Metallurgical Coal

ANNEX D
BIODIVERSITY MANAGEMENT PLAN

WEST CLIFF AREA 5
LONGWALLS 37 AND 38 EXTRACTION PLAN

Document No: <ADD No. HERE>

Rev: A

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Review History

Revision	Description of Changes	Date	Approved
P1	New Document	May 2013	
P2	Revised Draft	June 2013	
A	Draft for Agency Comment	June 2013	
A	Final (no further comments)	August 2013	

Persons involved in the development of this document include:

Name	Title	Company
Daniel Thompson	Environmental Planner	Cardno
Danyil Skora	Senior Environmental Planner	Cardno
Gary Brassington	Manager Approvals (Mining)	BHP Billiton Illawarra Coal

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 37 and 38 Extraction Plan for West Cliff Area 5. 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 is defined in accordance with Mine Subsidence Engineering Consultants (MSEC, 2013), as the surface area predicted to be affected by the proposed mining of Longwalls 37 and 38 and encompasses the area bounded by, whichever is the greater of the following limits:

- 35^0 Angle of Draw for the maximum depth of cover, which equates to a horizontal distance of between 320 m and 380 m outside the limit of the proposed extraction area); and
- The 20 mm predicted limit of vertical subsidence, which is generally within the 35^0 Angle of Draw.

Additionally, features sensitive to far-field movements, which includes potential horizontal, valley closure and valley upsidence movements, which may be outside the 20 mm subsidence zone or 35^0 Angle of Draw have been assessed including:

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

Two separate Study Areas have been defined, one for each of the longwalls. The Longwall 37 Study Area is located primarily to the west of the Georges River, with the Longwall 38 Study Area primarily to the east of the Georges River. The Study Area locations are illustrated by **Figure 1** (MSEC, 2013). It is noted that while the Study Areas do traverse the Georges River, neither of the proposed longwalls mine under the River.

1.3 OBJECTIVES

The objectives of this BMP are to identify the biodiversity within the Longwalls 37 and 38 Study Area and to manage the potential impact and/or environmental consequences of the proposed workings on terrestrial and aquatic biodiversity.

