have adverse effects on aquatic flora and fauna by resulting in loss of aquatic habitat, desiccation of fringing vegetation, reductions in longitudinal connectivity, deterioration of water quality and changes in the diversity of riparian and aquatic plants, aquatic macroinvertebrates and fish.

The assessment of potential impacts on aquatic ecology arising from the extraction of Longwalls 901-904 is based on the maximum predicted subsidence parameters for the sections of the Nepean River and its major tributaries and Harris Creek that flows through Appin Area 9 (MSEC 2011) and their predicted impacts on the physico-chemical characteristics of the waterways. The maximum predicted subsidence parameters, their effect on the physico-chemical characteristics of the water courses and their consequent effects on aquatic ecology are discussed in Section 3.2, 3.3 and 3.4, respectively.

3.2 Maximum Predicted Ground Movements in Watercourses

Table 2 compares the maximum predicted ground movements in the Nepean River, Nepean River Tributary No. 1 and Harris Creek based on the layout in the Extraction Plan (MSEC 2011) and layout of the EA Base Plan Longwalls indicated in the Bulli Seam Operations Part 3A Application, referred to hereafter as the Part 3A Application Layout (MSEC 2009). This comparison shows that the Extraction Plan layout results in the same maximum predicted subsidence and closure parameters, but a substantial reduction in the maximum predicted upsidence along the Nepean River. The maximum predicted subsidence, upsidence and closure movements in Nepean River Tributary No 1 and Harris Creek are significantly reduced under the Extraction Plan Layout. The potential effects of subsidence on the physico-chemical features of the watercourses will consequently also be reduced under the Extraction Plan Layout.

Table 2: The maximum predicted ground movements in the Nepean River, Nepean River Tributary No. 1 and Harris Creek based on the layout of longwalls presented in the Extraction Plan (MSEC 2011) and Part 3A Application Assessment (MSEC 2009).

Natural Surface Feature	Predicted Ground Movements Based on the Extraction Plan Layout	Predicted Ground Movements Based on the Part 3A Application Layout
Nepean River	Maximum subsidence - 30 mm in the upstream reach, but < 20 mm in the downstream reach.	Maximum subsidence - 30 mm.
	Maximum upsidence - 110 mm in the upstream reach and 70 mm in the downstream reach.	Maximum upsidence - 175 mm.
	Maximum closure - 200 mm in the upstream reach and 180 mm in the downstream reach.	Maximum closure - 190 mm.
	Maximum tilt along the alignment - < than 0.2 mm/m.	
	Maximum conventional tilt across the alignment of the river - of < than 0.5 mm/m.	
Nepean River Tributary No. 1	Maximum subsidence - 1175 mm.	Maximum subsidence - 1275 mm.
	Maximum upsidence - 575 mm.	Maximum upsidence - 725 mm.
	Maximum closure - 625 mm.	Maximum closure - 1300 mm.
	Maximum change in grade – 5.5 mm/m increase and a 3.5 mm/m decrease.	
	Maximum conventional hogging and sagging curvatures - 0.07 and 0.12 per km, respectively.	
Harris Creek	Maximum subsidence - < 20 mm.	Maximum subsidence - 725 mm.
	Maximum upsidence - < 20 mm.	Maximum upsidence - 375 mm.
	Maximum closure - <20 mm.	Maximum closure - 225 mm.
	Maximum change in grade - <0.5 mm/m	
	Maximum conventional hogging and sagging curvatures of <0.01 per km.	

3.3 Potential Impacts of Subsidence on Physico-Chemical Attributes of the Watercourses

The potential effects of the maximum subsidence on physico-chemical attributes of the major watercourses traversing the Appin 9 Study Area and the level of impact predicted under the Extraction Plan Layout are summarised in Table 3.

Table 3: Predicted impacts on physico-chemical attributes of the major watercourses under the Extraction Plan Layout

Watercourse	Attribute	Predicted Impacts
Nepean River	Surface water level	No measurable impact expected in the upstream reach and it is unlikely that there would be any significant change in the downstream reach.
	Change in levels of the river bed and banks	Small changes in levels may occur in the downstream reach, but these are not expected to result in any measurable impact.
	Ponding, flooding and scouring of stream banks	Unlikely to be any significant change.
	Change in stream alignment	Unlikely to be any significant change.
	River bed	Minor, localised fracturing of bedrock may occur, but the likelihood of this is very low beyond the predicted limit of subsidence.
	Surface water flows	Potential for loss or diversion is very low in the downstream reach. Minor, localised fracturing of rock bars may occur in the upstream reach, but the potential for diversion of flows is very low.
	Ground water inflows	Possible that mining-induced springs could develop.
	Gas emissions	Transient, localised emissions are likely to occur.
	Water quality	Localised iron staining may occur.
Nepean River Tributary No. 1 and Harris Creek	Ponding, flooding and scouring of stream banks	Significant increases are unlikely, but there could be small increases in ponding and flooding in localised areas.
	Creek beds and bedrock	Fracturing of the uppermost bedrock may occur, but the incidence is expected to be low. In creeks with alluvial deposits, fractures are likely to be infilled by deposits over time. Some surface water flows may be diverted into underlying strata and drainage of pools may occur. Water will re-emerge downstream, so net loss of water from the catchment is unlikely.
	Water quality	Localised iron staining may occur.

These predictions indicate that impacts on the physico-chemical features of the Nepean River will not be significant. Fracturing of the river bed may occur and result in both gas emissions and iron staining. These impacts, however, are expected to be localised, minor in extent and transient and are thus also unlikely to be significant. From these predictions it can be concluded that extraction of Longwalls 901-904 will result in negligible diversion of flows, negligible changes in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases in the Nepean River and that impacts on the physico-chemical attributes of the other watercourses will also not be significant. The predictions outlined in Table 3 are thus consistent with the Subsidence Impact Performance Measures for the Nepean River specified in the Project Approval for the Bulli Seam Operations Project.

3.4 Consequences for Aquatic Ecology

Table 4 compares the results of the original assessment of the consequences of the extraction of longwalls in Appin Area 9 and 8 on aquatic biota and their habitats undertaken by Bioanalysis (2009) for the BSO EA with an assessment based on the revised subsidence, upsidence, closure and tilt predictions provided by MSEC (2011) in support of the Extraction Plan layout. The predicted changes in surface water levels, ponding, flooding and scouring of river banks and surface flows would have negligible effects on aquatic habitats or biota in the Nepean River. The effects on aquatic ecology of changes in the level of river banks and fracturing of the river bed plus any gas emissions and iron staining would be localised, minor in extent and transient in nature and therefore unlikely to be significant. In Harris Creek and Nepean Tributary No. 1, the diversion of water into sub-surface layers during low flow periods and changes in surface water level are unlikely to have detectable effects on the availability of aquatic habitats or aquatic biota, because of the large variability in natural flows. If minor localised changes in ponding, flooding or scouring do occur in these watercourses, these would have minimal impact on the availability and quality of aquatic habitats and associated biota. The assessment of the consequences for aquatic ecology of any subsidence that occurs during extraction of Longwalls 901-904 based on the Extraction Plan layout is thus similar to that based on the Part 3A Application layout.

Table 4: Potential impacts on aquatic habitats, riparian vegetation, aquatic macrophytes, aquatic macroinvertebrates and fish identified in the Aquatic Ecology Assessment prepared on the basis of the Part 3A Application layout (Bioanalysis 2009) and predicted as a result of the Extraction Plan layout.

Component of Aquatic Ecology	Level of Potential Impact Predicted in the AEA prepared for the BSO EA	Potential Impacts Predicted on the Basis of Extraction Plan Layout
Aquatic habitat	Nepean River - Impacts on flow and pool depth are not expected in the Douglas Park Weir pool.	Same as for Part 3A layout. There are unlikely to be any measurable impacts on surface water level, availability or connectivity of aquatic habitats in the downstream reach of the river due to its flooded nature and very low gradient. In the upstream reach, any fracturing that occurs is expected to be isolated and minor in nature, so the potential for impacts on surface flow is limited. In the downstream reach, subsidence and upsidence may result in small changes in the levels of the river bed and banks. This could lead to minor increases and decreases, respectively in the availability of aquatic habitat, but may be difficult to detect. Dilation of the bedrock in the base of the river could result in a one-off minor decrease in water volume and availability of aquatic habitat.
	Some fracturing of bed rock is expected, as well as mobilisation of iron and other minerals and transient gas emissions in the weir pool.	There is a low probability of minor, localised fractures of the river bed occurring. The fractures would be filled by water and/or sediment. The likelihood of any diversion of surface flows and loss of aquatic habitat is consequently very low. Isolated, transient gas emissions may occur. If these lead to a substantial reduction in dissolved oxygen levels, there could be a short-term decrease in quality of aquatic habitat. Minor localised iron staining may occur, but is unlikely to lead to changes in water quality and should not therefore affect the quality of aquatic habitat. Significant changes in the levels of ponding, flooding or scouring of the river banks and stream alignment are not expected in either reach. There is consequently not expected to be any detectable impacts on the longitudinal connectivity of aquatic habitats.

Aquatic habitat	Harris Creek and Tributary no. 1 of the Nepean River - Potential impacts include isolated incidents of iron staining, short-term spikes in water quality parameters such as iron, gas emissions, reduced pool levels in dry weather and localised underflow and a reduction in the frequency and persistence of inter-pool flow. If diversion of surface water occurs, drainage of pools may result in a temporary loss of small areas of aquatic habitat.	The incidence of fracturing is expected to be low and unlikely to result in significant loss in surface water flows. Diversion of water into sub-surface layers during low flow periods could result in changes in quality and quantity of water. This is unlikely to have a detectable effect on the availability of aquatic habitats. Minor, localised increases in ponding, flooding or scouring may occur. These would have minimal impacts on the availability and quality of aquatic habitats.
Riparian vegetation	Changes in the level of water in streams and gas emissions are unlikely to disturb riparian vegetation to the extent that its ecological role would be significantly adversely impacted.	A small increase in the level of the bank or bed of the Nepean River could reduce the wetted perimeter and lead to desiccation of some of the riparian vegetation along the edge of the river. This may lead to minor changes in the composition and extent of the vegetation. Substantial localised gas emissions could result in localised die-back of riparian vegetation. Such impacts are considered unlikely and would be transient. Localised, minor fracturing of bedrock and cracking of surface soils along the river banks could have a minor, localised impact on riparian vegetation.
Aquatic macrophytes	Nepean River - No detectable changes in composition or distribution.	A small increase in the level of the bank or bed of the Nepean River could reduce the wetted perimeter and lead to stranding and desiccation of aquatic vegetation along the edge of the river. This may lead to minor changes in the composition and extent of macrophyte beds, but these are unlikely to be detected, because of the natural variability of these beds.
	Harris Creek - Reduced water levels in the downstream reach could lead to exposure and desiccation of macrophytes. These impacts would be short-term and localised and would not persist once water levels are restored.	Impacts on the aquatic flora that may inhabit these ephemeral watercourses are unlikely to be detectable, because of the large variability in natural flows.
Aquatic macroinvertebrates	Nepean River - Potential impacts would be similar in scale to those observed during mining of Appin Area 7 (i.e. none). Impacts on the western side of the Nepean River would be hard to detect, because of the degraded nature of the existing aquatic habitat.	In the Nepean River, minor changes in riparian and aquatic vegetation could lead to the loss of edge habitat and reduction in the abundance of aquatic macroinvertebrates living therein. Losses would be negligible relative to the amount of habitat available within the downstream reach of the river.

	Harris Creek - If diversion of surface water leads to temporary loss of small areas of pool habitat, macroinvertebrates dependent upon this habitat that are unable to relocate to other aquatic habitat are likely to perish as a result of dessication and/or predation. Drainage of pools after river bed or rock bar fracturing may prevent downstream drift of macroinvertebrates. If effects are isolated, macroinvertebrates in remaining pools could facilitate re-colonisation of impacted pools when water levels return. Significant adverse impacts are unlikely given that changes in water quality are expected to be short-lived and localised and macroinvertebrates should recover quickly once water levels return.	Impacts on the aquatic macroinvertebrates that may periodically inhabit these ephemeral watercourses due to diversion of flows are unlikely to be detectable, because of the large variability in natural flows. Minor, localised changes in ponding, flooding or scouring would have minimal impacts on aquatic macroinvertebrates that periodically inhabit this watercourse.
Fish	Nepean River - Potential impacts would be similar in scale to those observed during mining of Appin Area 7 (i.e. none). Reductions in dissolved oxygen associated with gas emissions are likely to be short-lived and localised and unlikely to have a significant effect, because fish populations are highly mobile.	Same as for Part 3A layout.
	Harris Creek and tributaries – If fracturing of bedrock leads to loss of habitat, a few species (e.g. eels) may be able to relocate to nearby pools, but most would perish due to desiccation and/or predation. As losses would be restricted to small, localised areas of habitat, this is unlikely to have a significant effect on fish assemblages within the Study Area.	Same as for Part 3A layout
Threatened Species	Macquarie perch - It is highly unlikely that a viable population is present in this section of the Nepean River, because of a lack of suitable habitat (including natural riffle habitat required for spawning and numerous barriers to fish passage from downstream.	Same as for Part 3A layout, however, it should be noted potential spawning habitat does occur in the upstream reach of the river.

4 Management of Potential Impacts on Aquatic Ecology

Four approaches would be used to manage potential impacts on aquatic ecology within the Appin Area 9 Study Area:

- Impact minimisation;
- Aquatic ecology monitoring;
- Additional aquatic ecology studies that would be triggered by specific impacts on physico-chemical characteristics of the watercourses.
- Contingent measures should impacts exceed predictions.

4.1 Impact Minimisation

The potential impacts of the extraction of Longwalls 901-904 on aquatic habitats and biota in the Nepean River would be minimised by:

- Adopting a mine layout that does not involve undermining of the river and setting the nearest longwall (901) at least 125 m back from the bank of the Nepean River; and
- Identifying triggers that would prompt surveys to assess any impacts on aquatic habitats and their biota identified during and after extraction of the longwalls.

4.2 Monitoring

An aquatic ecology monitoring program would be implemented to:

- Determine the nature and extent of any subsidence-induced impacts on aquatic ecology; and
- Assess the response of aquatic ecosystems to any stream remediation and management works implemented.

4.2.1 Objective

The objective of the aquatic ecology monitoring plan is to measure changes in the aquatic habitats and biota that may arise during or following the extraction of Longwalls 901-904 or as a result of any remediation works undertaken. In order to better understand and adequately assess the potential effects of subsidence on aquatic substrata and water quality and consequent changes in the ecology of the Nepean River, a baseline condition would be established two years prior to mining, in accordance with the recommendations in the "Southern Coalfields Strategic Review" (NSW DoP 2008). Aquatic biota would be monitored and relevant water quality variables measured at appropriate spatial and temporal scales, so that changes in aquatic habitats and biota resulting from extraction of longwalls and any remediation works can be distinguished from natural variability.

4.2.2 Study Sites and Frequency of Monitoring

Potential monitoring sites on the Nepean River for ongoing monitoring of aquatic ecology, including macrophyte mapping, AUSRIVAS macroinvertebrate and fish sampling, were

identified during site inspections undertaken by Cardno Ecology Lab on 16 September 2008 and 4 May 2010 (Figure 1). A set of paired monitoring sites would be established within the reach of the Nepean River included within the Study Area (Sites X3 and X4), with another pair upstream of the Study Area (Sites X5 and X6). A further site inspection is necessary to identify a second control location that has comparable geomorphology and hydrology to that of Sites X3 and X4 (i.e. an area with large pools interspersed by boulders and riffles that experiences moderate flows). The existing Appin Area 7 sites 1 and 2 downstream of the Study Area that are situated in the pool upstream of Douglas Park Weir would also be included in this monitoring program.

The suitability of aquatic habitats within the smaller watercourses traversing the Study Area was assessed on 15-16 September 2008. This assessment indicated that permanent aquatic habitat was limited in these watercourses and not suitable for monitoring.

Sampling would be conducted a minimum of two times in the two years prior to the commencement of mining in order to establish a baseline condition and once every two years during and after mining to detect any changes to the aquatic environment and its biota that could be attributed to mining activities.

4.2.3 Indicators

The following indicators of aquatic ecology would be monitored at each site:

- *In situ* water quality
- Aquatic macrophytes
- Aquatic macroinvertebrates
- Fish

4.2.4 Monitoring Methodology

4.2.4.1 Water Quality

At each site, two replicate measurements of dissolved oxygen (DO), electrical conductivity (EC), oxidation-reduction potential (ORP), pH, temperature and turbidity of the water would be taken from just below the surface of the water using a Yeo-Kal 611 probe. In the Nepean River Douglas Park Weir backwater, measurements would also be taken in deep holes so that stratification of the water column could be assessed. These measurements would be used to assist with interpretation of spatial patterns in aquatic biota, which would be sampled at the same time. Visual observations of any iron staining within the watercourse would also be noted when describing the instream habitat encountered at each site.

The EC, DO, pH and turbidity measures of the water at the surface and bottom of each site would be compared with the ANZECC (2000) default trigger values for slightly disturbed lowland rivers. Specific guidelines are not available for temperature and ORP measures.

4.2.4.2 Aquatic Macrophytes

Prior to mining, the beds of submerged macrophytes that occur at each study site would be mapped with a Differential Global Positioning System (DGPS) and Hondex PS-7 depth gauge. In navigable sections of the river a small boat would be used to motor around the edge of the macrophyte beds and collect GPS coordinates (northings and eastings in WGS 84 datum) every

1-3 m. In other areas mapping would be undertaken on foot. A viewing scope and rake would be used to assist in species identification.

The DGPS coordinates of each of the patches of macrophytes recorded in the field would be plotted on a base map of the Nepean River using GIS software. These data would be used to map the distribution of macrophytes in the various sites/reaches examined. The base map would be extracted from an ortho-rectified, geo-referenced aerial photograph of Nepean River supplied by BHPBIC.

As the distribution and abundance of aquatic macrophytes in the Nepean River is naturally variable, this component is unlikely to be a good indicator of impacts associated with mining. It is therefore recommended that mapping only be repeated if physical impacts are identified.

4.2.4.3 Aquatic Macroinvertebrates

At each site, samples of aquatic macroinvertebrates associated with the pool edge habitat would be collected by using dip nets (250 µm mesh) to agitate and scoop up material from vegetated areas of the river bank. Additional samples would be collected from riffle habitat, providing this habitat is represented at all monitoring sites. Riffle habitat would be sampled by placing the dip net immediately downstream of the collector's feet and vigorously agitating the substratum while slowly shuffling upstream. Samples would be collected over a period of 3-5 mins from a 10 m length of habitat along the river, in accordance with the AUSRIVAS Rapid Assessment Method (RAM) (Turak *et al.* 2004). If the required habitat was discontinuous, patches of habitats with a total length of 10 m would be sampled. Each RAM sample would be rinsed from the net onto a white sorting tray from which animals are picked using forceps and pipettes. Each tray would be picked for a minimum period of forty minutes, after which they would be picked at ten minute intervals for either a total of one hour or until no new specimens are found.

In accordance with the AUSRIVAS protocol, RAM samples would be sorted under a binocular microscope (at 40 X magnification), macroinvertebrates identified to family level and up to ten animals of any one taxon counted (Turak and Waddell 2001). A randomly chosen 10% of the RAM sample identifications would be checked by a second experienced scientist to validate macroinvertebrate identifications.

Data would be analysed using the spring AUSRIVAS predictive models for the edge habitat (Turak and Waddell 2001). AUSRIVAS models generate the following indices:

OE50Taxa Score - This is the ratio of the number of macroinvertebrate families with a greater than 50% predicted probability of occurrence that were actually observed (i.e. collected) at a site to the number of macroinvertebrate families expected with a greater than 50 % probability of occurrence. OE50 taxa values range from 0 to 1 and provide a measure of the impairment of macroinvertebrate assemblages at each site, with values close to 0 indicating an impoverished assemblage and values close to 1 indicating that the condition of the assemblage is similar to that of the reference streams.

Overall Bands - These indicate the level of impairment of the assemblage and are derived from OE50Taxa scores. These bands are graded as follows:

Band X = Richer invertebrate assemblage than reference condition.

Band A = Equivalent to reference condition.

Band B = Sites below reference condition (i.e. significantly impaired).

Band C = Sites well below reference condition (i.e. severely impaired).

Band D = Impoverished.

The revised SIGNAL2 biotic index (Stream Invertebrate Grade Number Average Level) developed by Chessman (2003) would also be used to determine the environmental quality of sites on the basis of the presence or absence of families of macroinvertebrates. This method assigns grade numbers to each macroinvertebrate family or taxa found, based largely on their responses to chemical pollutants. The sum of all grade numbers for that habitat is then divided by the total number of families recorded in each habitat to calculate the SIGNAL2 index. The SIGNAL2 index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site. SIGNAL2 values greater than 6, between 5 and 6, 4 and 5 and less than 4 indicate that the quality of the water is clean, doubtful, mildly, moderately or severely degraded, respectively.

4.2.4.4 Fish

A combination of backpack electrofishing and bait traps would be used to sample fish occurring at the monitoring sites. Backpack electrofishing, a non-destructive technique that is restricted to depths of approximately 1 m (hip height) and water bodies with low to moderate salinity, would be used to sample fish occurring in shallow sections of the river. The operator of the electrofisher would stun fish by discharging electric pulses into the water enabling them to be captured by an assistant equipped with a dip net. Electrofishing would be conducted in riffles, shallow pools and beneath overhanging banks and vegetation along standardised 50 m lengths of river bank or for a set time interval.

At each site, eight baited traps would be deployed amongst macrophytes, snags and adjacent to edge habitat, where available. The traps used would be 350 mm long, 200 mm wide with an entrance that tapered in to 45 mm, with 3 mm mesh size throughout. Traps would be baited with 70 ml of a mixture of chicken pellets and sardines. Traps would be deployed in the afternoon and retrieved the next morning. The fish caught would be identified and then released.

4.3 Additional Aquatic Ecology Studies

Additional aquatic ecology studies would be triggered by events such as significant changes in water quality and availability of aquatic habitats. Trigger values for aquatic ecology monitoring parameters are outlined in Table 5. These values may be revised in consultation with relevant stakeholders following analysis of natural variability within the pre-mining baseline data. Each trigger value corresponds to either a negligible or significant impact on the aquatic habitat and/or biota within the Extraction Plan Area and management actions are presented if thresholds are exceeded.

4.4 Contingent Measures

In the event that the impacts of the extraction of Longwalls 901-904 on aquatic habitats and biota in the Nepean River are greater than predicted the following contingent measures would be implemented:

- Reviewing the mine layout and the appropriate offset distances from the Nepean River;

- Implementing stream remediation measures, such as backfilling or grouting, in areas where fracturing of controlling rock bars and/or the stream bed leads to diversion of stream flow and drainage of pools; and
- Implementing appropriate control measures, such as installation of sediment fences down slope of areas where subsidence has led to erosion and stabilisation of areas prone to erosion and soil slumping using rock, brush matting or vegetation, to limit the potential for deposition of eroded sediment into the Nepean River.
- If these management strategies prove ineffectual, appropriate offset and compensatory measures would be implemented.

Table 5: Trigger values for aquatic ecology monitoring and management actions if thresholds are exceeded.

Monitoring				Management			
Sites (Fig 1)	**Parameters**	**Frequency**	**Purpose**	**Trigger (at impact sites only)**	**Action**	Responsibility	Purpose
•Sites 1 and 2 located in the Nepean River downstream of the Study Area •Sites X3 and X4 located in the Nepean River adjacent to Longwalls 901 and 902 and within the Extraction Plan Area. • Sites X5 and X6 located in the Nepean River Upstream of the Extraction Plan Area. • Sites X7 and X8 to be identified	• Habitat Surveys • Photographic records • Aquatic Macrophyte Mapping • Macroinvertebrate Monitoring • Fish Sampling • *In Situ* Water Quality Measurements • Monitored in conjunction with: – Flow – River Morphology	• Prior to mining yearly for 2 years • During mining every 2nd year • Yearly for 2 years post mining	• To provide pre-mining baseline aquatic ecology survey data for comparison with during and pos-mining data. • Identify any impacts on aquatic habitat and biota that can be attributed to mining activity	**Negligible** • Negligible reduction in aquatic habitat observed during BHPB IC Nepean River monitoring. These may be revised in consultation with key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Capture photographic record immediately, if visible. • Continue with approved monitoring program • Report annually with Annual Environmental Management Reporting (AEMR).	• Manager Environment (BHPB IC)	• Identify, investigate and report on impacts to aquatic ecology. • Investigate any mitigation measures required and implement in consultation with key agencies. • Keep stakeholders and agencies informed of any impacts, investigations or results.
				Minor • Minor reduction in aquatic habitat (i.e. desiccation of macrophyte beds as compared to baseline assessment or control site) as resulting from mining. • Reduction in macroinvertebrate AUSRIVAS Band Score resulting from mining (>2 Band Score difference as compared to baseline assessment or control site). • Threatened species detected in the area and mining impacts occur or identified mortality of a threatened species.	• Capture photographic record. • Notify relevant stakeholders within 24 hours. • Notify relevant agencies and specialists within 24 hours. • Contract specialists within 1 week to investigate and report on changes identified. • Collect water quality samples within 2 weeks. • Collect water quality samples within 2 weeks. • Conduct targeted fish and aquatic invertebrate sampling within 2 weeks. • Review monitoring program within 1 month. • Implement additional monitoring or increase frequency if required within 1 month. • Monthly updates from specialists on investigation process.	• Manager Environment (BHPB IC) • Expert Aquatic Ecology Consultants	

				These may be revised in consultation with NSW I&I and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Inform relevant stakeholders and agencies of results of investigation within 1 week of completion. • Develop site CMA in consultation with key stakeholders if required within 1 month (pending stakeholder availability) and seek approvals. • Watercourses of 3rd order or above subject to subsidence impacts restored to pre-mining surface flow and pool holding capacity as soon as reasonably practicable. • Implement CMA as agreed with stakeholders following approvals. • Conduct initial follow up monitoring and reporting within 2 months of CMA completion. • Report within AEMR.		

5 Acknowledgements

This assessment was prepared by Dr Theresa Dye and Matt Harper and reviewed by Dr Arthur Dye and Gary Brassington of BHPBIC.

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7 Figures

Figure 1: Aerial photo of the study area showing proposed aquatic ecology monitoring sites in the Nepean River relative to Appin Area 9 Longwalls 901 to 904.

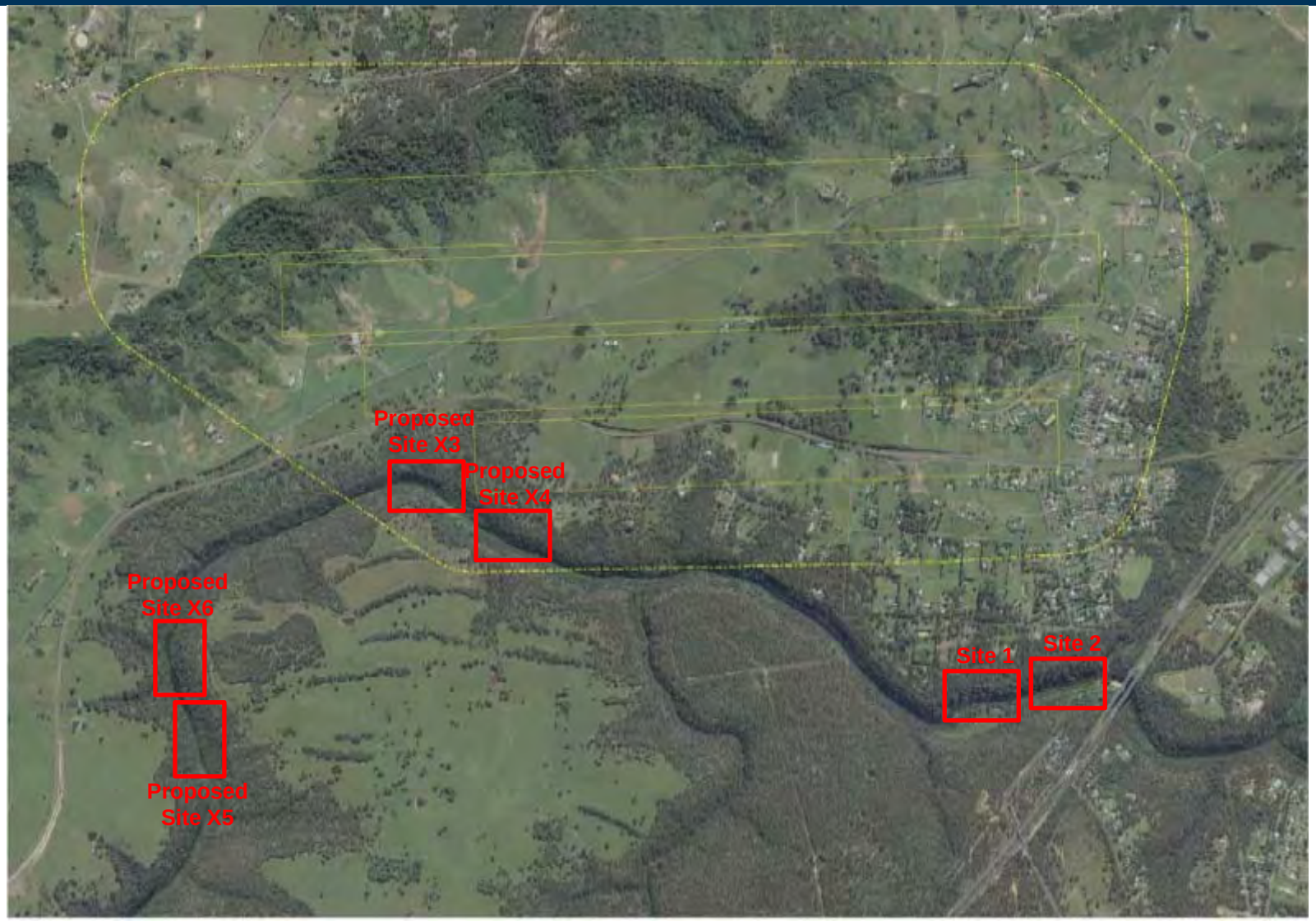

Figure 1: Aerial photo of the study area showing proposed aquatic ecology monitoring sites in the Nepean River relative to Appin Area 9 Longwalls 901 to 904.

8 Appendices

Appendix 1: GPS co-ordinates and mean (± S.E.) measurements of water quality parameters recorded at various sites on the two reaches of the Nepean River within the Study Area during the site inspection undertaken on 16 August 2008.

Appendix 2: Aquatic macrophyte taxa recorded in the upper reaches of the Nepean River adjacent to Appin Areas 7 and 9.

Appendix 3: Aquatic macroinvertebrate taxa recorded in the upper reaches of the Nepean River adjacent to Appin Areas 7 and 9.

Appendix 4: Total number of aquatic macroinvertebrates, OE50 taxa scores and AUSRIVAS bands for the six sites on the Nepean River that form part of the Appin Area 7 Monitoring Program

Appendix 5: Species of fish recorded in the upper reaches of the Nepean River adjacent to Appin Areas 7 and 9.

Appendix 1: GPS co-ordinates (WGS 84 Zone 56) and mean (± S.E.) measurements of water quality parameters recorded at various sites on the two reaches of the Nepean River within the Study Area during the site inspection undertaken on 16 August 2008. Values in bold are outside the ANZECC/ARMCANZ (2000) guidelines for slightly disturbed lowland rivers in south-east Australia.

Site	Location	Northing	Easting	Temperature C		Conductivity µ		pH		ORP		DO (%)		Turbidity	
				Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
151	Upstream reach	286309	6214974	13.46	0.01	493.00	0.00	**8.64**	0.00	359.50	0.50	83.15	0.25	**2.53**	0.07
153	Upstream reach	286021	6215054	13.73	0	479.00	0.00	**8.70**	0.00	345.00	1.00	86.30	0.00	**2.22**	0.03
155	Upstream reach	286806	6214700	13.57	0.01	491.50	0.50	**8.63**	0.01	365.50	0.50	78.95	0.05	**2.42**	0.07
156 - 5 m depth	Downstream of confluence with Allens Creek	287129	6214667	13.97	0.04	510.00	1.00	**8.68**	0.00	377.50	0.50	82.70	0.90	**3.18**	0.07
156 - 1.7 m depth				13.83	0.00	505.00	0.00	**8.66**	0.00	382.50	0.50	83.10	0.00	**2.83**	0.14
158	Douglas Park Weir	289072	6214220	13.75	0.00	553.00	0.00	**8.78**	0.00	394.50	0.50	100.35	0.15	**4.18**	0.02

Appendix 2: Aquatic macrophyte taxa recorded in the upper reaches of the Nepean River adjacent to Appin Areas 7 and 9. (Shading indicates species recorded in the reach adjacent to the Appin Area 9 Study Area). Note that *Elodea canadensis* was misidentified as *Egeria/Hydrilla* in The Ecology Lab (2004 and 2006).

Taxon	The Ecology Lab (2004)	The Ecology Lab (2006)	Bioanalysis (2009) - NP1	Bioanalysis (2009) - NP2	Cardno Ecology Lab (2009)	Cardno Ecology Lab (2011)
Ageratina riparia				X		
Carex fascicularis			X			
Cynodon dactylon				X		
Cyperus eragrostis			X			
Elodea canadensis	X		X		X	X
Gahnia sp.				X		
Gleichenia dicarpa				X		
Hemarthria uncinata				X		
Hydrilla verticillata			X			X
Isolepis cernua				X		
Juncus prismatocarpus				X		
Juncus sarophorus			X	X		
Juncus subsecundus			X			
Lomandra fluviatilis				X		
Lomandra longifolia			X	X		
Nasturtium officinale				X		
Paspalum distichum			X			
Persicaria decipiens			X			
Potamogeton crispus					X	
Potamogeton ochreatus	X	X			X	X
Potamogeton sulcatus	X	X		X	X	X
Triglochin microtuberosum				X		
Triglochin procerum			X			
Vallisneria sp.		X			X	

Appendix 3: Aquatic macroinvertebrate taxa recorded in the upper reaches of the Nepean River adjacent to Appin Areas 7 and 9. (Shading indicates species recorded in the reach adjacent to the Appin Area 9 Study Area)

Taxon	The Ecology Lab (2004)	Cardno Ecology Lab (2009)	Bioanalysis (2009) - NP1	Bioanalysis (2009) - NP2	Cardno Ecology Lab (2011)
Acarina	X				
Aeshnidae					X
Aphididae					X
Araneae		X		X	X
Atyidae	X	X	X	X	X
Baetidae	X	X	X		X
Caenidae	X	X	X	X	
Calamoceratidae	X	X	X		X
Ceinidae			X		
Ceratopogonidae	X	X			X
Chironominae	X	X	X	X	X
Chrysomelidae			X		
Cladocera		X			X
Coenagrionidae	X	X	X		X
Collembola				X	
Copepoda		X			X
Corbiculidae/ Sphaeriidae		X			X
Cordulephyidae		X			
Corixidae	X	X	X	X	X
Corydalidae		X			
Culicidae		X			X
Cyclopoida			X		
Dolichopodidae					X
Dugesiidae	X	X			X
Dytiscidae	X	X	X	X	X
Ecnomidae		X			
Elmidae		X			X
Empididae		X			
Entomobryidae		X			X
Gelastocoridae		X			X
Gerridae					X
Glossiphoniidae	X	X			X
Gomphidae	X	X			X
Gripopterygiidae		X			
Gyrinidae	X				
Haliplidae		X			X
Hemicorduliidae		X			X
Hirudinea			X		X
Hydracarina		X			X
Hydraenidae		X	X		
Hydridae		X			
Hydrometridae		X			X
Hydrophilidae	X	X	X	X	X
Hydroptilidae		X			X
Hypogastruridae		X			X
Isotictidae	X	X			
Leptoceridae	X	X	X	X	X
Leptophlebiidae	X	X			X
Libellulidae		X	X	X	
Lymnaeidae	X	X			X
Megapodagrionidae				X	
Mesoveliidae		X	X	X	X
Naucoridae		X			X
Nematoda				X	
Nemertea	X				X
Nepidae		X			X
Notonectidae		X			X
Oligochaeta	X	X			X
Oniscidae					X
Orthocladinae	X	X			X
Ostracoda		X			X
Physidae	X	X			X
Planorbidae	X	X			X
Pleidae		X	X		X
Protoneuridae		X	X		X
Pyralidae	X	X	X		X
Scirtidae	X	X	X		X
Sialidae	X				X
Sphaeriidae	X				
Stratiomyidae		X			
Tanypodinae	X	X	X		X
Telephlebiidae		X			X
Tipulidae		X			
Tricladida			X		
Turbellaria	X				
Veliidae		X	X		X

Appendix 4: Total number of aquatic macroinvertebrates, OE50 taxa scores and AUSRIVAS bands for the six sites on the Nepean River that form part of the Appin Area 7 Monitoring Program (Shading indicates sites in the reach adjacent to the Appin Area 9 Study Area) (The Ecology Lab 2004; Cardno Ecology Lab 2009 and 2011).

Survey	Indicator	Site					
		1	2	3	4	5	6
September 2003	No. of taxa	13	14	15	16	14	13
	OE50 taxa score	0.52	0.58	0.64	0.58	0.52	0.58
	AUSRIVAS band	B	B	B	B	B	B
November 2008	No. of taxa	32	30	32	32	25	27
	OE50 taxa score	1.05	0.87	0.99	0.93	0.64	0.76
	AUSRIVAS band	A	A	A	A	B	B
December 2010	No. of taxa	30	27	25	31	25	15
	OE50 taxa score	0.93	0.99	0.82	0.76	0.81	0.47
	AUSRIVAS band	A	A	B	B	B	C

Appendix 5: Species of fish recorded in the upper reaches of the Nepean River adjacent to Appin Areas 7 and 9. (Shading indicates species recorded in the reach adjacent to the Appin Area 9 Study Area)

Species name	Common name	Bionet (2008)	The Ecology Lab (2004)	Baumgartner and Reynoldson (2007)	The Ecology Lab (2006)	Bioanalysis (2009) - NP1	Bioanalysis (2009) - NP2	Cardno Ecology Lab (2009)	Cardno Ecology Lab (2011)
Fish									
Anguilla reinhardtii	Longfinned eel	X		X					
Potamalosa richmondia	Freshwater herring	X							
Retropinna semoni	Australian smelt	X	X		X	X	X		
*Cyprinus carpio**	Carp	X		X					
*Carassius auratus**	Goldfish	X		X					
Tandanus tandanus	Freshwater catfish	X							
*Gambusia holbrooki**	Eastern gambusia	X		X		X	X	X	X
Macquaria australasica#	Macquarie perch	X							
Macquaria novemaculata	Australian bass	X		X		X			
Gobiomorphus coxii	Cox's gudgeon	X		X					
Hypseleotris galii	Firetailed gudgeon	X	X	X				X	X
Gobiomorphus australis	Striped gudgeon	X				X			
Philypnodon grandiceps	Flathead gudgeon	X	X	X	X	X	X	X	X
Philypnodon sp.	Dwarf flathead gudgeon		X		X	X	X	X	X
Hypseleotris compressa	Empire Gudgeon							X	
Mugil cephalus	Flathead Mullet	X							
Crustaceans									
Paratya sp	Glass shrimp								X
Macrobrachium sp.	Freshwater shrimp								X

Attachment B – Appin Area 9 Longwalls 901 to 904 Biodiversity Impact Assessment (Biosis, 2012)

BIOSIS
RESEARCH

Appin Area 9
Longwalls 901-904
Biodiversity Impact Assessment

Final Report

May 2012

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DOCUMENT CONTROL SHEET

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ABBREVIATIONS AND COMMON TERMS

BHPBIC	BHP Billiton Illawarra Coal
Biodiversity	The variety of biological life (plants and animals)
BIA	Biodiversity Impact Assessment
BSO	Bulli Seam Operations
CAMBA	*China-Australia Migratory Bird Agreement*
CEEC	Critically Endangered Ecological Community
CPW	Cumberland Plain Woodland
DECCW	Department of Environment, Climate Change ad Water (now DPC – OEH)
DPC – OEH	Department of Premier and Cabinet – Office of Environment and Heritage (formerly NSW Department of Environment, Climate Change and Water)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (formerly Department of the Environment, Water Heritage and the Arts)
EA	Environmental Assessment
EEC	Endangered Ecological Community
EP&A Act	*Environmental Planning and Assessment Act* 1979
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
EPI	Environmental Planning Instrument
I&I NSW	Industry and Investment NSW
JAMBA	*Japan-Australia Migratory Bird Agreement*
LEP	Local Environmental Plan
LGA	Local Government Area
Locality	10 km radius of Study Area
Mesic	Relating to, or adapted to a moderately moist habitat
MSEC	Mine Subsidence Engineering Consultants

MSW	Moist Shale Woodland
NSW	New South Wales
NPWS	NSW National Parks and Wildlife Service (now part of the DPC-OEH)
PMST	Protected Matters Search Tool (DSEWPaC database)
RBIA	Revised Biodiversity Impact Assessment
ROKAMBA	*Republic of Korea-Australia Migratory Bird Agreement*
RS	Riparian Scrub
SEPP	State Environmental Planning Policy
SoE	State of Environment
SSTF	Shale Sandstone Transition Forest
Study Area	The surface area that could be potentially affected by vertical subsidence and is inclusive of sensitive structures where additional subsidence effects may occur as a result of the extraction of coal from Longwall 901 to 904 (Figure 2).
TEC	Threatened Ecological Community
Threatened Species	Species listed on the threatened species schedules of the TSC or EPBC Acts.
TSC Act	*Threatened Species Conservation Act* 1995
Resilience	Refers to the manifested recovery of a plant community, species or ecosystem following disturbance, as well as the potential of the plant community, species or ecosystem to recover after disturbance (Department of Infrastructure 2003; McDonald 1996).
ROTAP	Rare or Threatened Australian Plants (Briggs and Leigh 1995)
SCA	Sydney Catchment Authority
sp.	species (singular)
spp.	species (plural)
ssp.	subspecies
var.	variety
WSDR	Western Sydney Dry Rainforest
WSGF	Western Sydney Gully Forest

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1.0 INTRODUCTION

BHP Billiton Illawarra Coal (BHPBIC) commissioned Biosis Research to prepare a Biodiversity Impact Assessment (BIA) to inform the Biodiversity Management Plan (BMP) component of the Appin Area 9, Longwalls 901 to 904, Extraction Plan.

1.1 Project Background

BHPBIC owns and operates the Appin Colliery. The Appin Colliery is located in the Southern Coalfields of New South Wales (NSW), approximately 25 km west of Wollongong, in the Wollondilly Local Government Area (LGA) (Figure 1). The Appin Colliery uses longwall mining techniques to extract premium quality, hard coking coal (used for steel production) and some energy coal from the Bulli Seam.

In 2009 BHPBIC sought approval under Part 3A of the *Environmental Planning and Assessment Act* 1979 (EP&A Act) to expand its underground coal mining operations at the Appin Colliery to extract coal in Areas 5, 7, 8, and 9. Collectively this area is known as the Bulli Seam Operations (BSO).

On 22nd December 2011 the Minister for Planning approved the BSO Project. This approval will allow BHPBIC to continue mining operations for a further 30 years. BHPBIC is now seeking Extraction Approval for Longwalls 901 to 904 in Appin Area 9, which is located to the west of the currently active longwall mining operations in Appin Area 7.

The Study Area for the BIA is defined as the surface area that could potentially be affected by vertical subsidence movements as well as any sensitive features where additional subsidence effects may occur as a result of the extraction of coal from Longwalls 901 to 904 (Figure 2). This includes the 35 degree angle of draw line from the proposed extents of Longwalls 901 to 904 and the predicted limit of vertical subsidence (MSEC 2012). The topography and natural surface features of this area are shown in Figure 3.

An assessment of the impacts of subsidence on terrestrial ecological values in accordance with the EP&A Act and *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) was completed for the BSO Project Part 3A Environmental Assessment (EA) (BHPBIC 2009) . The Part 3A EA was conducted on a longwall layout different to that referred to in this report and the Extraction Plan for Longwalls 901 to 904, as the layout was modified to achieve the following two objectives:

- Setback from the Nepean River and the cliffs within the valley to minimise potential impacts on these sensitive structures; and,
- Minimisation of the volume of sterilised coal which could be efficiently extracted within the mining and environmental constraints of the area.

1.2 Objectives

The objectives of this report are to:

- Outline the biodiversity values present within the Study Area using data collected during the initial EA, as well as supplementary data collected by Biosis Research;
- Identify potential impacts to these biodiversity values resulting from subsidence predictions contained within MSEC (2012);
- Determine if the predicted impacts to biodiversity values differ from those contained within the BSO EA (BHPBIC 2009);
- Provide recommendations to avoid, minimise and mitigate impacts to identified biodiversity values; and,
- Report on residual impacts to biodiversity values and ensure they are consistent with the Conditions of Approval for the BSO (see Section 2.2).

This BIA will be used to devise the biodiversity management recommendations contained within the Appin Area 9 Extraction Plan.

1.3 Statutory Requirements

The statutory obligations with regard to Appin Area 9 are contained in:

- The Conditions of Project Approval for the Bulli Seam Operations Project; and
- Relevant biodiversity legislation, including:
    - *Threatened Species Conservation Act 1995* (TSC Act); and,
    - *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The relevant Conditions of Project Approval are outlined in Section 2.2.

2.0 MINE SUBSIDENCE PREDICTIONS AND BIODIVERSITY PERFORMANCE MEASURES FOR APPIN AREA 9

2.1 Predicted Impacts to Natural Surface Features for Longwalls 901 to 904

Subsidence predictions for Longwalls 901 to 904 are contained within MSEC (2012). A brief summary of these predictions is provided in Table 1 below.

Table 1: Predicted impacts to natural surface features as a result of subsidence for Longwalls 901 to 904 (MSEC 2012)

Natural Surface Feature	Predicted Impacts Due to Subsidence
Nepean River	○ Minor and isolated fracturing of the streambed; ○ Low to negligible potential for diversion of surface water flows; ○ Gas emissions likely to occur; and, ○ Localised iron staining resulting in potential changes to water quality.
Drainage Lines	○ Changes in grade of drainage lines are considered small in comparison to natural grades. This is unlikely to result in significant increases in ponding, flooding or scouring, although some very localised impact may occur; and, ○ Fracturing of uppermost bedrock in drainage lines located directly above longwalls. Where the creek bed consists of alluvial deposits fractures will be filled over time. Where the creek bed consists of bedrock diversion of surface water flows may occur during low flow events. These flows will be forced to the surface once a fracture network is no longer available for this flow.
Cliffs	○ Possible rock falls from cliffs. Extremely low risk of cliff falls.
Rock Outcrops	○ Fracturing of a small percentage of rock outcrops in discrete locations.
Steep Slopes	○ Tension cracks at the tope of slopes due to downslope movements.

2.2 Biodiversity Performance Indicators and Measures

Performance Measures for the BSO Project Approval are outlined in Table 1 of Schedule 3, Condition 1. There is one Performance Measure relevant to biodiversity as outlined in Table 2 below.

Table 2: Subsidence Impact Performance Measures for Biodiversity

Biodiversity	
Threatened species, threatened populations, or endangered ecological communities	Negligible environmental consequences

Negligible is defined within the Project Approval as: *Small and unimportant, such as to be not worth considering.*

Appin Area 9 is known to support four Threatened Ecological Communities (TEC; see Section 3.2.2.1 and Figure 4) and known habitat for three threatened fauna species (see Section 3.2.2.4), and provides potential habitat for eight threatened flora species (see Section 3.2.2.2)

and 24 threatened fauna species (see Section 3.2.2.4). The potential impacts to terrestrial flora and fauna habitats are discussed further in Section 4.0 below.

A number of other Performance Measures are relevant to the BMP as outlined in Table 3.

Table 3: Other Relevant Subsidence Impact Performance Measures

Watercourses	
Nepean River	Negligible environmental consequences including: • negligible diversion of flows or changes in the natural drainage behaviour of pools; • negligible gas releases and iron staining; and, • negligible increases in water cloudiness.
Other watercourses	No greater subsidence impact or environmental consequences than predicted in the EA and PPR.
Land	
Cliffs of "special significance" (i.e. cliffs longer than 200 m and/or higher than 40 m; and cliff-like rock faces higher than 5 m that constitute waterfalls)	Negligible environmental consequences (that is occasional rockfalls displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 0.5% of the total face area of such cliffs within any longwall mining domain).
Other cliffs flanking the Nepean River	Negligible impact (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 0.5% of the total face area of such cliffs within any longwall mining domain).
Other cliffs	Minor impacts (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 3% of the total face area of such cliffs within any longwall mining domain).

3.0 APPIN AREA 9 BIODIVERSITY VALUES

This section reviews ecological studies that have been conducted in the Study Area to date, including:

- Part 3A Environmental Assessments, including:
    - *Bulli Seam Operations. Terrestrial Flora Assessment. Appendix E. (FloraSearch 2009);*
    - *Bulli Seam Operations. Terrestrial Fauna Assessment. Appendix F. (Biosphere 2009).*
- Additional field surveys undertaken by Biosis Research in 2010.

Terrestrial flora and fauna assessments undertaken as a part of the EA were conducted across a much broader area that encompassed the current Study Area, as well as other extraction areas, and areas designated for upgrades to surface facilities, exploration activities, gas drainage works and a variety of associated infrastructure needs and other uses. Hence, the level of survey effort conducted in the current Study Area as part of the EA is relatively limited (Figure 5).

For this reason additional surveys were undertaken by Biosis Research in 2010 to supplement work undertaken during the EA and provide a more thorough assessment of the biodiversity values present within the Study Area (see Section 3.2).

Data that was collected during these studies has been used in this section to describe the biodiversity values present within the Study Area.

3.1 Part 3A Environmental Assessment

3.1.1 Terrestrial Flora Assessment (FloraSearch 2009)

The terrestrial flora assessments by FloraSearch (2009) detailed the findings of vegetation surveys within the broader EA area, which encompassed the current Study Area above Longwalls 901 to 904. Findings relevant to the current Study Area are summarised in Table 4.

Table 4: Summary of the Findings of FloraSearch (2009)

Vegetation mapping from FloraSearch (2009; Figure 4). Naming of vegetation communities consistent with Tozer *et. al.* (2006)	Eight vegetation communities mapped within the Study Area, including: • p2 – Cumberland Shale Sandstone Transition Forest; • p6 – Burragarang – Nepean Hinterland Woodland; • p28 – Cumberland Shale Hills Woodland; • p29 – Cumberland Shale Plains Woodland; • p38 – Grey Myrtle Dry Rainforest; • p58 – Sandstone Riparian Scrub; • p142 – Hinterland Sandstone Gully Forest; and, • p514 – Cumberland Moist Shale Woodland. Remnant vegetation thinned due to grazing and in poor condition.

Endangered Ecological Communities (EEC)	Four EECs were identified within the Study Area, including: • Shale Sandstone Transition Forest (p2 above); • Cumberland Plain Woodland (p28 and p29 above); • Western Sydney Dr Rainforest in the Sydney Basin Bioregion (p38 above); and, • Moist Shale Woodland in the Sydney Basin Bioregion (p514 above).
Threatened species, and populations	No threatened species were recorded within the Study Area. *Grevillea parviflora* ssp. *parviflora* Small-flower Grevillea and *Epacris purpurascens* var. *purpurascens* were recorded nearby to the south. No threatened flora populations were documented as occurring within the Study Area.

3.1.2 Terrestrial Fauna Assessment (Biosphere 2009)

The terrestrial fauna assessments by Biosphere (2009) detailed the findings of habitat based and targeted fauna assessment utilising a variety of general and more selective techniques within the broader EA area, which encompassed the current Study Area above Longwalls 901 to 904. Findings relevant to the current Study Area are summarised in Table 5.

Table 5: Summary of the Findings of Biosphere (2009)

Major habitat types present within the Study Area (Biosphere 2009)	Two fauna habitat types documented as occurring within the Study Area, including: • Dry rainforest; and, • Riparian. Four additional fauna habitat types are documented as occurring within the greater BSO EA Study Area and are likely to occur within the current Study Area: • Open Woodland; • Gully Forest; • Cleared agricultural land; and, • Water.
Threatened species and populations	Three species were recorded within or immediately adjacent to the Study Area: • Powerful Owl *Ninox strenua*; • New Holland Mouse *Pseudomys novahollendiae; and,* • Large-footed Myotis *Myotis macropus*.

3.2 Supplementary Surveys Undertaken By Biosis Research

This section describes additional flora and fauna surveys undertaken by Biosis Research within the current Study Area. The purpose of these surveys was to provide more detailed information on the biodiversity values present, and thus provide a more detailed impact assessment and more detailed and tailored management measures. It includes searches of databases for previous records of threatened species in the Locality, as well as field surveys of the Study Area. The methodology for these surveys is outlined below.

3.2.1 Methodology

Background Research

A list of documents reviewed in the preparation of this report is provided in the *References* section. Specifically, this assessment included a review of:

- Subsidence predictions with regard to natural surface features (MSEC 2012);
- Previous flora and fauna assessments of the Study Area (FloraSearch 2009, Biosphere 2009);
- Topographic maps and aerial photographs of the Study Area;
- The broad scale regional vegetation mapping of the Cumberland Plain (NPWS 2002a); and,
- State and Commonwealth databases.

Records of threatened species, populations and ecological communities were obtained from the Office of Environment and Heritage (OEH) Atlas of NSW Wildlife within the 10 km radius of the Study Area. A list of threatened species, populations and ecological communities with potential to occur within a 10 km radius of the Study Area were obtained from the DSEWPaC Protected Matters Search Tool (PMST). Database searches were conducted in July and August 2010.

Field Surveys

Terrestrial flora and fauna habitat assessments were carried out in the Study Area on the 5th, 6th, 7th and 30th July 2010. The general condition of the Study Area was assessed and observations were made of plant communities, plant and animal species and flora and fauna habitats in areas considered most vulnerable to the predicted levels of subsidence.

Flora surveys were carried out at multiple locations in the Study Area (Figure 6) to validate the presence of native plant communities from the NPWS (2002a) mapping (Figure 4). Flora survey effort of the Study Area focused on ground-truthing existing plant community mapping, defining plant communities where these were not otherwise identified in the existing regional surveys and searches for threatened flora species. Formal survey techniques involved a combination of 20 m x 20 m quadrats, transects, random meanders and spot locations where dominant species were recorded. This report adopts the NPWS (2002a) Cumberland Plain vegetation mapping.

Fauna surveys focused on identifying and classifying the major habitat types present within the Study Area. Fauna habitats were assessed by examining the following characteristics:

- Structure and floristics of the canopy;

- Understorey and ground cover vegetation;
- Size range of hollows and fissures in trees;
- Structure and composition of the litter layer;
- Rock outcrops, overhangs and crevices;
- Disturbances, including weed invasion, clearing, rubbish dumping or fire;
- Potential foraging, nesting or roosting resources; and,
- Connectivity to off site habitats.

The following criteria were used to evaluate the values of habitat present.

Good	Good condition endemic vegetation supporting a full range of fauna habitat components are usually present (e.g. hollow bearing trees, fallen timber, feeding and roosting resources) and habitat linkages to other remnant ecosystems in the landscape are intact.
Moderate	Some fauna habitat components are missing (for example, old-growth trees and fallen timber), although linkages with other remnant habitats in the landscape are usually intact, but sometimes degraded.
Poor	Many fauna habitat elements in low quality remnants have been lost, including old growth trees (for example, due to past timber harvesting or land clearing) and fallen timber, and tree canopies are often highly fragmented. Habitat linkages with other remnant ecosystems in the landscape have usually been severely compromised by extensive clearing in the past.

The presence of fauna species in the Study Area was also determined through consideration of suitable habitats; opportunistic recordings during the course of habitat assessments through incidental sightings and aural recognition of calls; and, observing indirect evidence of species' presence, such as scats, feathers, hair, tracks, diggings, sap feeding incisions in trees and, burrows.

The likelihood of occurrence assessment for threatened flora and fauna and migratory fauna species was based on previous records collected from database searches, field surveys, the current (known) distribution of these species, and the presence and condition of suitable habitat in the Study Area. The criteria used to assess the likelihood of threatened or migratory species to occur within the Study Area is presented in Appendix 1. The likelihood of occurrence assessments for threatened flora and fauna are provided in Appendix 2.

Limitations

This report does not repeat the detailed flora and fauna impact assessments for the BSO Project EA prepared by Biosphere (2009) and FloraSearch (2009). This report reviews the predicted impacts on terrestrial biodiversity provided by those assessments in light of new knowledge provided by this study. Therefore, the limitations of the impact assessments for the BSO Project EA apply for this current assessment as they relate to the Study Area except where additional information obtained in this study supplements the impact assessments in the EA.

Terrestrial flora and fauna surveys have been carried out to inform this biodiversity assessment. The survey effort was based on the level of assessment required to collect sufficient baseline data, outline monitoring requirements and inform the preparation of management actions to address the potential for biodiversity impacts as a result of the extraction of coal from Longwalls 901 to 904.

Due to access restrictions some areas of flora and fauna habitats have not been inspected; however, a reasonable sample of the broad habitats at a landscape scale have been assessed for the preparation of this plan.

3.2.2 Results

The natural environment of the Study Area contains flora and fauna habitats which range from remnant stands of open woodland, riparian scrub in drainage lines to closed grassland and fringing aquatic vegetation around constructed dams in grazed paddocks.

Appendix 2 summarises the vegetation and fauna habitat at 13 sites surveyed during the current assessment that have been used to establish baseline (pre-mining) conditions.

Appendix 3 provides lists of flora and fauna species recorded within the Study Area during current surveys.

Appendix 4 provides a list of flora and fauna species listed on the TSC Act and/or EPBC Act and assesses the likelihood of those species occurring in the Study Area. The locations of records of these species are shown in Figure 7 and Figure 8 (flora) and Figure 9 and Figure 10 (fauna).

3.2.2.1 Vegetation communities

Nine vegetation communities are mapped by NPWS (2002a) as occurring within the Study Area (Table 6; Figure 4). Six of these communities correspond to four Endangered Ecological Communities (EECs) listed under the TSC Act, while four of these communities correspond with two Threatened Ecological Communities listed under the EPBC Act. Vegetation communities present within the Study Area and their conservation status are summarised in Table 6.

Table 6: NPWS (2002a) vegetation communities in the Study Area and their conservation status.

Cumberland Plain mapping (NPWS 2002a)	TSC Act status	EPBC Act status
Shale Sandstone Transition Forest (Low Sandstone Influence)	Shale Sandstone Transition Forest (EEC)	Shale Sandstone Transition Forest (Endangered)
Shale Sandstone Transition Forest (High Sandstone Influence)		
Shale Hills Woodland	Cumberland Plain	Cumberland Plain

Cumberland Plain mapping (NPWS 2002a)	TSC Act status	EPBC Act status
Shale Plains Woodland	Woodland (CEEC)	Shale Woodland (Critically Endangered)
Moist Shale Woodland	Moist Shale Woodland (EEC)	-
Western Sydney Dry Rainforest	Western Sydney Dry Rainforest (EEC)	-
Upper Georges River Sandstone Woodland	-	-
Western Sandstone Gully Forest	-	-
Riparian Scrub	-	-

Descriptions of the vegetation communities, including TECs present, and their distribution in the Study Area are provided in the following sub sections.

Shale Sandstone Transition Forest (SSTF)

NPWS (2002a) maps two sub-units of this vegetation community (Shale Sandstone Transition Forest – High Sandstone Influence and Low Sandstone Influence, Figure 4). The final determination for SSTF does not distinguish between the low and high sandstone influence sub-units described by Tozer (2003), and the community as listed under the TSC and EPBC Acts incorporates both subunits. This community is present as a variable band in the Study Area adjacent to the Nepean River (Figure 4). SSTF in the Study Area, closer to the Nepean River, includes stands of the community that are currently subject to disturbance from grazing and other areas that are fully structured and highly resilient. There are several patches of the community on the elevated plain above the Nepean River characterised by open canopy with understorey sparse or absent as a result of grazing.

Flora survey was undertaken at seven sites within SSTF (sites 5, 6, 7, 8, 10, 11 and 12; Figure 6, Appendix 2).

Cumberland Plain Woodland (CPW)

Cumberland Plain Woodland (CPW) incorporating Shale Plains Woodland (SPW) and Shale Hills Woodland (SHW) is listed as a Critically Endangered Ecological Community (CEEC) under both the TSC and EPBC Acts. This community is present on the low hills in the eastern portion of the Study Area and in places on Razorback Range (Figure 4).

The NSW Scientific Committee (2009a) states that less disturbed stands of CPW may have a woodland or forest structure that is characterised by an open tree canopy, sometimes with layers of shrubs and/or small trees and a near-continuous groundcover dominated by grasses

and herbs. Shrubs may sometimes occur in locally dense stands. Small trees or saplings can dominate the community in relatively high densities after partial or total clearing, and the groundcover may be relatively sparse, especially where densities of trees or shrubs are high. Further, the NSW Scientific Committee (2009a) has determined that the community also includes 'derived' native grasslands which result from removal of the woody strata from the woodlands and forests.

Areas mapped as CPW by NPWS (2002a) and inspected during the current surveys are in a degraded condition and occur as stands of characteristic canopy species with a degraded understorey dominated by woody weeds and disturbed groundcover stratums.

No additional flora survey was required within CPW for this assessment as these areas are unlikely to be affected by subsidence.

Moist Shale Woodland (MSW)

Moist Shale Woodland (MSW) is described by NPWS (2002c) as being restricted to rugged areas at higher elevations in the southern half of the Cumberland Plain. This community appears to represent the endpoint of the gradient in increasing elevation, rainfall and ruggedness from the central Cumberland Plain to the Razorback Range at Picton.

MSW occurs exclusively on soils derived from Wianamatta Shale and is found in very similar environments to Western Sydney Dry Rainforest (WSDR). MSW tends to occupy upper slopes while WSDR is often found on lower slopes and in gullies. Presumably this provides a more reliably moist environment for the constituent rainforest species of WSDR and Tozer (2003) suggest it is possible that MSW represents a stage in the recovery of WSDR from fire.

A suite of eucalypt species dominates the canopy. A small tree stratum consisting of the characteristic canopy species is often evident, and the relatively sparse shrub stratum is dominated by mesophyllic species with the ground stratum variable in cover and species.

Figure 4 shows the distribution of this TSC Act listed TEC according to mapping by NPWS (2002c). In the Study Area MSW is mapped by NPWS (2002a) on the south facing slopes of Donald's Ridge and the crest and slopes of the isolated hill to the north of Douglas Park village.

Flora survey was undertaken at two sites within MSW (sites 1 and 2; Figure 6, Appendix 2).

Western Sydney Dry Rainforest (WSDR)

WSDR is highly restricted in distribution, occurring almost exclusively on soils derived from Wianamatta Shale. Sites occurring on Mittagong Formation soils are likely to be influenced by the sandstone and may have a different floristic composition (NPWS 2002c).

Generally this community occupies sheltered lower slopes and gullies on steeply sloping, rugged topography with transition to CPW often abrupt, and is likely to relate primarily to moisture availability, but also fire history. WSDR is likely to have been more widely

distributed in areas receiving higher rainfall than in flatter drier country where it was probably restricted to sheltered gullies. Gullies would also have provided protection from fire.

No particular species of eucalypt characteristically occurs in WSDR with the tree and small tree strata typically composed of a mixture of sclerophyllous and mesic species. The mesic species are predominant in the shrub stratum, with the ground stratum consisting primarily of a mixture of fern and herb species, with relatively few grass species present (NPWS 2002c). WSDR is mapped by NPWS (2002a) in association with MSW over Donald's Ridge in the north of the Study Area (Figure 4).

No additional flora survey sites were undertaken in WSDR for this assessment.

Western Sandstone Gully Forest (WSGF)

Western Sandstone Gully Forest (WSGF) is dominated by a number of *Eucalyptus* spp. and other closely related tree species. A sparse layer of smaller trees is usually present, with the shrub and ground layers also generally sparse. WSGF occurs on the lower slopes of sandstone gullies on the western side of the Woronora Plateau where annual rainfall falls below approximately 1050 mm. The gradation into sandstone woodland communities generally occurs less than half way up the slope from the gully floor. In particularly sheltered gullies, mesic species form a dense small tree stratum. Vines may also be locally abundant and dense patches of ferns present in these sheltered gullies. The community often occurs in association with a narrow band of Riparian Scrub usually where it occurs on creeklines and rivers.

WSGF occurs over the narrow benches and escarpments of the Nepean River and Harris Creek in the Study Area as shown in the NPWS (2002a) mapping (Figure 4).

Flora survey was undertaken at one site within WSGF (Site 9; Figure 6, Appendix 2).

Riparian Scrub (RS)

Riparian Scrub (RS) is generally dominated by mesic tree species. The shrub stratum is locally dense, but shrub patches are frequently interspersed between rock pavement, recent deposits of sediment and water. The ground stratum is similarly variable and includes a suite of sedges, rushes and ferns with purely aquatic flora species occasionally present in intermittent pools (NPWS 2002c). Riparian Scrub is present in the Study Area over the lower banks of the Nepean River (Figure 4).

Flora survey was undertaken at one site within RS (Site 13; Figure 6, Appendix 2)

3.2.2.2 Threatened Flora

No threatened flora species were recorded in the current surveys (Appendix 3).

Twenty-one threatened flora species (or their potential habitats) appear on database searches of the locality (Appendix 4, Figure 7 and Figure 8). Eight of these species have a medium likelihood of occurring in the Study Area (Appendix 4).

3.2.2.3 Fauna Habitats

Suitability, size and configuration of vertebrate fauna habitats broadly correlate to the structure, connectivity and quality of local and regional vegetation types. The Study Area contains a range of habitat types with varying levels of disturbance. Some local habitats in the Study Area comprise much larger contiguous habitat corridors that span the broader locality, whilst others are restricted and some offered limited habitat resources. Broadly, these habitats comprise mostly closed grassland with scattered components of open woodland, forest and riparian scrub. Finer scale habitat features on and near the Study Area includes rock outcrops, caves, overhangs, tree hollows, hollow logs, riparian habitats including creeks, and ephemeral drainage lines. These habitats and their species associations are discussed in further detail below.

Open Woodland, Open Forest and Scrub

Open woodland occurs at various elevations in the Study Area ranging from scattered patches located in farm paddocks through to more intact sections located along ridgelines at the Razorback Range. Forest habitats occur in the Study Area along the Nepean River corridor and form contiguous fauna movement pathways to other areas in the broader locality. Scrub habitats are primarily located along the Nepean River and major drainage lines in the Study Area.

Myrtaceous trees, mostly *Eucalyptus* spp., dominate the upper canopy in these habitats and supply direct (foliage, nectar, exudates) and indirect food resources (arthropods) for a range of vertebrates, particularly birds and arboreal mammals. Key foraging tree species for the Glossy Black-cockatoo (*Calyptorhynchus lathami*) in the form of *Allocasurina littoralis* are also present in this habitat. These habitats also provide protection for arboreal and ground-dwelling mammal species.

Tree hollows (formed in stags, mature and/or senescent trees) provide nesting and roosting habitat for hollow-dwelling fauna (e.g. cockatoos & parrots, owls, gliders, possums and bats) and are important habitat components of native forests. These may be utilised by locally threatened species for nesting and roosting including: Powerful Owl (*Ninox strenua*), Barking Owl (*Ninox connivens*), Glossy Black-cockatoo and Gang-gang Cockatoo (*Callocephalon fimbriatum*).

The open woodland and forest provide habitat for threatened species such as the Koala (*Phascolarctos cinereus*), Brown Treecreeper (*Climacteris picumnus victoriae*), Hooded Robin, Scarlet Robin (*Melanodryas cucullata*), Varied Sittella (*Daphoenositta chrysoptera*) and Cumberland Plain Land Snail (*Meridolum corneovirens*). Scrub habitats provide protection for small birds (e.g. fairy wrens, scrub wrens and weebills) and ground-dwelling mammals, such as marsupials (e.g. *Antechinus* spp.) and rodents (*Rattus* spp.).

These habitats range in condition from medium to good with some relatively intact sections and other sections that have been disturbed by farming practices, weed invasion (e.g. African Olive) and the presence of feral species (e.g. feral goats).

Rock Outcrops, Caves and Overhangs

Rock outcrops with crevices primarily occur along the escarpments of the Nepean River and the ridgeline of the Razorback Range. These habitats provide refuge for a wide range of reptile species.

Caves and overhangs generally occur within rocky gullies, below escarpment areas in the Study Area. These areas can provide roosting habitat for cave-dwelling micro-bats, including the threatened Large-eared Pied Bat (*Chalinolobus dwyeri*), Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*), and Southern Myotis (*Myotis macropus*). Small caves and crevices may provide den habitat for the threatened Spotted-tailed Quoll (*Dasyurus maculatus maculatus*).

Riparian

Riparian habitats border the Nepean River and major drainage lines in the Study Area (e.g. Allen's Creek). These areas provide habitat for a range of vertebrates (amphibians, reptiles and small ground-dwelling mammals) and invertebrate species.

Artificial aquatic habitats, in the form of farm dams, occur along drainage lines. These provide habitat for common amphibian species (e.g. Common Eastern Froglet *Crinia signifera*) and wading birds including potential habitat for threatened and migratory species such as the Cattle Egret (*Ardea ibis)*, Australian Painted Snipe (*Rostratula australis*) and Latham's Snipe (*Gallinago hardwickii)*.

This habitat ranges in condition from poor in disturbed areas through to good condition in areas supporting a full complement of fauna habitat features such as, aquatic emergent vegetation, pools, and intact native riparian vegetation.

Closed grassland

Grassland habitat is the dominant habitat type in the Study Area and consists of areas devoid of canopy cover. Despite most of this habitat offering only limited fauna habitat resources, some areas support a high diversity of native ground covers in close proximity to open woodland. These areas are likely to provide essential foraging habitat for threatened raptor species such as the Spotted Harrier (*Circus assimilis*) and Little Eagle (*Hieraaetus morphnoides*).

These areas also support foraging and browsing habitat for large native mammals including the Eastern Grey Kangaroo (*Macropus giganteus*), Swamp Wallaby (*Wallabia bicolor*), Red-necked Wallaby (*Macropus rufogriseus*) and Common Wombat (*Vombatus ursinus*). This habitat also supports introduced species including the European Rabbit (*Oryctolagus cuniculus*) and Red Fox (*Vulpes vulpes*).

3.2.2.4 Threatened Fauna

Three threatened fauna species were recorded in the Study Area and immediate surrounds during the current field surveys in Open Woodland, Open Forest or Scrub habitat: Cumberland Plain Land Snail, Brown Treecreeper and Koala (Appendix 3; Figure 10). Four additional species, Hooded Robin, Speckled Warbler Southern Myotis and Varied Sitella have been recorded within the Study Area previously (Appendix 4; Figure 10).

Forty-seven threatened fauna species (or their potential habitats) appear on database searches of the locality (Appendix 4, Figure 9 and Figure 10). Twenty-eight of these species have a medium likelihood or greater of occurring in the Study Area (Appendix 4).

3.2.2.5 State Environmental Planning Policy 44 – Koala Habitat Protection

The State Environmental Planning Policy (SEPP) 44 – Koala Habitat Protection is applicable to the Wollondilly LGA. The Study Area contains two Koala feed tree species, Grey Gum (*Eucalyptus punctata*) and Forest Red Gum (*Eucalyptus tereticornis*) within the open woodland and forest habitats, which comprise Core Koala Habitat (i.e. greater than 15% Schedule 2 tree species in the canopy). Koala scats were also found within the Study Area (Figure 10). Consequently, it is considered likely that the Study Area supports a local population of Koala.

3.2.2.6 Migratory Species

Australia is a signatory to international agreements aimed at protecting migratory species. These include the *Japan Australia Migratory Bird Agreement* (JAMBA), the *China Australia Migratory Bird Agreement* (CAMBA), the *Republic* of *Korea Australia Migratory Bird Agreement* (RoKAMBA), and the *Bonn Convention on the Conservation of Migratory Species of Wild Animals* (Bonn Convention). Migratory species are considered to be Matters of National Environmental Significance and as such are protected under the EPBC Act.

Twelve species listed under the migratory provisions of the EPBC Act have been predicted to occur within the Locality (Appendix 4). No migratory bird species were recorded during the field surveys. On the basis of the proximity of previous records and the habitat features present in the Study Area, five migratory bird species are considered likely to occur in the Study Area on occasion (Appendix 4).

4.0 POTENTIAL IMPACTS TO FLORA AND FAUNA

This section outlines the potential impacts to flora and fauna species resulting from subsidence associated with the extraction of coal from Longwalls 901 to 904.

The potential impacts of the project in relation to vegetation, fauna habitats and threatened flora and fauna species for the broader BSO area were assessed by FloraSearch (2009), Biosphere (2009) and as part of the BSO EA. Additional assessment has been undertaken by Biosis Research following the current surveys.

Potential impacts, the level of impact across the broader BSO EA area and any residual risks assessed by Biosis Research are outlined in Table 7 below. Where residual risk differs from that contained within the EA the reason for this difference is outlined.

Table 7: Potential impacts assessed for fauna and fauna habitat in the EA relevant to the Study Area.

Potential impact assessed	Level of impact according to FloraSearch (2009), Biosphere (2009) and BSO EA	Level of impacts based on Current Survey
Vegetation	Slope and ridgetop vegetation • Small, isolated impacts to vegetation due to cracking Riparian vegetation • Small, localised impacts to vegetation due to ponding, flooding, scouring or gas release Gently undulating lands • Negligible impacts due to surface cracking	As for BSO EA. Negligible residual risk
Fauna habitats	Slope and ridgetop habitats: • Potential for small animals to become trapped in cracks. Impacts expected to be minor • Rare impacts to fauna due to rockfall Riparian habitats: • Negligible impacts to fauna and fauna habitat. Gently undulating lands • Minor impacts due to surface cracking Water habitats: • Impacts to water habitat unlikely to result in impacts to fauna	As for BSO EA. Negligible residual risk
Threatened flora	No significant impacts on threatened flora species predicted	As for BSO EA. Negligible residual risk
Threatened fauna	No significant impacts on threatened fauna species predicted.	As for BSO EA. Negligible residual risk
Koala habitat	As described above for other fauna habitats, the predicted effects of subsidence on Koala habitat are likely to be minimal and are not considered to have any real effect on the species.	As for BSO EA. Negligible residual risk

Potential impact assessed	Level of impact according to FloraSearch (2009), Biosphere (2009) and BSO EA	Level of impacts based on Current Survey
Spread of amphibian Chytrid Fungus and impacts on frog species	Collection and handling of frogs or the inadvertent transport of the infected material between frog habitat by persons, vehicles or equipment may promote the spread of the disease.	Provided mitigation measures outlined in the BSO EA are implemented residual risk is negligible
Infection of Native Plants by *Phytophthora cinnamomi*	Project-related activities have the potential to introduce or spread the infection of native plants by *P. cinnamomi*.	Provided mitigation measures outlined in the BSO EA are implemented residual risk is negligible
Weeds	The Project has the potential to increase the spread of weeds through vegetation clearing activities, dispersal of seed or soil material containing seed via continued movement of vehicles across the Project area and through rehabilitation or restoration activities	Low residual risk remains due to potential for spread of weeds through vehicle movement and movement of monitoring teams. Mitigation measures to reduce the risk if spread of weeds is managed as outlined in Section 6.2.2.

Potential impacts as assessed by Biosis Research are largely consistent with those outlined within the BSO EA. Lower risk ratings are present within the Appin Area 9 Study Area when compared to the broader BSO EA area due to less sensitive vegetation communities, substantial areas of cleared vegetation and a lack of vegetation clearing to be undertaken within this area.

5.0 MONITORING

It is recommended that the monitoring program described below be implemented to monitor the impacts of subsidence across Appin Area 9. The monitoring program reflects the small magnitude of subsidence effects on biodiversity values predicted to occur within the Study Area.

Monitoring will focus on detecting significant changes to vegetation communities and fauna habitat present within the Study Area and will aim to ensure complete coverage across Appin Area 9. Subsidence effects are more likely to result in changes to natural features through the diversion of surface water flows and therefore impacts to groundwater dependant ecological features (PAC 2010). Groundwater dependant vegetation communities present within the Study Area, as shown in Figure 4, include Riparian Scrub, Western Sandstone Gully Forest, and Western Sydney Dry Rainforest.

Other vegetation communities are not considered dependant on groundwater and are thus less likely to be impacted as a result of subsidence effects. The recommended monitoring program for these communities takes this low risk profile into account.

Visual inspections of vegetation communities and fauna habitat will be undertaken across the Appin Area 9 Study Area, according to the methodology outlined below.

5.1 Visual Inspections

Visual inspections of vegetation communities within the Study Area will be undertaken as a part of routine landscape and water monitoring programs. Targeted inspection by a qualified ecologist will occur should vegetation health appear to be impacted.

Inspections of vegetation condition will assess the following:

- Does the vegetation appear healthy?
- Are there any detectable visual impacts (e.g. canopy thinning, thinning of shrub layer, loss of ground cover, dead branches present)?
- Are there any significant detectable visual impacts (e.g. canopy loss with areas of dieback present, loss of whole shrubs, loss of ground cover over large areas)?

All areas of impact or any subsidence effects will be mapped and documented using digital photography.

Where a significant impact is observed a qualified ecologist will be engaged to document the following:

- The total area of impact. This will be mapped using a GPS and aerial photo interpretation;

- The Foliage Percentage Cover (FPC); and
- Modified Braun-Blanquet cover abundance scores for each species using a seven point scale:

1	Species cover less than five per cent – three or less individuals
2	Species cover less than five per cent – more than three individuals but sparsely scattered consistent throughout plot
3	Species cover less than five per cent – many individuals throughout plot and any number less than five per cent cover abundance
4	Species covers between five per cent and 25 per cent of the plot
5	Species covers between 25 per cent and 50 per cent of the plot
6	Species covers between 50 per cent and 75 per cent of the plot
7	Species covers between 75 per cent and 100 per cent of the plot

This information will be used to objectively assess extent and degree of impact. Assessment of similar vegetation communities or fauna habitat within the broader locality will be undertaken to determine if the detected changes are within normal variation or represent a possible impact of mining. Additional studies (e.g. gas release measurements) will be commissioned in response to an observed mining impact to understand the mechanism involved and consider any Corrective Management Actions (CMAs) that may be required.

Impacts are to be monitored as a part of ongoing visual monitoring to determine any change in extent or degree.

It is recommended that BHPBIC implement remediation measures outlined below where impacts to vegetation communities or fauna habitat are deemed to be caused by subsidence effects.

5.2 Remediation

It is recommended, that with appropriate consultation and approvals, BHPBIC implement remedial measures to address subsidence effects (e.g. cracking, shearing leading to vegetation die-back).

Management measures, including actions to remediate impacts to biodiversity values due to subsidence effects, are outlined in Section 6.0.

5.3 Reporting

The monitoring program will be reported annually in the Annual Environmental Management Report (AEMR). This report will: detail the outcomes of monitoring undertaken; provide results of visual inspections: determine whether performance indicators have been exceeded: and whether CMAs are required.

6.0 MANAGEMENT MEASURES

This section describes the management measures recommended for Longwalls 901 to 904, including actions to remediate impacts to biodiversity values due to subsidence effects.

Management measures are divided into:

a) measures to be implemented to remediate impacts to biodiversity values (Section 6.1); and
b) other management measures to be implemented generally to address other potential impacts outlined in Section 4.0 (Section 6.2)

This study supports a Biodiversity Management Plan being prepared as part of the Appin Area 9 Extraction Plan.

6.1 Intensive Management Measures

Where significant impacts are observed and are a result of subsidence effects, it is recommended that BHPBIC implement a remediation program. The remediation program should commence with remediation measures to address subsidence effects (where possible).

Following this, management measures should be implemented to address any ecological impacts. These management measures are aimed at ensuring long term viability of impacted biodiversity values through assisted regeneration and replanting, as well as measures to continue to address subsidence effects that are causing impacts.

Assisted regeneration will include weed management measures outlined in Section 6.2.2 below, as well as fencing off effected areas to prevent grazing (where agreed with the landowner and the relevant statutory authority). Where assisted regeneration is not meeting expected outcomes, replanting of ground cover, shrubs species and trees will be implemented. All replanting will be undertaken using species characteristic of the vegetation community, and sourced from local stock.

Should all intensive management measures outlined above fail to remediate detected impacts offsets will be sought in consultation with relevant stakeholders.

6.2 Other Management Measures

Management measures are required where field crews and other BHPBIC staff or contractors are required to access surface areas as a part of monitoring and/or rehabilitation programs. These additional management measures are outlined below.

6.2.1 Prevention of Vegetation Disturbance

All BHPBIC staff and contractors accessing the Appin Area 9 Study Area should restrict vehicular access to recognised tracks and disturbed areas where possible to avoid and

minimise impacts to native vegetation and fauna habitat. Should access to areas of native vegetation be required access on foot will be preferred to vehicular access.

If vegetation clearing is required a suitably qualified ecologist will be engaged to determine the vegetation/fauna habitat characteristics of the area to determine the potential impacts and recommended measures to reduce these impacts.

6.2.2 Weed Management

Mitigation measures contained within the BSO EA should be implemented.

In addition to these measures, and to prevent the spread of weed species into areas of native vegetation, it is recommended that all BHPBIC staff and contractors undertake inspections to ensure vehicles, equipment and clothing are free of weed species (including seeds) prior to entry.

Vehicles should be cleaned prior to accessing areas containing, or adjacent to, native vegetation.

6.2.3 Spread of Amphibian Chytrid Fungus

Mitigation measures to prevent the spread of Chytrid fungus outlined in the BSO EA should be implemented during works requiring access to waterways, dams and other waterbodies. These measures include:

- The thorough cleaning and disinfecting of footwear using a suitable disinfecting agent containing benzalkonium chloride;
- The thorough cleaning and disinfecting of equipment (such as nets, callipers, headlamps and waders) using a suitable disinfecting agent (see DECC 2008);
- Restricting the movement of vehicles to formed tracks and pre-existing roads, where practicable; and,
- In the event Chytrid fungus is known to be present at a site, that site would be the last site surveyed/sampled, where practicable.

6.2.4 Infection of native plants by Phytophthora cinnamomii

Mitigation measures to prevent and manage the infection of native plants by *Phytopthora cinnamomi* (listed as a key threatening process on the TSC Act) outlined within the BSO EA should be implemented. These measures include:

- Restricting vehicular access to recognised tracks;
- Avoid and minimise soil disturbance; and,
- Encourage natural regeneration in areas requiring revegetation.

Where an infestation is identified, the following additional measures should be implemented:

- Limiting access to the infestation area;
- Preventing access to other areas of native vegetation following access to the infestation area (if such access is necessary);
- Implementation of strict hygiene measures, including:
    - Spray all surfaces in contact with the ground, including vehicle tyres and footwear, with a suitable agent such as Phytoclean solution; and,
    - Implement wash-down procedures when transferring between isolated areas of native vegetation.

All BHPBIC staff and contractors should be made aware of possible Phytopthora infection and the potential signs of infection.

FIGURES

FIGURES

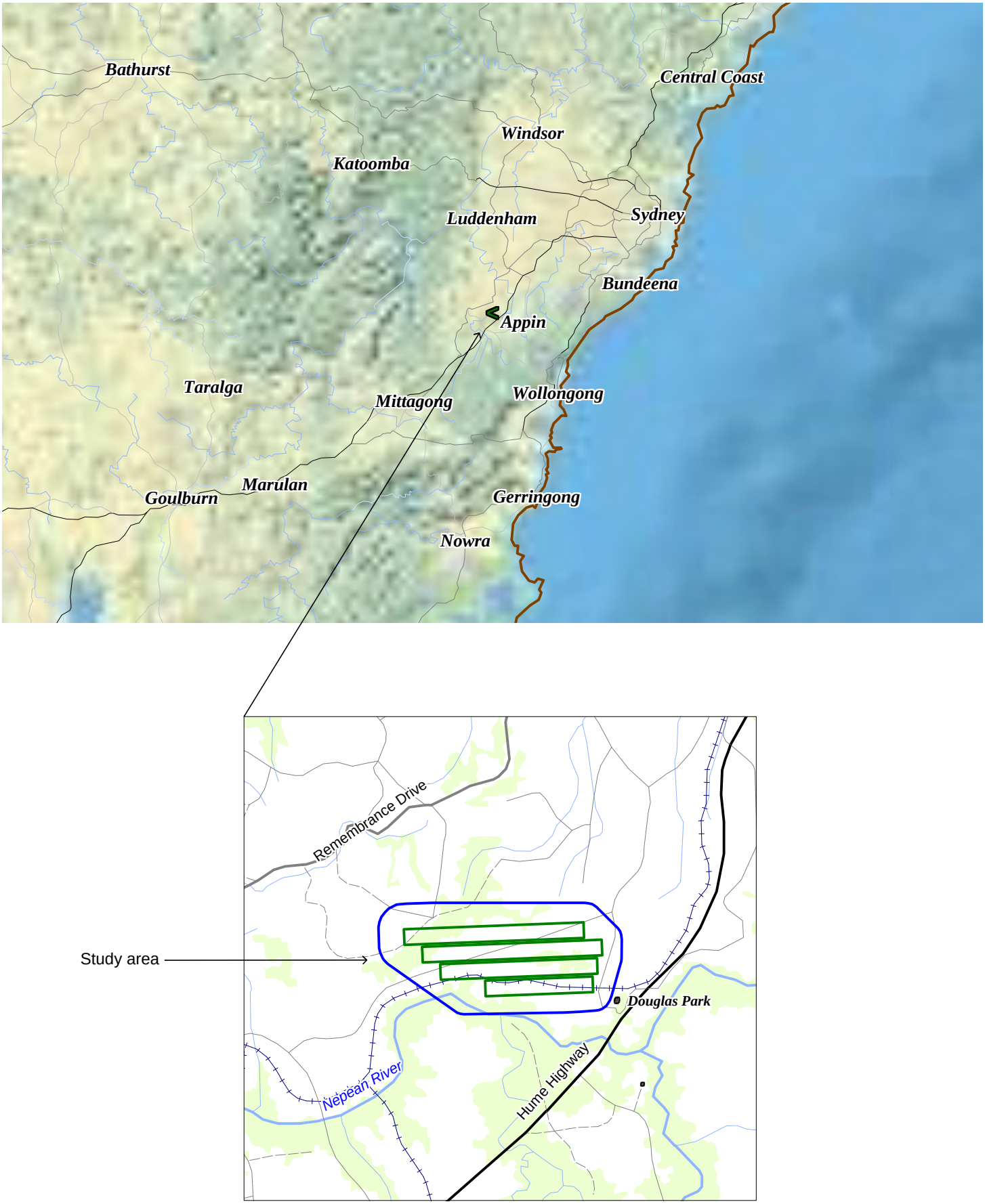

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Figure 1: Location of the Study Area in a regional context

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File number: 11340	Checked by: MWR
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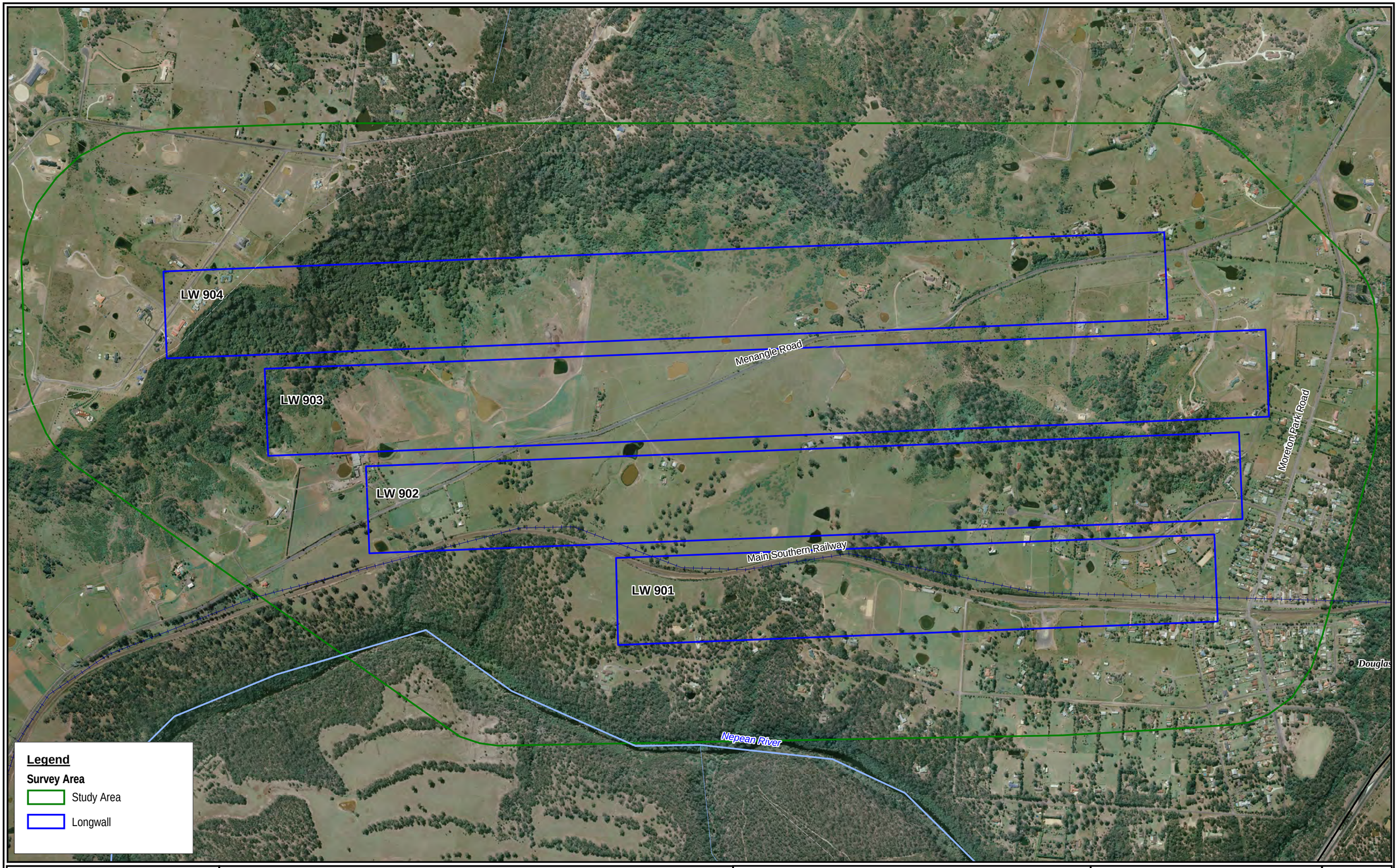

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Figure 2: Extent of Study Area for Appin Area 9 Longwalls 901 - 904.

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Location:-..P:\11300s\11340\Mapping\Report Figures\11340_F2 Overview.WOR	

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Figure 2

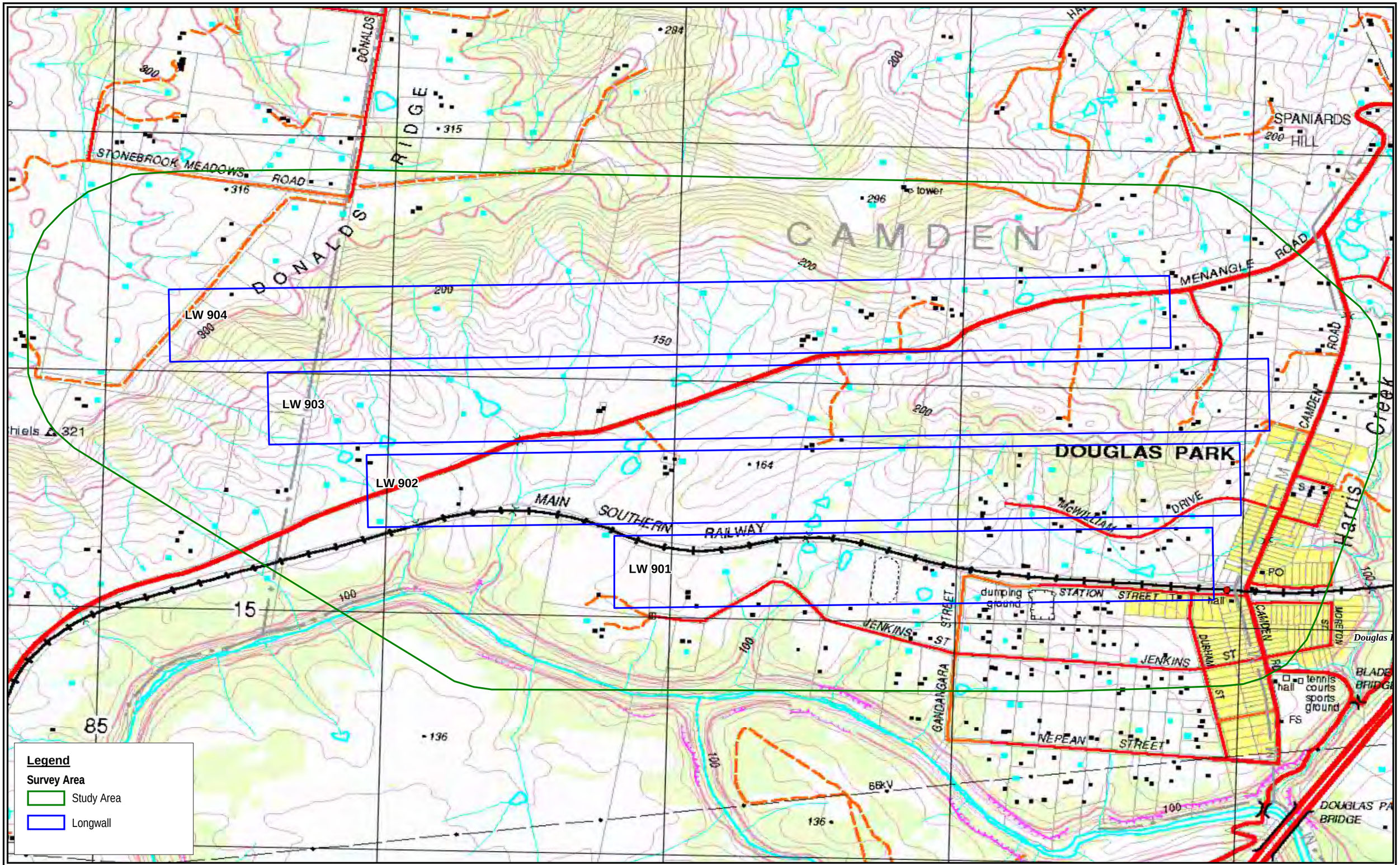

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Figure 3: Topographic map illustrating the natural surface features in the Study Area.

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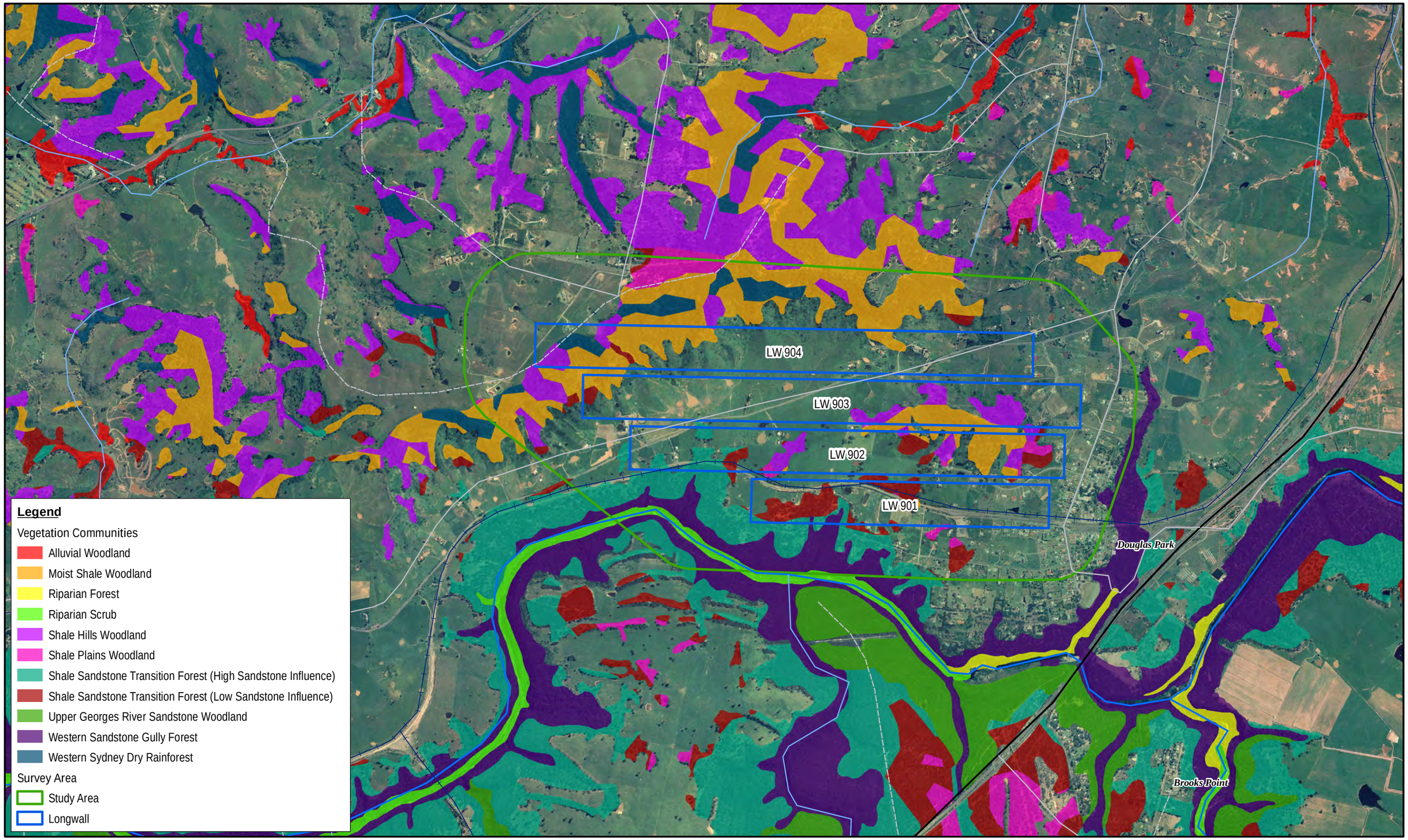

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Figure 4: Vegetation communities in the Study Area (NPWS 2002)

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Job number: 11340 | Checked by: NMG

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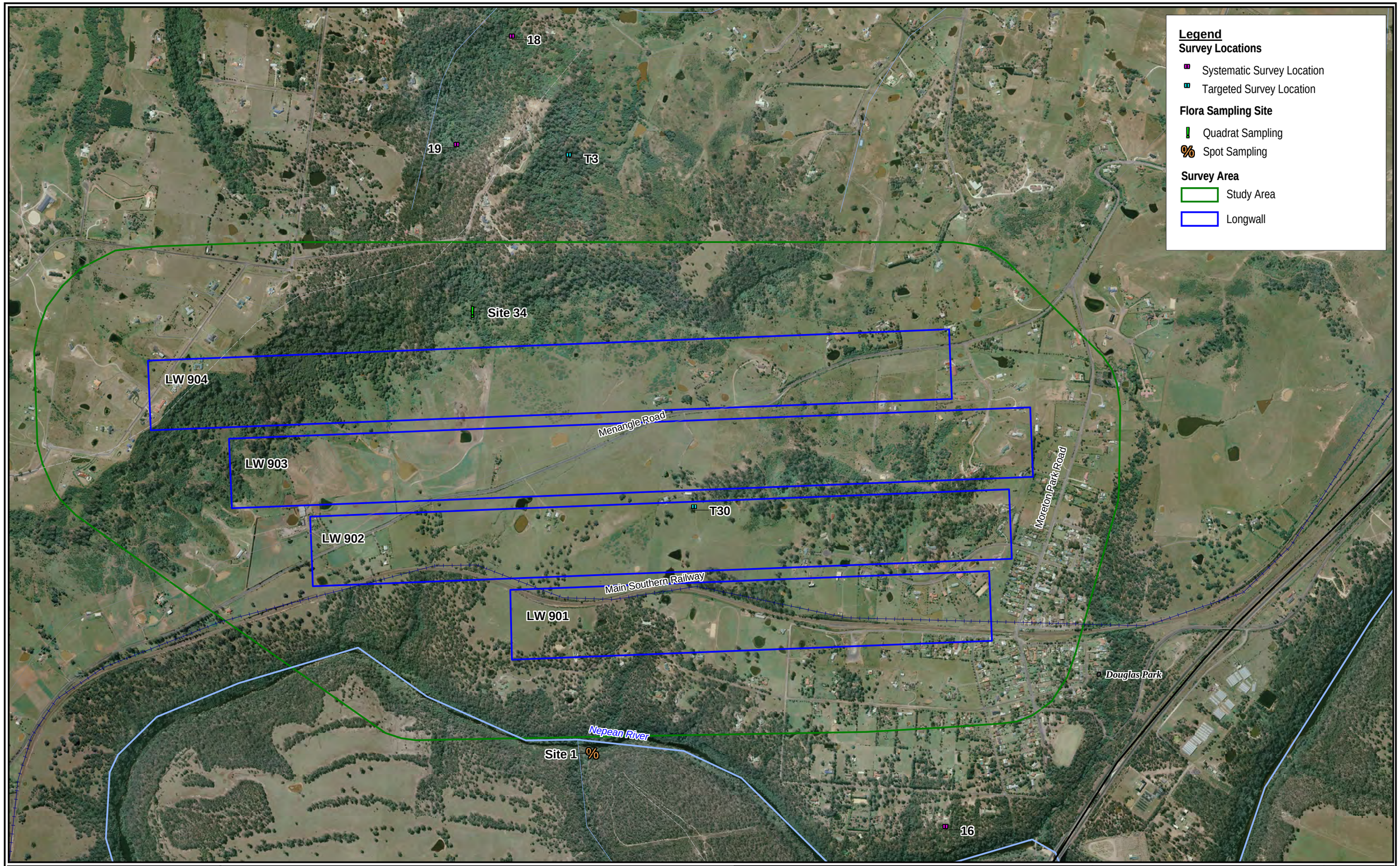

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Figure 5: : Location of systematic and targeted survey locations used in the terrestrial flora and fauna Part 3A Environmental Assessment for the Bulli Seam Operations Project.

Date: 15 July 2011	Drawn by: ANP
File number: 11340	Checked by: NMG
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Figure 5

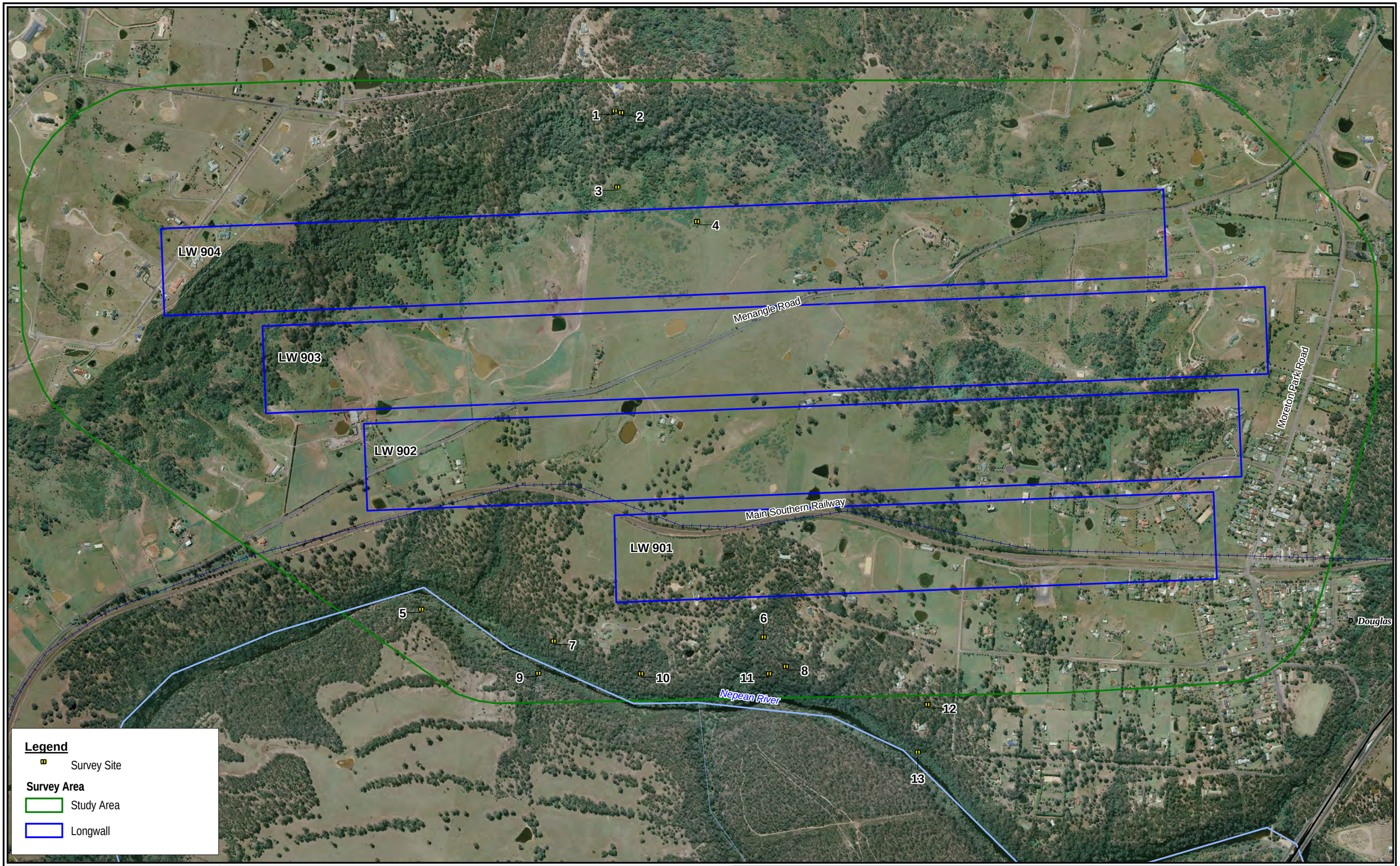

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Figure 6: Survey site for the revised biodiversity assessment.

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Figure 6

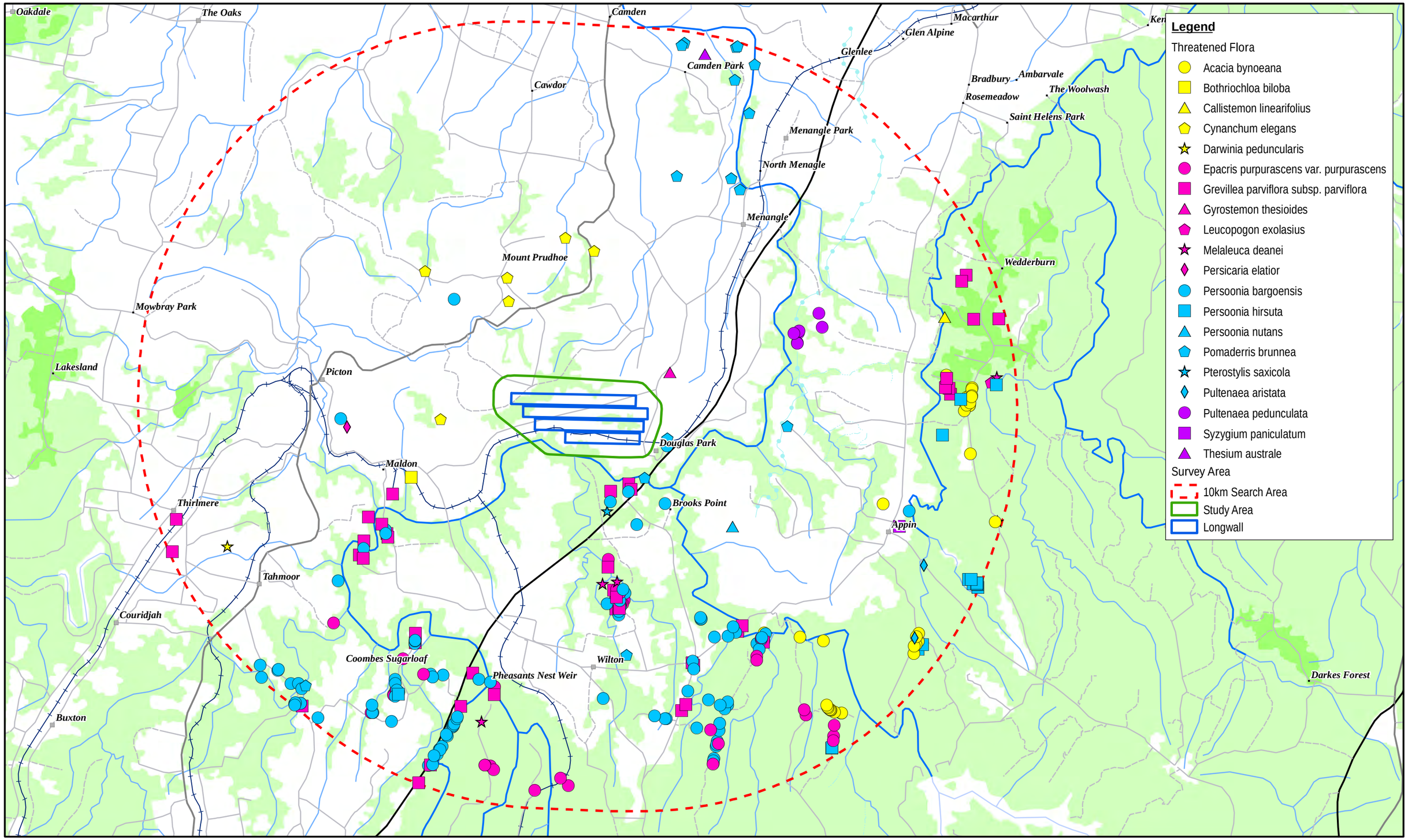

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Figure 7: Threatened flora species previously recorded in the Locality.

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Job number: 11340 | Checked by: BWM

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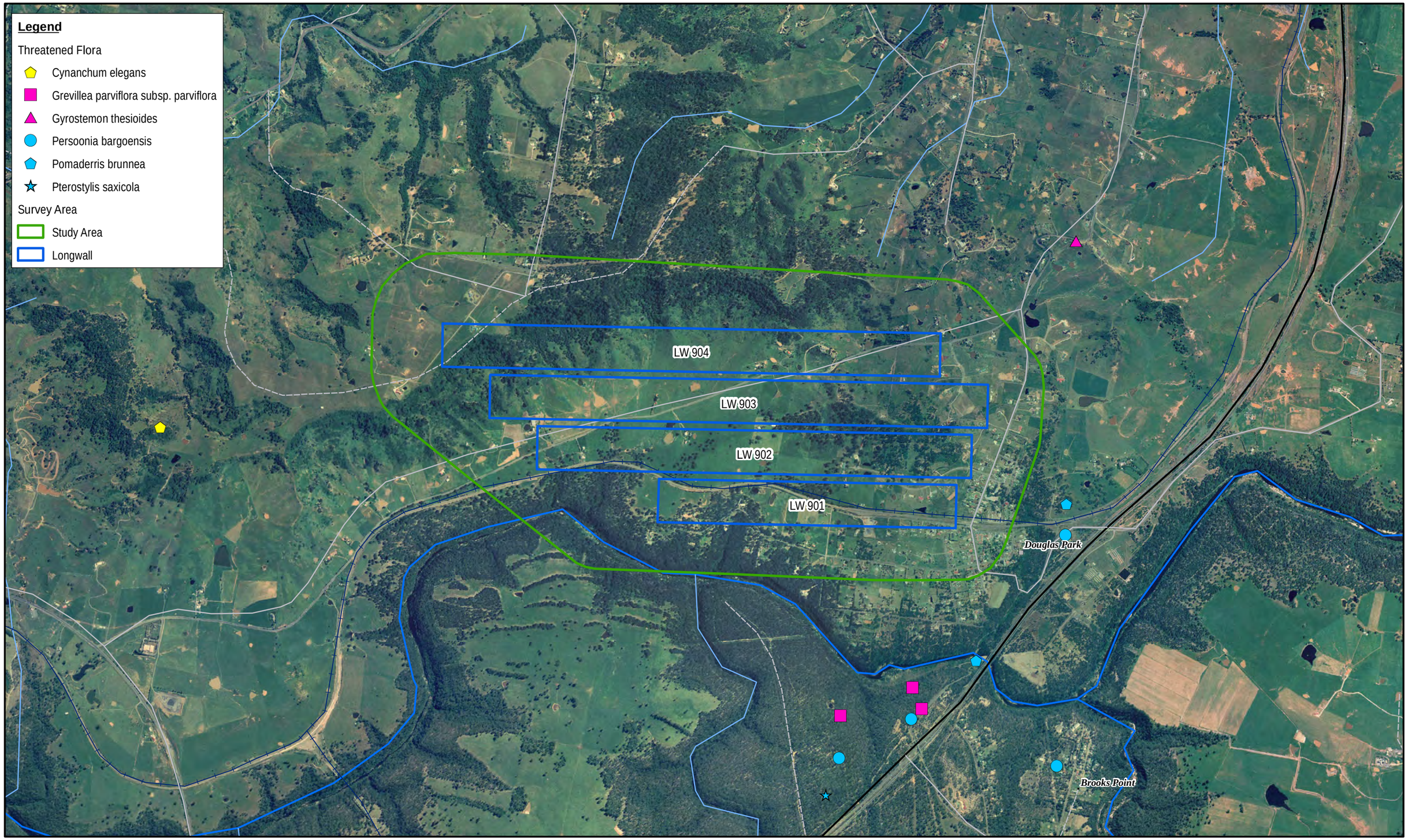

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Figure 8: Threatened flora species previously recorded in the Study Area and immediate surrounds.

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Location: ...P:\11300s\11340\Mapping\Report Figures\11340_F8_Threatened Flora_Study Area.mxd	

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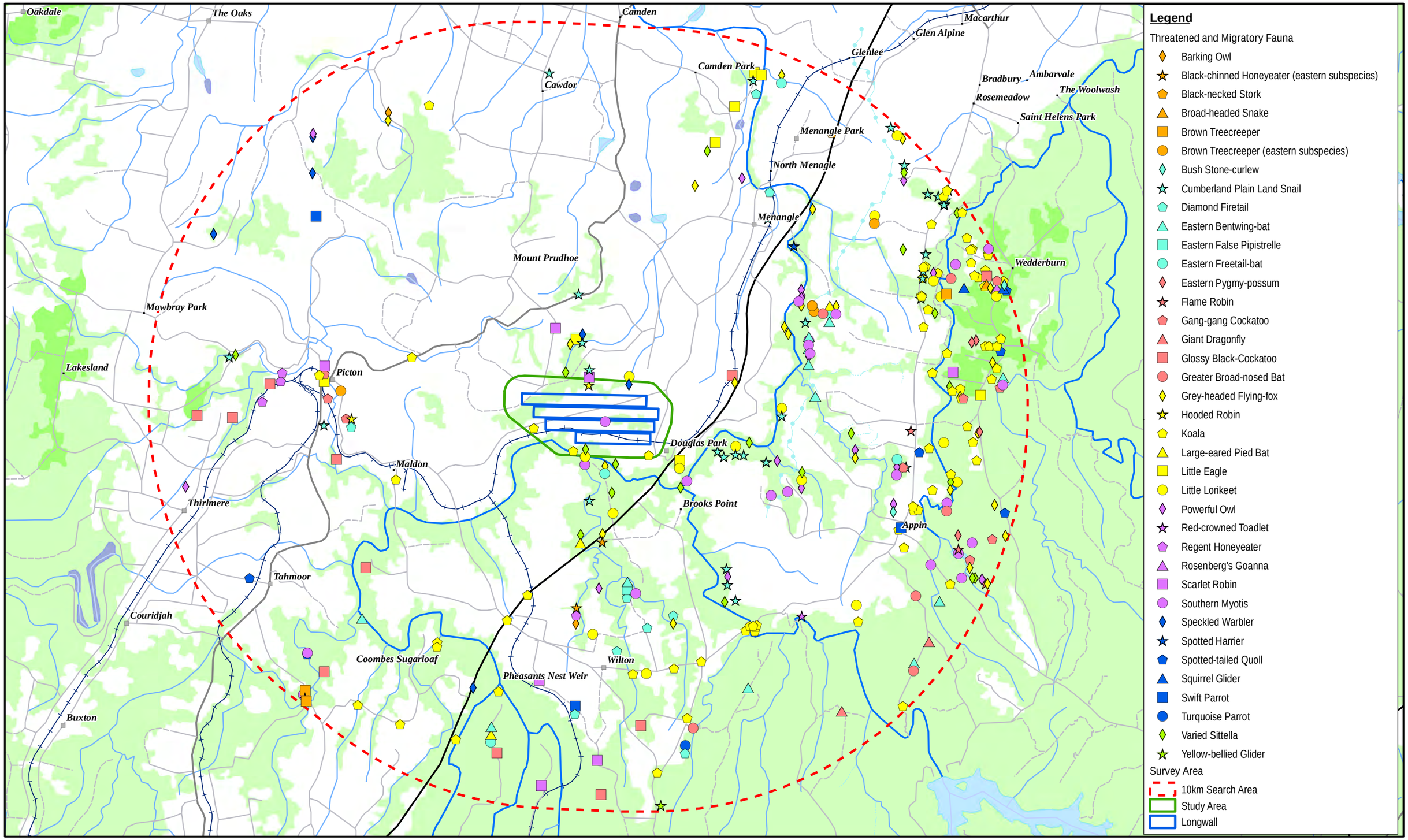

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Figure 9: Threatened fauna species previously recorded in the Locality.

Date: 15 July 2011 | Drawn by: ANP

Job number: 11340 | Checked by: NMG

Location: ...P:\11300s\11340\Mapping\Report Figures\11340_F9_Threatened Fauna_Locality.mxd

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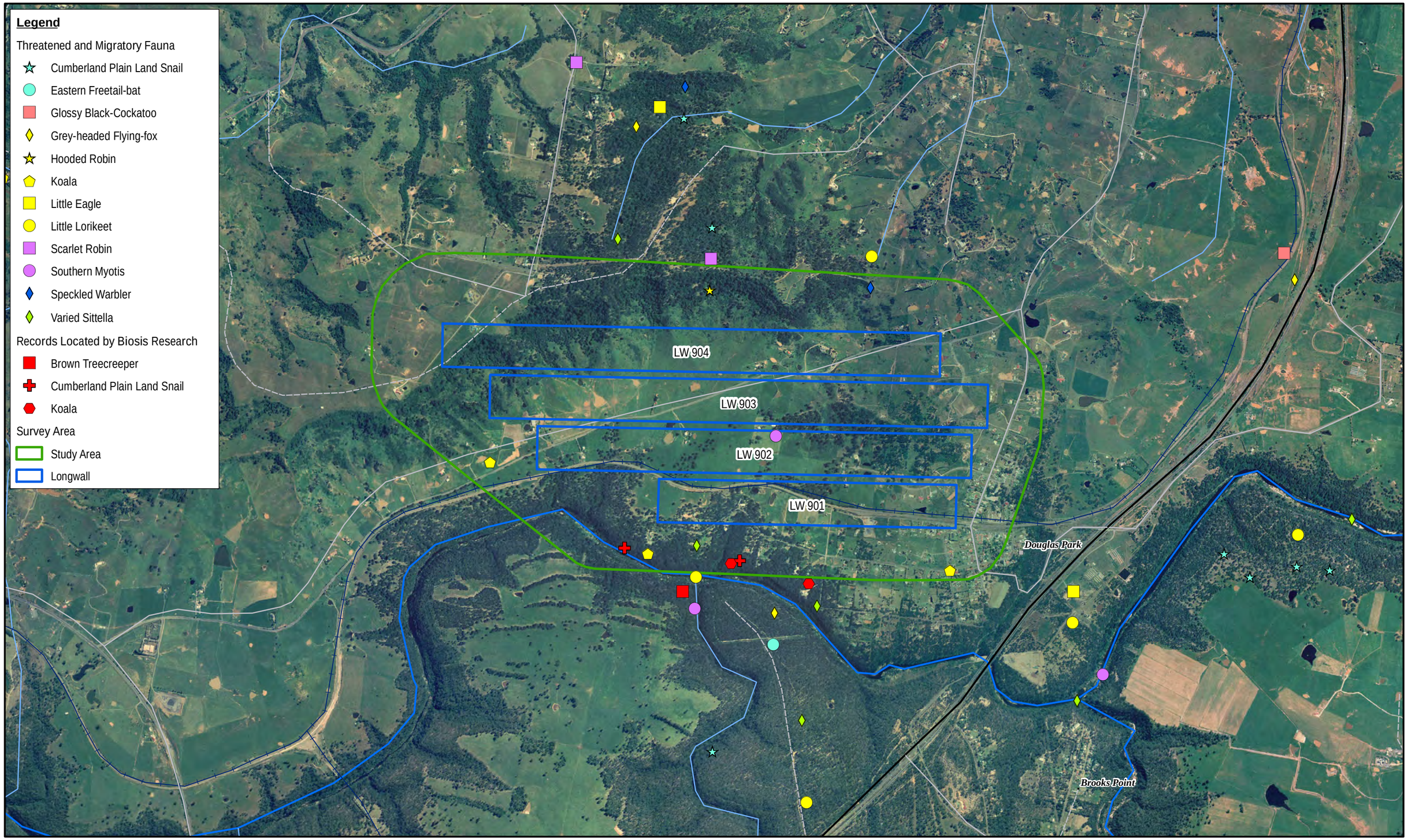

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Figure 10: Threatened fauna species previously recorded in the Study Area and immediate surrounds.

Date: 15 July 2011	Drawn by: ANP
Job number: 11340	Checked by: NMG
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Kilometers

Scale: 1:25,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
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APPENDICES

APPENDIX 1

Likelihood of Occurrence

Likelihood of occurrence

Table A1.1: Likelihood of occurrence criteria

Likelihood of occurrence	Assessment Criteria
Low	Species considered to have a low likelihood of occurrence include species not recorded in the field surveys that fit one or more of the following criteria: • Have not been recorded previously in the Study Area or Locality and the Study Area is beyond the known distribution or range. • Are dependent on a narrow range or specific habitats that do not or are not likely to occur in the Study Area. • Are considered locally extinct. • Are a non-cryptic perennial flora species that were targeted during field surveys. • Are flora species that have a very limited range and highly specific dispersal mechanisms.
Moderate	Species considered to have a moderate likelihood of occurrence include species not recorded in the field surveys that fit one or more of the following criteria: • There are infrequent records for the species in the Study Area and Locality. • Preferential habitats of the species are present in the Study Area but these are mainly in a poor or modified condition. • May use or occur in habitats within the Study Area opportunistically during seasonal migration but are unlikely to be present on permanent basis as a populations or vagrant individuals. • Are cryptic flowering flora species that were not seasonally targeted during surveys.
High	Species considered to have a high likelihood of occurrence include species recorded during the field surveys or species not recorded that fit one or more of the following criteria: • Have a high incidence of previous records in the Study Area and Locality. • Preferentially use habitats that are present in the Study Area which are abundant and/or in good condition. • Resident populations are known in the Study Area or Locality. • Are known to regularly use habitats of the site or Locality or are highly likely to visit the site during seasonal dispersal or migration.
Recorded	Species has been recorded within the Study Area, either during current surveys or is recorded on database searches.

APPENDIX 2

Summary survey results

Table A2.1: Appin Area 9 Study Area survey sites for the current assessment (Error! Reference source not found.**)**

Sample site	Easting	Northing	Vegetation assessment	Habitat assessment
1	286800.8	6216744	Moist Shale Woodland	Moderate condition open woodland – high activity of feral goats; few trees containing hollows, rocky outcrops present on ridgeline and high abundance of small woodland bird species.
2	286822.9	6216739	Moist Shale Woodland	Moderate condition open woodland – high activity of feral goats; few trees containing hollows, rocky outcrops present on ridgeline and high abundance of small woodland bird species.
3	286809.3	6216479	Regrowth Shrubland	Poor to moderate condition open woodland – high levels of disturbance from grazing; shrub layer consisting of *Bursaria spinosa* provides some habitat for small native bird species.
4	287088.4	6216358	Aquatic	Moderate condition aquatic habitat (farm dam) – habitat for common amphibian species and wading birds.
5	286123.7	6215001	Shale Sandstone Transition Forest	Good condition open gully forest - high abundance of woodland bird species; few trees containing hollows and high quantity of rocky outcrops.
6	287321.5	6214904	Shale Sandstone Transition Forest	Good condition open forest - Koala SEPP 44 habitat, habitat for Cumberland Plain Land Snail and several threatened woodland bird species. Feed trees of Glossy Black-cockatoo (*Allocasurina littoralis*) present. Rocky outcrops common.
7	286586.5	6214889	Shale Sandstone Transition Forest	Good condition open forest – Koala SEPP 44 habitat, habitat for Cumberland Plain Land Snail and several threatened woodland bird species. Rock outcrops common. Good vegetation structure and composition.
8	287399.3	6214800	Shale Sandstone Transition Forest	Good condition open forest - Koala SEPP 44 habitat, habitat for Cumberland Plain Land Snail and several threatened woodland bird species. Rocky outcrops common.
9	286533.5	6214776	Western Sandstone Gully Forest	Good condition riparian forest – habitat for small to medium bird species, foraging habitat for native herbivores and microbats. Habitat for common amphibian species. Good vegetation structure and composition.
10	286892.3	6214775	Shale Sandstone Transition Forest	Good condition open woodland – Koala SEPP 44 habitat, habitat for Cumberland Plain Land Snail and several threatened woodland bird species. Rocky outcrops common. Good vegetation structure and composition.
11	287340.4	6214775	Shale Sandstone Transition Forest	Good condition open forest - Koala SEPP 44 habitat, habitat for Cumberland Plain Land Snail and several threatened woodland bird species. Rocky outcrops common.
12	287894.7	6214667	Shale Sandstone Transition Forest	Good condition riparian forest/scrub – habitat for small to medium bird species, foraging habitat for native herbivores and microbats. Good vegetation structure and composition.
13	286892.4	6214754	Shale Sandstone Transition Forest	Good condition open woodland - Koala SEPP 44 habitat, habitat for Cumberland Plain Land Snail and several threatened woodland bird species. Rock outcrops common and caves potentially occur in escarpment. Good vegetation structure and composition.

APPENDIX 3

Flora and fauna species inventories

A3.1 Flora inventory

Table A3.1: Native and exotic flora recorded during current surveys

General Status	
*	Exotic (not native to Australia)
N( )	Noxious weeds and 'Control Class' as listed on the NSW Noxious Weeds Act 1993 for the Wollondilly LGA
nl	Non - locally occurring native species (does not naturally occur at this locality)
Conservation Status	
CE	Critically Endangered - listed under Schedule 1A of the TSC Act
E	Endangered - listed under Schedule 1 of the TSC Act
V	Vulnerable - listed under Schedule 2 of the TSC Act
CE +	Critically Endangered - listed under the EPBC Act
E +	Endangered - listed under the EBPC Act
V +	Vulnerable - listed under the EPBC Act
ROTAP	Rare or Threatened Australian Plant
Plant Communities	
MSW	Moist Shale Woodland
SSTF	Shale Sandstone Transition Forest
WSGF	Western Sandstone Gully Forest
RipScb	Riparian Scrub
ClGnd	Closed Grassland
Modified Braun Blanquet Cover Abundance (BB)	
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%

Status	Family	Genus species	Common Name	MSW	SSTF	WSGF	RipScb	ClGnd
	Fabaceae - Mimosoideae	*Acacia binervia*	Coast Myall		4			
	Fabaceae - Mimosoideae	*Acacia floribunda*	White Sally Wattle				3	
	Fabaceae - Mimosoideae	*Acacia implexa*	Hickory Wattle	2				
*	Polygonaceae	*Acetosella vulgaris*	Sorrel					2
	Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair	3			3	
*	Asteraceae	*Ageratina adenophora*	Crofton Weed				3	
*	Asteraceae	*Ageratina riparia*	Mistflower				3	
	Casuarinaceae	*Allocasuarina torulosa*	Forest Oak	3				
*	Primulaceae	*Anagallis arvensis*	Scarlet Pimpernel					2
	Myrtaceae	*Angophora bakeri*	Narrow-leaved Apple		2	2		
	Poaceae	*Anisopogon avenaceus*	Oat Speargrass		3	2		
*	Apocynaceae	*Araujia sericifera*	Moth Vine				3	
	Poaceae	*Aristida ramosa*	Purple Wiregrass	2				
	Poaceae	*Aristida vagans*	Threeawn Speargrass		2			3
N4	Asparagaceae	*Asparagus asparagoides*	Bridal Creeper	3			2	2
	Rubiaceae	*Asperula conferta*	Common Woodruff					1
	Aspleniaceae	*Asplenium flabellifolium*	Necklace Fern	2				
	Araliaceae	*Astrotricha latifolia*				2	1	
	Poaceae	*Austrodanthonia tenuior*						3
	Poaceae	*Austrostipa ramosissima*	Stout Bamboo Grass	2				
*	Poaceae	*Axonopus fissifolius*	Narrow-leafed Carpet Grass					3
*	Asteraceae	*Bidens pilosa*	Cobblers Pegs	2				
	Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry		1	1		
	Poaceae	*Bothriochloa macra*	Red Grass					2
	Euphorbiaceae	*Breynia oblongifolia*	Coffee Bush	2			3	
*	Poaceae	*Briza maxima*	Quaking Grass					2
*	Poaceae	*Bromus catharticus*	Praire Grass					3
	Acanthaceae	*Brunoniella australis*	Blue Trumpet		3			
	Pittosporaceae	*Bursaria spinosa* ssp *spinosa*	Blackthorn	3		3		
	Asteraceae	*Calotis dentex*			3	3		
	Casuarinaceae	*Casuarina cunninghamiana* ssp *cunninghamiana*	River Oak				4	

Status	Family	Genus species	Common Name	MSW	SSTF	WSGF	RipScb	ClGnd
	Vitaceae	*Cayratia clematidea*	Native Grape	2				
*	Gentianaceae	*Centaurium erythraea*	Common Centaury					3
	Apiaceae	*Centella asiatica*	Indian Pennywort	2				
*	Caryophyllaceae	*Cerastium vulgare*	Mouse Ear Chickweed					2
	Adiantaceae	*Cheilanthes sieberi* ssp *sieberi*	Mulga Fern		2			
*	Poaceae	*Chloris gayana*	Rhodes Grass					3
*	Asteraceae	*Cirsium vulgare*	Spear Thistle	2			2	2
	Cyperaceae	*Cladium procerum*					2	
	Ranunculaceae	*Clematis aristata*	Old Man's Beard	2				
	Verbenaceae	*Clerodendrum tomentosum*	Hairy Clerodendrum	2		1		
*	Asteraceae	*Conyza* sp	Fleabane				3	3
	Rutaceae	*Correa reflexa* var *speciosa*	Common Correa			2		
*	Apiaceae	*Cyclospermum leptophyllum*	Slender Celery					3
	Poaceae	*Cynodon dactylon*	Couch					3
	Cyperaceae	*Cyperus gracilis*	Slender Flat-sedge	2				
	Fabaceae - Faboideae	*Desmodium varians*	Slender Tick-trefoil	3				
	Phormiaceae	*Dianella caerulea* var *producta*				3	2	
	Phormiaceae	*Dianella revoluta*	Paroo Lily			3		
	Poaceae	*Dichelachne crinita*	Longhair Plumegrass					3
	Convolvulaceae	*Dichondra repens*	Kidney Weed	3				2
	Poaceae	*Echinopogon ovatus*	Forest Hedgehog Grass	2				
*	Poaceae	*Ehrharta erecta*	Panic Veldtgrass				3	
	Chenopodiaceae	*Einadia trigonos ssp trigonos*	Fishweed					3
	Poaceae	*Entolasia marginata*	Bordered Panic			3		
	Poaceae	*Entolasia stricta*	Wiry Panic		3	3		
	Poaceae	*Eragrostis brownii*	Brown's Lovegrass	2				
*	Poaceae	*Eragrostis curvula*	African Lovegrass					4
	Poaceae	*Eragrostis leptostachya*	Paddock Lovegrass					3
	Myrtaceae	*Eucalyptus baueriana*	Blue Box					2
	Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark		4			
	Myrtaceae	*Eucalyptus eugenioides*	Thin-leaved Stringybark			2		
	Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint			2		
	Myrtaceae	*Eucalyptus punctata*	Grey Gum		3	5		

Status	Family	Genus species	Common Name	MSW	SSTF	WSGF	RipScb	ClGnd
	Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum	4				2
*	Apiaceae	*Foeniculum vulgare*	Fennel					2
	Cyperaceae	*Gahnia aspera*	Rough Saw-sedge		2	2	2	
	Rubiaceae	*Galium propinquum*	Maori Bedstraw	2				
*	Asteraceae	*Gamochaeta americana*	Cudweed				2	2
	Geraniaceae	*Geranium homeanum*	Native Geranium				1	
	Fabaceae - Faboideae	*Glycine microphylla*	Small-leaf glycine	3				
*	Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush					2
	Goodeniaceae	*Goodenia hederacea* ssp *hederacea*	Forest Goodenia		3			
	Proteaceae	*Grevillea mucronulata*				2		
	Fabaceae - Faboideae	*Hardenbergia violacea*	Purple Coral Pea			2		
N4	Clusiaceae	*Hypericum perforatum*	St. Johns Wort					4
*	Asteraceae	*Hypochaeris glabra*	Smooth Catsear					3
*	Asteraceae	*Hypochaeris radicata*	Catsear					2
	Juncaceae	*Juncus usitatus*	Common Rush					2
	Myrtaceae	*Kunzea ambigua*	Tick Bush		2			
	Asteraceae	*Lagenophora gracilis*	Slender Lagenophora		2			
	Sterculiaceae	*Lasiopetalum ferrugineum* var *cordatum*			2			
	Cyperaceae	*Lepidosperma gunnii*			3			
	Cyperaceae	*Lepidosperma laterale*			3			
	Myrtaceae	*Leptospermum polygalifolium*	Yellow Tea-tree			2		
	Lomandraceae	*Lomandra cylindrica*			2			
	Lomandraceae	*Lomandra filiformis* ssp *filiformis*	Wattle Mat-rush		2	3		
	Lomandraceae	*Lomandra glauca*	Pale Mat-rush			3		
	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	2			3	
	Lomandraceae	*Lomandra multiflora* ssp *multiflora*	Many-flowered Mat-rush		2	3		
	Lomandraceae	*Lomandra obliqua*				3		
	Apocynaceae	*Marsdenia rostrata*	Milk Vine	3				
	Violaceae	*Melicytus dentatus*	Tree Violet	3			3	
	Poaceae	*Microlaena stipoides* var *stipoides*	Weeping Grass	2	3	3		5
	Rubiaceae	*Morinda jasminoides*	Sweet Morinda				2	
	Oleaceae	*Notelaea longifolia*	Large Mock-olive	2		2		

Status	Family	Genus species	Common Name	MSW	SSTF	WSGF	RipScb	ClGnd
*	Oleaceae	*Olea europaea* ssp *cuspidata*	Olive	2				2
	Poaceae	*Oplismenus aemulus*	Oplismenus				3	
	Poaceae	*Oplismenus imbecillis*	Oplismenus	3				
	Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine	3				
	Poaceae	*Panicum simile*	Two-colour Panic		2			
*	Poaceae	*Paspalum dilatatum*	Paspalum					4
	Passifloraceae	*Passiflora herbertiana* ssp *herbertiana*	Native Passionfruit				2	
*	Poaceae	*Pennisetum clandestinum*	Kikuyu Grass					3
	Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung			3	1	
*	Poaceae	*Phalaris aquatica*	Phalaris					3
	Plantaginaceae	*Plantago gaudichaudii*	Narrow plantain	2				
*	Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	2				2
	Apiaceae	*Platysace lanceolata*	Shrubby Platysace			3		
	Lamiaceae	*Plectranthus parviflorus*	Cockspur Flower	3				
	Poaceae	*Poa affinis*	Poa	4				
	Poaceae	*Poa labillardierei*	Tussock Grass				3	2
	Fabaceae - Faboideae	*Podolobium ilicifolium*	Prickly Shaggy Pea			3		
	Rubiaceae	*Pomax umbellata*	Pomax		3	3		
	Lobeliaceae	*Pratia purpurascens*	Whiteroot	3	2		2	
*	Iridaceae	*Romulea rosea*	Onion Grass					2
N4	Rosaceae	*Rubus fruticosus* agg sp	Blackberry					2
*	Polygonaceae	*Rumex crispus*	Curled Dock					2
	Asteraceae	*Senecio diaschides*		2			2	
*	Asteraceae	*Senecio madagascariensis*	Fireweed	2				3
*	Poaceae	*Setaria gracilis*	Slender Pigeon Grass				2	
*	Poaceae	*Setaria pumila*	Pale Pigeon Grass					2
	Asteraceae	*Sigesbeckia orientalis* ssp *orientalis*					2	
	Smilacaceae	*Smilax glyciphylla*	Sweet Sarsaparilla			2		
	Solanaceae	*Solanum campanulatum*			1			
	Solanaceae	*Solanum prinophyllum*	Forest Nightshade	2	2		2	
*	Solanaceae	*Solanum pseudocapsicum*	Winter Cherry	2			1	
	Solanaceae	*Solanum stelligerum*	Devil's Needles	3				
*	Asteraceae	*Sonchus oleraceus*	Common Sowthistle	1			3	

Status	Family	Genus species	Common Name	MSW	SSTF	WSGF	RipScb	ClGnd
	Poaceae	*Sporobolus creber*	Western Rat-tail Grass					3
	Proteaceae	*Stenocarpus salignus*	Scrub Beefwood				2	
	Poaceae	*Tetrarrhena juncea*	Wiry Ricegrass		3			
	Poaceae	*Themeda australis*	Kangaroo Grass	3				4
*	Commelinaceae	*Tradescantia fluminensis*	Wandering Jew				3	
	Myrtaceae	*Tristaniopsis laurina*	Water Gum				2	
	Apocynaceae	*Tylophora barbata*	Bearded Tylophora	2				
*	Verbenaceae	*Verbena bonariensis*	Purpletop					2
	Scrophulariaceae	*Veronica plebeia*	Trailing Speedwell	2				
*	Apocynaceae	*Vinca major*	Greater Periwinkle					2
	Violaceae	*Viola hederacea*	Native Violet				2	
	Asteraceae	*Vittadinia cuneata*	Fuzzweed	2				
	Rutaceae	*Zieria fraseri* ssp *compacta*				3		

A3.2 Fauna inventory

Table A3.2: Terrestrial fauna species recorded during the current surveys

Latin Name	Common Name	EPBC Act	TSC Act (NSW)	Observation type
Amphibians				
Litoria dentata	Bleating Tree Frog			W
Crinia signifera	Common Eastern Froglet			W
Birds				
Streptopelia chinensis	Spotted Turtle-Dove		U	O
Acridotheres tristis	Common Myna		U	O
Chenonetta jubata	Australian Wood Duck			OW
Egretta novaehollandiae	White-faced Heron			O
Cracticus torquatus	Grey Butcherbird			W
Grallina cyanoleuca	Magpie-lark			OW
Gymnorhina tibicen	Australian Magpie			O
Cacatua galerita	Sulphur-crested Cockatoo			O
Cacatua roseicapilla	Galah			OW
Cacatua sanguinea	Little Corella			O
Cacatua tenuirostris	Long-billed Corella			O
Coracina novaehollandiae	Black-faced Cuckoo-shrike			OW
Coracina tenuirostris	Cicadabird			OW
Psophodes olivaceus	Eastern Whipbird			W
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)		V	O
Cormobates leucophaeus	White-throated Treecreeper			OW
Macropygia amboinensis	Brown Cuckoo-Dove			OW
Ocyphaps lophotes	Crested Pigeon			O
Corcorax melanorhamphos	White-winged Chough			O
Corvus coronoides	Australian Raven			W
Rhipidura albiscapa	Grey Fantail			OW
Rhipidura leucophrys	Willie Wagtail			W
Falco longipennis	Australian Hobby			O
Dacelo novaeguineae	Laughing Kookaburra			W
Todiramphus sanctus	Sacred Kingfisher			O
Hirundo neoxena	Welcome Swallow			O
Malurus cyaneus	Superb Fairy-wren			W
Acanthorhynchus tenuirostris	Eastern Spinebill			O
Lichenostomus chrysops	Yellow-faced Honeyeater			OW
Lichenostomus leucotis	White-eared Honeyeater			W
Manorina melanocephala	Noisy Miner			O
Manorina melanophrys	Bell Miner			W
Meliphaga lewinii	Lewin's Honeyeater			W
Menura novaehollandiae	Superb Lyrebird			F
Colluricincla harmonica	Grey Shrike-thrush			W
Falcunculus frontatus	Crested Shrike-tit			W
Pachycephala pectoralis	Golden Whistler			OW
Pachycephala rufiventris	Rufous Whistler			OW
Acanthiza chrysorrhoa	Yellow-rumped Thornbill			OW

Latin Name	Common Name	EPBC Act	TSC Act (NSW)	Observation type
Acanthiza nana	Yellow Thornbill			O
Acanthiza pusilla	Brown Thornbill			OW
Acanthiza reguloides	Buff-rumped Thornbill			O
Gerygone mouki	Brown Gerygone			W
Pardalotus punctatus	Spotted Pardalote			W
Pardalotus striatus	Striated Pardalote			W
Pycnoptilus floccosus	Pilotbird			W
Sericornis frontalis	White-browed Scrubwren			W
Smicrornis brevirostris	Weebill			OW
Neochmia temporalis	Red-browed Finch			O
Taeniopygia bichenovii	Double-barred Finch			OW
Eopsaltria australis	Eastern Yellow Robin			O
Alisterus scapularis	Australian King-Parrot			O
Platycercus elegans	Crimson Rosella			O
Psephotus haematonotus	Red-rumped Parrot			O
Porphyrio porphyrio	Purple Swamphen			O
Zosterops lateralis	Silvereye			OW
Invertebrates				
Meridolum corneovirens	Cumberland Plain Land Snail		E1	SH
Mammals				
Capra hircus	Goat (feral)		U	P
Oryctolagus cuniculus	Rabbit		U	OP
Vulpes vulpes	Fox		U	OP
Macropus giganteus	Eastern Grey Kangaroo			P
Macropus robustus	Common Wallaroo			O
Wallabia bicolor	Swamp Wallaby			O
Trichosurus vulpecula	Common Brushtail Possum			P
Phascolarctos cinereus	Koala		V	P
Vombatus ursinus	Common Wombat			P

Key: Observation Type: O – observed, W – Heard, P – scats, F/T- tracks, SH – shell; U – Unprotected, E – Endangered and V – Vulnerable under TSC Act/EPBC Act; M – migratory under EPBC Act

APPENDIX 4

Terrestrial flora and fauna listed on the TSC and/or EPBC Acts previously recorded in the Locality and likelihood to occur in the Study Area

A4.1 Threatened flora

Table A4.1: Terrestrial flora listed on the TSC and/or EPBC Acts previously recorded in the Locality

Key: *1) Listed on the EPBC Act as Critically Endangered (Z), Endangered (E) or Vulnerable (V)*

2) Listed on the TSC Act as Endangered (E1) or Vulnerable (V)

Latin Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Acacia bynoeana	V	E1	*Acacia bynoeana* is found in central eastern NSW, in the following catchment regions – Hawkesbury/Nepean, Hunter/Central Rivers, Southern Rivers, and Sydney Metropolitan. More specifically it is found 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 (DEC 2005a). It seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and recently burnt patches (DEC 2005a). It grows in sandy clay soils often containing ironstone gravels (Fairley 2004). Main vegetation types include heath or dry sclerophyll forest on sandy soils (DEC 2005a). Associated overstorey species include *Corymbia gummifera*, *Corymbia maculata*, *Eucalyptus parramattensis*, *Banksia serrata* and *Angophora bakeri* (DEC 2005a). Flowering period is mainly summer.	Low. Very marginal habitat for the species is present. All records in the Study Area are to the east in Scribbly Gum Woodland of the Metropolitan Special Area.
Caladenia tessellata	V	E1	*Caladenia tessellata* is found in the Sydney Metropolitan, Southern Rivers, Hawkesbury/Nepean, and Hunter/Central Rivers Catchment Management Regions. Currently known from three disjunct areas: Braidwood on southern tablelands, Ulladulla on the south coast and three populations in Wyong area on the Central Coast (DEC 2005c). It is generally found in grassy, dry sclerophyll forests/woodland, particularly those associated with clay loam, or sandy soils. However, there is one population at Braidwood in lowland on stony soil (DEC 2005c). This species only grows in very dense shrubbery in coastal areas (Bishop 1996). Flowers appear between September and November, but generally late September or early October in extant southern populations (DEC 2005c).	Low. Although some habitat for the species may occur there are no records in the Study Area with the nearest records to the north-east at Loftus.

Latin Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Callistemon linearifolius		V	Occurs chiefly from Georges River to the Hawkesbury River where it grows in dry sclerophyll forest (Harden 2002), open forest, scrubland (Fairley and Moore 2000) or woodland on sandstone. Found in damp places, usually in gullies (Robinson 1994). Flowers in Spring.	Low. Although habitat for the species may occur in the Study Area there are very few records in the Locality with the nearest at Wedderburn to the northeast.
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. The larger populations typically occur in woodland dominated by *Eucalyptus sclerophylla, E. sieberi, Corymbia gummifera* and *Allocasuarina littoralis;* appears to prefer open areas in the understorey of this community and is often found in association with *Cryptostylis subulata* (DEC 2005h).	Low. Although habitat for the species may occur in the Study Area there are no records in the Locality.
Cynanchum elegans	E	E1	Restricted to eastern NSW where it is distributed from Brunswick Heads on the north coast to Gerroa in the Illawarra region. The species has been recorded as far west as Merriwa in the upper Hunter River valley. Catchment Management Regions include Hawkesbury/Nepean , Hunter/Central Rivers, Northern Rivers, Southern Rivers and Sydney Metropolitan (DEC 2005v). *Cynanchum elegans* usually occurs on the edge of dry rainforest vegetation. Other associated vegetation types include littoral rainforest; *Leptospermum laevigatum, Banksia integrifolia* subsp. *integrifolia; Eucalyptus tereticornis* open forest and woodland; *Eucalyptus maculata* open forest and woodland; and *Melaleuca armillaris* scrub to open scrub (DEC 2005v). Flowering occurs between August and May, with a peak in November. Flower abundance on individual plants varies from sparse to prolific (DEC 2005v).	Moderate. There are number of the records of the species near to the Study Area on Razorback Range. Habitat for the species occurs on the south facing slopes to the north of the Study Area in the native vegetation associated with greater shale influence.
Darwinia peduncularis		V	Occurs in the Hawkesbury/Nepean Catchment area, from Hornsby to Hawkesbury River and west to near Glen Davis. It grows in dry sclerophyll forest on sandstone hillsides and ridges. Usually grows on or near rocky outcrops on sandy, well drained, low nutrient soil over sandstone. Flowers in winter to early spring (DEC 2005d).	Low. Although habitat for the species may occur there are not records in the Study Area and very few records in the Locality.

Latin Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Epacris purpurascens var. purpurascens		V	Located in the Hawkesbury/Nepean, Hunter/Central Rivers/and Sydney Metropolitan catchment authority region - from Gosford in the north, to Narrabeen in the east, Silverdale in the west and Avon Dam vicinity in the South (DEC 2005e). *Epacris purpurascens* var. *purpurascens* grows in Dry Sclerophyll forests, scrub and swamps(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 ridge top drainage depressions supporting wet heath within or adjoining shale cap communities (including Shale Sandstone Transition Forest, Turpentine Ironbark Margin Forest, Stringybark/Scribbly Gum Woodland and Scribbly Gum/Grey Gum/Red Bloodwood Woodland). 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 (NPWS 2002e).	Moderate. The Study Area supports are range of preferred habitats for this species including vegetation community, soils and topographic features. There is a high number of records in the south-eastern section of the Locality.
Grevillea parviflora ssp. *parviflora*	V	V	Located in Hawkesbury/Nepean, Hunter/Central Rivers and Sydney Metropolitan Catchment. Sporadically distributed throughout the Sydney Basin with the main occurrence centred in Picton, Appin, Wedderburn and Bargo. Northern populations are found in the Lower Hunter Valley. To the west of Sydney, small populations occur at Kemps Creek & Voyager Point (DEC 2005g). *Grevillea parviflora* ssp. *parviflora* grows on sandy clay loam soils, often with ironstone gravels. Soils are mostly derived from Tertiary sands or alluvium and from the Mittagong Formation with alternating bands of shale and fine-grained sandstones(NPWS 2002b). The species is found on crests, upper slopes or flat plains in both low-lying areas and on higher topography. The plant prefers open habitat conditions with the largest populations in open woodland and along exposed roadside areas (NPWS 2002b). *G. parviflora* subsp. *parviflora* has been recorded in a range of vegetation types from heath and shrubby woodland to open forest. Canopy species vary greatly with community type but generally are species that favour soils with a strong lateritic influence including *Eucalyptus fibrosa, E. parramattensis, Angophora bakeri* and *Eucalyptus sclerophylla* (NPWS 2002b).	Moderate. The Study Area supports are range of preferred habitats for this species including vegetation community, soils and topographic features. There is a high number of records in the south and eastern areas of the Locality.

Latin Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Gyrostemon thesioides		E	Within NSW, has only ever been recorded at three sites, to the west and south of Sydney, near the Colo, Georges and Nepean Rivers. The most recent sighting was of a single male plant near the Colo River within Wollemi National Park. The species has not been recorded from the Nepean and Georges Rivers for 90 and 30 years respectively, despite searches. Also occurs also in Western Australia, South Australia, Victoria and Tasmania. Grows on hillsides and riverbanks and may be restricted to fine sandy soils (DEC 2005h).	Low. Although habitat for the species may occur in the Study Area there are very few records in the Locality. The nearest record of the species was at Douglas Park in 1910.
Leucopogon exolasius	V	V	Occurs in Hawkesbury/Nepean and Sydney Metropolitan Catchment (DEC 2005w), restricted to the Woronora and Grose Rivers (Harden 1991). The plant occurs in woodland on sandy alluvium and rocky sandstone hillsides near creeks, and on low nutrient soils (Powell 2007). Flowering occurs in August and September (Harden 1991). Associated species include *Eucalyptus piperita* and *E. sieberi* and the shrubs *Pultenaea flexilis, Leptospermum trinervium* and *Dillwynia retorta* (Powell 2007).	Low. Although habitat for the species is present most records in the Locality are to the east in Scribbly Gum Woodland of the Metropolitan Special Area.
Melaleuca deanei	V	V	*Melaleuca deanei* occurs in the Hawkesbury/Nepean, Southern Rivers, and Sydney Metropolitan Catchment Management Regions. Distinctly it occurs in the Ku-ring-gai/Berowra and Holsworthy/Wedderburn areas. There are also more isolated occurrences at Springwood (in the Blue Mountains), Wollemi National Park, Yalwal (west of Nowra) and Central Coast (Hawkesbury River) areas (DEC 2005j). The species grows in wet heath on sandstone (Harden 1991). Flowers appear in summer but seed production appears to be small and consequently the species exhibits a limited capacity to regenerate(DEC 2005j).	Low. The Study Area does not support habitat for the species. Although habitat for the species.
Persicaria elatior	V	V	Tall Knotweed has been recorded in south-eastern NSW (Mt Dromedary (an old record), Moruya State Forest near Turlinjah, the Upper Avon River catchment north of Robertson, Bermagui, and Picton Lakes. In northern NSW it is known from Raymond Terrace and the Grafton area (Cherry Tree and Gibberagee State Forests). The species also occurs in Queensland. This species normally grows in damp places, especially beside streams and lakes. Occasionally in swamp forest or associated with disturbance (DEC 2005k).	Low. Although habitat for the species may occur in the Study Area there are very few records in the Locality. The nearest record of the species was at Picton in 1949.

Latin Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Persoonia bargoensis	V	E1	Found in the Sydney Metropolitan and Hawkesbury/Nepean Catchment Authority Regions. 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(DEC 2005l). *P. bargoensis* grows in woodland to dry sclerophyll forest on sandstone and clayey laterite on heavier, well drained, loamy, gravelly soils of the Hawkesbury Sandstone and Wianamatta Shale(NPWS 2000). More specifically, *P.bargoensis* seems to prefer the interfaces between shale-derived soils such as the Blacktown Soil Landscape, the complex soils of the Mittagong Formation (Lucas Heights Soil Landscape), and the underlying sandstone (Hawkesbury and Gymea Soil Landscapes). Some of the vegetation in which *P. bargoensis* occurs can be recognised as the endangered Shale/Sandstone Transition Forest (NPWS 2000). This species seems to benefit from the reduced competition and increased light available on disturbance margins including roadsides (DEC 2005l). Flowering occurs mainly in summer but can extend into autumn(NPWS 2000).	Moderate. The Study Area supports a range of preferred habitats for this species including vegetation community, soils and topographic features. There is a number of records in the south and eastern areas of the Locality.
Persoonia hirsuta	E	E1	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 1998a). 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 2005m).	Moderate. Although there are not a high number of records in the Locality the Study Area supports preferred habitats for this species including vegetation community and soils.

Latin Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Persoonia nutans	E	E1	Occurs in Hawkesbury/Nepean and Sydney Metropolitan Catchment. Restricted to the Cumberland Plain between Richmond in the north and Macquarie Fields in the south. Core distribution occurs within the Penrith LGA, and to a lesser extent, Hawkesbury LGA. Small populations also occur in the Liverpool, Campbelltown, Bankstown and Blacktown LGAs (DEC 2005n). Confined to aeolian and alluvial sediments and occurs in a range of sclerophyll forest and woodland vegetation communities with the majority of individuals occurring within Agnes Banks Woodland or Castlereagh Scribbly Gum Woodland (DEC 2005n). *P. nutans* also occurs on Shale/Gravel Transition Forest and Cooks River Castlereagh Ironbark Forest (DEC 2005n). In Castlereagh Scribbly Gum Woodlands it is found in open woodland with dominant overstorey species being *Angophora bakeri, Eucalyptus sclerophylla* and *Melaleuca decora*. The Agnes Banks Woodlands have a similar array of tree species, with the addition of *Banksia serrata* and *Banksia aemula* (DEC 2005n). *Persoonia nutans* is found on the Agnes Banks and Berkshire Park soil landscapes. Drainage appears to influence the distribution of *P. nutans* as the species is more common on the deeper sands at Agnes Banks. At other locations on the Cumberland Plain it occurs on low rises as opposed to swales or other low lying areas(DEC 2005n).	Low. Although marginal habitat for the species may occur there no records in the Study Area and very few records in the Locality.
Pomaderris brunnea	V	V	*Pomaderris brunnea* is found in a very limited area around the Nepean and Hawkesbury Rivers, including the Bargo area. Occurs in the Central West, Hawkesbury/Nepean, and Hunter/Central Rivers Catchments. Occurs on clay & alluvial soils (Fairley and Moore 1995). In the Hawkesbury/Nepean region, the species is known to be associated with Dry sclerophyll forests (Cumberland, Upper Riverina, Sydney Coastal, Sydney Hinterland, Sydney Sand Flats), Coastal Floodplain Wetlands and Coastal Valley Grassy Woodlands (DEC 2005o).	Moderate. Although there is no records in the Study Area with most records in the Locality to the north, the Study Area supports a range of preferred habitats for this species including vegetation community, soils and physiographic features.

Latin Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Pterostylis saxicola	E	E1	Restricted to western Sydney between Freemans Reach in the north and Picton in the south (Hawkesbury/Nepean and Sydney Metropolitan Catchment) (DEC 2005x). Most commonly found growing in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. The vegetation communities above the shelves where *Pterostylis saxicola* occurs are sclerophyll forest or woodland on shale/sandstone transition soils or shale soils (DEC 2005x). All species of Pterostylis are deciduous and die back to fleshy, rounded underground tuberoids. The time of emergence and withering has not been recorded for this species; however flowering occurs from October to December and may vary due to climatic conditions. The above ground parts of the plant whither and die following seed dispersal and the plant persists as a tuberoid until the next year (DEC 2005x).	Moderate. Although there are no records in the Study Area with one record in the Locality to the south north, the Study Area supports a range of preferred habitats for this species including vegetation community, soils and physiographic features.
Pultenaea aristata	V	V	Restricted to the Woronora Plateau, a small area between Helensburgh, south of Sydney, and Mt Keira above Wollongong. The species occurs in either dry sclerophyll woodland or wet heath on sandstone. Flowering has been recorded in winter and spring (DEC 2005q).	Low. Although habitat for the species is present most records in the Locality are to the east in Scribbly Gum Woodland of the Metropolitan Special Area.
Pultenaea pedunculata		E1	Restricted to the Cumberland Plain and near Merimbula where it grows in dry sclerophyll forest and disturbed sites (Harden 2002). In western Sydney it occurs in three locations: within industrial and residential areas at Villawood and Prestons, and north-west of Appin between the Nepean River and Devines Tunnel No. 2 (NPWS 2002d). Associated with Hawkesbury/Nepean, Southern Rivers and Sydney Metropolitan Catchment areas. It occurs in clay or sandy clay soils (Blacktown soil landscape) on Wianamatta shale, close to localised patches of Tertiary alluvium (Liverpool) or the shale/sandstone influence (west of Appin) (DEC 2005r). At all sites there is a lateritic influence in the soil with characteristic ironstone gravels present (DEC 2005r). This species is known to occur in remnants of Cooks River Clay Plain Scrub Forest (James *et al.* 1999).	Moderate. There is a cluster of records near to the Study Area and the Study Area supports a range of preferred habitats for this species including vegetation community, soils and physiographic features.

Latin Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Syzygium paniculatum	V	V	Subtropical and littoral rainforest on sandy soils or stabilised dunes near the sea (Harden 1991). Found only in NSW, in a narrow, linear coastal strip from Bulahdelah to Conjola State Forest. On the south coast the Magenta Lilly Pilly occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral (coastal) rainforest. On the central coast Magenta Lilly Pilly occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities (DEC 2005u). The species occurs in the Hunter/Central Rivers, Hawkesbury/Nepean, Sydney Metropolitan, and Southern Rivers Catchment Authority Regions	Low. The species is not recorded in the Study Area and records in the Locality are likely to be planted specimens. The Study area doesn't support habitat for the species.
Thelymitra sp. *Kangaloon*	Z		*Thelymitra* sp. *Kangaloon* is a terrestrial orchid endemic to New South Wales, and is known from three locations near Robertson in the Southern Highlands. The swamp habitat in which the species occurs has an extent of occurrence of 300km^2 and an area of occupancy of 10km^2. The three swamps are Butlers Swamp, Stockyard Swamp and Wildes Meadow Swamp, and are all located above what is known as the Kangaloon aquifer. It flowers in late October and early November. The species grows amongst tall sedges and rushes in seasonally swampy sedgeland on grey silty clay loam at 600-700m above sea level (Threatened Species Listing Advice, 2008 20176 /id).	Nil. Although habitat for the species may occur in the Locality the species is highly geographically restricted.

A4.2 Threatened fauna

Table A4.2: Terrestrial fauna listed on the TSC and/or EPBC Acts previously recorded in the Locality

Key: *1) Listed on the EPBC Act as Endangered (E), Vulnerable (V), Migratory (M) or nominated for listing (N)*

2) Listed on the TSC Act as Endangered (E1) or Vulnerable (V)

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Amphibians					
Litoria aurea	Green and Golden Bell Frog	V	E1	Most existing locations for the species occur as small, coastal, or near coastal populations, with records occurring between south of Grafton and northern VIC (NSW Government 2009). The species is found in marshes, dams and stream sides, particularly those containing bullrushes or spikerushes. 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 (NPWS 1999c; White and Pyke 1996), although the species has also been recorded from highly disturbed areas including disused industrial sites, brick pits, landfill areas and cleared land. Breeding usually occurs in summer. Tadpoles, which take approximately 6 weeks to develop, feed on algae and other vegetative matter. Adults eat insects as well as other frogs, including juveniles of their own species (DEC 2005f).	Low. Unlikely to occur in the Study Area.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Litoria littlejohni	Littlejohn's Tree Frog	V	V	The species is distributed along the eastern slopes of the Great Dividing Range from Watagan State Forest near Wyong, south to Buchan in north-eastern VIC. It is not known from coastal habitats (DEH 2005). Occurs in wet and dry sclerophyll forests and heath communities associated with sandstone outcrops between 280 and 1000 m (Barker *et al.* 1995). Littlejohn's Tree Frog prefers permanent and semi-permanent 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. The species breeds in autumn but will also breed after heavy rainfall in spring and summer (NSW Scientific Committee 2000). The species has been recorded calling in all seasons with variously reported peak calling periods (DEH 2005). Eggs are laid in loose gelatinous masses attached to submerged twigs; eggs and tadpoles are most often recorded in slow-flowing pools that receive extended exposure to sunlight (DEW 2007).	Low. Unlikely to occur in the Study Area.
Heleioporus australiacus	Giant Burrowing Frog	V	V	Prefers hanging swamps on sandstone shelves adjacent to perennial non-flooding creeks (Daly 1996; Recsei 1996). Can also occur within shale outcrops within sandstone formations. Known from wet and dry forests and montane woodland in the southern part range (Daly 1996). 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). Spends the majority of its time in non-breeding habitat 20-250m from breeding sites (Penman *et al.* 2008).	Low. Unlikely to occur in the Study Area.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
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 moves 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).	Low. Unlikely to occur in the Study Area.
Birds					
Circus assimilis	Spotted Harrier		V	The Spotted Harrier is found throughout Australia but rarely in densely forested and wooded habitat of the escarpment and coast (NSW Scientific Committee 2010a). Preferred habitat consists of open and wooded country with grassland nearby for hunting. Habitat types include open grasslands, acacia and mallee remnants, spinifex, open shrublands, saltbush, very open woodlands, crops and similar low vegetation. The Spotted Harrier is more common in drier inland areas, nomadic part migratory and dispersive, with movements linked to the abundance of prey species. Nesting occurs in open or remnant woodland and unlike other harriers, the Spotted Harrier nests in trees (Marchant and Higgins 1993).	Moderate.
Haliaeetus leucogaster	White-bellied Sea-eagle	M		A migratory species that is generally sedentary in Australia, although immature individuals and some adults are dispersive (Marchant and Higgins 1993). Found in terrestrial and coastal wetlands; favouring deep freshwater swamps, lakes and reservoirs; shallow coastal lagoons and saltmarshes. It hunts over open terrestrial habitats. Feeds on birds, reptiles, fish, mammals, crustaceans and carrion. Roosts and makes nest in trees (Marchant and Higgins 1993).	Moderate. Species previously recorded near Douglas Park and may utilise the Nepean River corridor.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Hieraaetus morphnoides	Little Eagle		V	The Little Eagle is most abundant in lightly timbered areas with open areas nearby providing an abundance of prey species (NSW Scientific Committee 2009b). It has often been recorded foraging in grasslands, crops, treeless dune fields, and recently logged areas. The Little Eagle nests in tall living trees within farmland, woodland and forests (Marchant and Higgins 1993).	Moderate. Key habitat features required by this species are present in the Study Area.
Apus pacificus	Fork-tailed Swift	M		Almost exclusively aerial (foraging). The fork-tailed swift breeds in Asia but migrates to Australia from September to April (Higgins 1999). Individuals or flocks can be observed hawking for insects at varying heights from only a few metres from the ground and up to 300 metres high (Boehm 1944).	Low. Species may occasionally fly over the Study Area.
Hirundapus caudacutus	White-throated Needletail	M		An aerial species found in feeding concentrations over cities, hilltops and timbered ranges. Breed in Asia (Pizzey and Knight 1997).	Low. Species may occasionally fly over the Study Area.
Ardea alba	Great Egret	M		Terrestrial wetlands, estuarine and littoral habitats and moist grasslands. Inland, prefer permanent waterbodies on floodplains; shallows of deep permanent lakes (either open or vegetated), semi-permanent swamps with tall emergent vegetation and herb dominated seasonal swamps with abundant aquatic flora. Also regularly use saline habitats including mangrove forests, estuarine mudflats, saltmarshes, bare saltpans, shallows of salt lakes, salt fields and offshore reefs. Breeding requires wetlands with fringing trees in which to build nests including mangrove forest, freshwater lakes or swamps and rivers (Marchant and Higgins 1990).	Low.
Ardea ibis	Cattle Egret	M		Occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands (Marchant and Higgins 1990).	Moderate. Species has been previously been recorded in closed grassland within the Study Area.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
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 subalpine 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).	Moderate.
Calyptorhynchus lathami	Glossy Black-cockatoo		V	Inhabits forest with low nutrients, characteristically with key Allocasuarina species. Tends to prefer drier forest types (NPWS 1999b). Often confined to remnant patches in hills and gullies. Breed in hollows stumps or limbs, either living or dead (Higgins 1999).	Moderate. Foraging and breeding habitat present in the Study Area.
Ephippiorhynchus asiaticus	Black-necked Stork		E1	Found in swamps, mangroves and mudflats. Can also occur in dry floodplains and irrigated lands and occasionally forages in open grassy woodland. Nests in live or dead trees usually near water (Pizzey and Knight 1997).	Low.
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)		V	Lives 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).	Recorded. Species recorded in open woodland habitat during the field surveys.
Monarcha melanopsis	Black-faced Monarch	M		A migratory species found during the breeding season in damp gullies in temperate rainforests. Disperses after breeding into more open woodland (Pizzey and Knight 1997).	Low.
Myiagra cyanoleuca	Satin Flycatcher	M		Migratory species that occurs in coastal forests, woodlands and scrubs during migration. Breeds in heavily vegetated gullies (Pizzey and Knight 1997).	Low.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Rhipidura rufifrons	Rufous Fantail	M		Migratory species that prefers dense, moist undergrowth of tropical rainforests and scrubs. During migration it can stray into gardens and more open areas (Pizzey and Knight 1997).	Low.
Anthochaera 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 (NPWS 1999d; Pizzey and Knight 1997). Key eucalypt species include Mugga Ironbark, Yellow Box, Blakely's Red Gum, White Box and Swamp Mahogany. Also utilises: *E. microcarpa, E. punctata, E. polyanthemos, E. mollucana, Corymbia robusta, E. crebra, E. caleyi, C.maculata, E.mckieana, E. macrorhyncha, E. laevopinea* and *Angophora floribunda*. Nectar and fruit from the mistletoes *A. miquelii, A. pendula, A. cambagei* are also eaten during the breeding season (DEC 2005s). Regent Honeyeaters usually nest in horizontal branches or forks in tall mature eucalypts and she-oaks. Also nest in mistletoe haustoria. An open cup-shaped nest is constructed of bark, grass, twigs and wool by the female (DEC 2005s).	Low.
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).	Moderate.
Merops ornatus	Rainbow Bee-eater	M		Usually occurs in open or lightly timbered areas, often near water. Nest in embankments, including banks of creeks and rivers, in sand dunes, in quarries and in roadside cuttings. Breeding occurs from November to January. It has complex migratory movements in Australia. NSW populations migrate north for winter (Higgins 1999).	Moderate.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Daphoenositta chrysoptera	Varied Sittella		V	The Varied Sittella is a sedentary species which inhabits a wide variety of dry eucalypt forests and woodlands, usually with either shrubby understorey or grassy ground cover or both, in all climatic zones of Australia. Usually inhabit areas with rough-barked trees, such as stringybarks or ironbarks, but also in mallee and acacia woodlands, paperbarks or mature Eucalypts (Higgins and Peter 2002; NSW Scientific Committee 2010b). The Varied Sittella feeds on arthropods gleaned from bark, small branches and twigs. It builds a cup-shaped nest of plant fibres and cobweb in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years (NSW Scientific Committee 2010b).	Recorded. Species has been previously recorded in open woodland around the perimeter of the Study Area.
Chthonicola 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 (Blakers *et al.* 1984; NSW Scientific Committee 2008a). 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 (Blakers *et al.* 1984; NSW Scientific Committee 2008a). Home ranges vary from 6-12 hectares (NSW Scientific Committee 2008a).	Recorded. Species has been recorded previously in woodland habitat around the perimeter of the Study Area.
Stagonopleura guttata	Diamond Firetail		V	Found in a range of habitat types including open eucalypt forest, mallee and acacia scrubs (Pizzey and Knight 1997). Often occur in vegetation along watercourses (Higgins *et al.* 2006).	Moderate.
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).	Recorded. Species has been previously recorded on the Razorback Range within the Study Area.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Petroica boodang	Scarlet Robin		V	During the breeding season the Scarlet Robin is found in eucalypt forests and temperate woodlands, often on ridges and slopes. During autumn and winter it moves to more open and cleared areas. It has dispersive or locally migratory seasonal movements. The Scarlet Robin forages amongst logs and woody debris for insects which make up the majority of its diet (NSW Scientific Committee 2009c). The nest is an open cup of plant fibres and cobwebs, sited in the fork of a tree (often a dead branch in a live tree, or in a dead tree or shrub) which is usually more than 2 m above the ground (NSW Scientific Committee 2009c). It is conspicuous in open and suburban habitats (Morcombe 2003).	High. Species has been previously recorded on the Razorback Range within the Study Area.
Glossopsitta pusilla	Little Lorikeet		V	Distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range in NSW, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri. Mostly occur in dry, open eucalypt forests and woodlands. They feed primarily on nectar and pollen in the tree canopy. Nest hollows are located at heights of between 2 m and 15 m, mostly in living, smooth-barked eucalypts. Most breeding records come from the western slopes (NSW Scientific Committee 2008b).	High. Species has been previously recorded on the Razorback Range within the Study Area.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Lathamus discolor	Swift Parrot	E	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). Favoured feed trees include winter flowering species such as Swamp Mahogany *Eucalyptus robusta*, Spotted Gum *Corymbia maculata*, Red Bloodwood *C. gummifera*, Mugga Ironbark *E. sideroxylon*, and White Box *E. albens*. Commonly used lerp infested trees include Grey Box *E. microcarpa*, Grey Box *E. moluccana* and Blackbutt *E. pilularis* (DEC 2005t). This species is migratory, breeding in Tasmania and also nomadic, moving about in response to changing food availability (Pizzey and Knight 1997).	Moderate.
Rostratula australis	Australian Painted Snipe	VM	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 and Higgins 1993).	Moderate.
Gallinago hardwickii	Latham's Snipe	M		Typically found on wet soft ground or shallow water with good cover of tussocks. Often found in wet paddocks, seepage areas below dams (Pizzey and Knight 1997).	Moderate.
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 and Knight 1997). Territories are typically 2000 ha in NSW habitats (DEC 2005b).	Moderate.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Ninox strenua	Powerful Owl		V	The Powerful Owl occupies wet and dry eucalypt forests and rainforests. It may inhabit 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 (Debus and Chafer 1994b; Debus and Chafer 1994a). 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). It has a large home range of between 450 and 1450 ha (DEC 2005p).	Moderate.
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 1999a).	High. Species was recorded during the current surveys.
Mammals					

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Dasyurus maculatus maculatus	Spotted-tailed Quoll (south-eastern mainland)	E	V	Occurs along the east coast of Australia and the Great Dividing Range (Belcher *et al.* 2008). Uses a range of habitats including sclerophyll forests and woodlands, coastal heathlands and rainforests (Dickman and Read 1992). Occasional sightings have been made in open country, grazing lands, rocky outcrops and other treeless areas (NPWS 1999k). 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). 70% of the diet is medium-sized mammals, and also feeds on invertebrates, reptiles and birds. Individuals require large areas of relatively intact vegetation through which to forage (NPWS 1999e). The home range of a female is between 180 – 1000 ha, while males have larger home ranges of between 2000 – 5000 ha. Breeding occurs from May to August (Belcher *et al.* 2008).	Moderate. Key fauna habitats (e.g. suitable den sites) required by this species are present within the Study Area
Petrogale penicillata	Brush-tailed Rock-wallaby	V	E1	Occurs along the Great Dividing Range south to the Shoalhaven, and also occurs in the Warrumbungles and Mt Kaputar. Habitats range from rainforest to open woodland. It is found in areas with numerous ledges, caves and crevices, particularly where these have a northerly aspect. Individuals defend a specific rock shelter, emerging in the evening to forage on grasses and forbs, as well as browse in drier months. Home sizes range from 2-30 ha (Eldridge and Close 1995).	Low.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Mormopterus norfolkensis	Eastern Freetail Bat		V	Distribution extends east of the Great Dividing Range from southern Queensland to south of Sydney (Churchill 1998). Most records are from dry eucalypt forests and woodland. Individuals tend to forage in natural and artificial openings in forests, although it has also been caught foraging low over a rocky river within rainforest and wet sclerophyll forest habitats. The species generally roosts in hollow spouts of large mature eucalypts (including paddock trees), although individuals have been recorded roosting in the roof of a hut, in wall cavities, and under metal caps of telegraph poles. Foraging generally occurs within a few kilometres of roosting sites (Churchill 2008; Hoye *et al.* 2008).	High. Species has been previously recorded in the Nepean River corridor.
Pseudomys novaehollandiae	New Holland Mouse	V		The New Holland Mouse currently has a disjunct, fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. Across the species' range the New Holland Mouse is known to inhabit open heathlands, open woodlands with a heathland understorey, and vegetated sand dunes. The home range of the New Holland Mouse can range from 0.44 ha to 1.4 ha. The New Holland Mouse is a social animal, living predominantly in burrows shared with other individuals. The species is nocturnal and omnivorous, feeding on seeds, insects, leaves, flowers and fungi, and is therefore likely to play an important role in seed dispersal and fungal spore dispersal. It is likely that the species spends considerable time foraging above-ground for food, predisposing it to predation by native predators and introduced species, Breeding typically occurs between August and January, but can extend into autumn.(Threatened Species Scientific Committee 2010).	High. Species has been previously recorded in the Study Area.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Isoodon obesulus obesulus	Southern Brown Bandicoot	E	E1	This species prefers sandy soils with scrubby vegetation and/or areas with low ground cover that are burn from time to time (Braithwaite 1995). A mosaic of post fire vegetation is important for this species (Maxwell *et al.* 1996).	Low.
Phascolarctos cinereus	Koala	N	V	In NSW the Koala mainly occurs on the central and north coasts with some populations in the western region (DEC 2005i). Koalas feed almost exclusively on eucalypt foliage, and their preferences vary regionally (Martin *et al.* 2008). Primary feed trees include *Eucalyptus robusta, E. tereticornis, E. punctata, E. haemostoma* and *E. signata* (DoP 1995). They are solitary with varying home ranges. In high quality habitat home ranges may be 1-2 ha and overlap, while in semi-arid country they are usually discrete and around 100 ha (Martin *et al.* 2008).	High. Species was recorded in open woodland during the current field surveys.
Potorous tridactylus	Long-nosed Potoroo	V	V	Occurs from Queensland to Victoria, normally within 50 km of the coast (Claridge *et al.* 2007). 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. Known to eat fungi, arthropods, fleshy fruit, seeds and plant tissue. It is solitary and sedentary, buts tends to aggregate in small groups. It has two breeding seasons, one in late winter-early spring and the other in late summer (Johnston 2008). This species appears to benefit from a lack of recent disturbance (Claridge *et al.* 2007).	Low.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Occurs along the NSW coast, extending further inland in the north. This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, melaleuca swamps and banksia woodlands. Roosts in large colonies (camps), commonly in dense riparian vegetation. 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).	High. Species has been previously recorded in the Nepean River corridor.
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Occurs from the Queensland border to Ulladulla, with largest numbers from the sandstone escarpment country in the Sydney Basin and Hunter Valley (van dyck and Strahan 2008). Primarily found in dry sclerophyll forests and woodlands, but also found in rainforest fringes and subalpine woodlands (Churchill 2008; Hoye and Schulz 2008). Forages on small, flying insects below the forest canopy. Roosts in colonies of between three and 80 in caves, Fairy Martin nests and mines, and beneath rock overhangs, but usually less than 10 individuals. Likely that it hibernates during the cooler months (Churchill 2008). The only known existing maternity roost is in a sandstone cave near Coonabarabran (Pennay 2008).	Moderate.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Falsistrellus tasmaniensis	Eastern False Pipistrelle		V	Distribution extending east of the Great Dividing Range throughout the coastal regions of NSW, from the Queensland border to the Victorian border. Prefers wet high-altitude sclerophyll and coastal mallee habitat, preferring wet forests with a dense understorey but being found in open forests at lower altitudes (Churchill 2008). Apparently hibernates in winter. Roosts in tree hollows and sometimes in buildings in colonies of between 3 and 80 individuals. Often change roosts every night. Forages for beetles, bugs and moths below or near the canopy in forests with an open structure, or along trails (Law *et al.* 2008). Has a large foraging range, up to 136 ha (Churchill 2008; Law *et al.* 2008). Records show movements of up to 12 km between roosting and foraging sites (Menkhorst and Lumsden 1995).	Low.
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat		V	Occurs from Victoria to Queensland, on both sides of the Great Dividing Range. Forms large maternity roosts (up to 100,000 individuals) in caves and mines in spring and summer. Individuals may fly several hundred kilometres to their wintering sites, where they roost in caves, culverts, buildings, and bridges. They occur in a broad range of habitats including rainforest, wet and dry sclerophyll forest, paperbark forest and open grasslands. Has a fast, direct flight and forages for flying insects (particularly moths) above the tree canopy and along waterways (Churchill 2008; Hoye and Hall 2008).	Moderate. Key fauna habitats (e.g. suitable roosting sites) required by this species are present within the Study Area.

Latin Name	Common Name	EPBC Act[1]	TSC Act[2]	Habitat	Likelihood of occurrence in the Study Area
Myotis macropus	Southern Myotis		V	Scattered, mainly coastal distribution extending to South Australia along the Murray River. Roosts in caves, mines or tunnels, under bridges, in buildings, tree hollows, and even in dense foliage. Colonies occur close to water bodies, ranging from rainforest streams to large lakes and reservoirs. They catch aquatic insects and small fish with their large hind claws, and also catch flying insects (Richards *et al.* 2008).	High. Species has been previously recorded during the field surveys.
Scoteanax rueppellii	Greater Broad-nosed Bat		V	Occurs along the Great Dividing Range, generally at 500 m but up to 1200 m, and in coastal areas. Occurs in woodland and rainforest, but prefers open habitats or natural or human-made openings in wetter forests. Often hunts along creeks or river corridors. Flies slowly and directly at a height of 30 m or so to catch beetles and other large, flying insects. Also known to eat other bats and spiders. Roosts in hollow tree trunks and branches (Churchill 2008; Richards *et al.* 2008).	Low.
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; Webb and Shine 1998).	Low.

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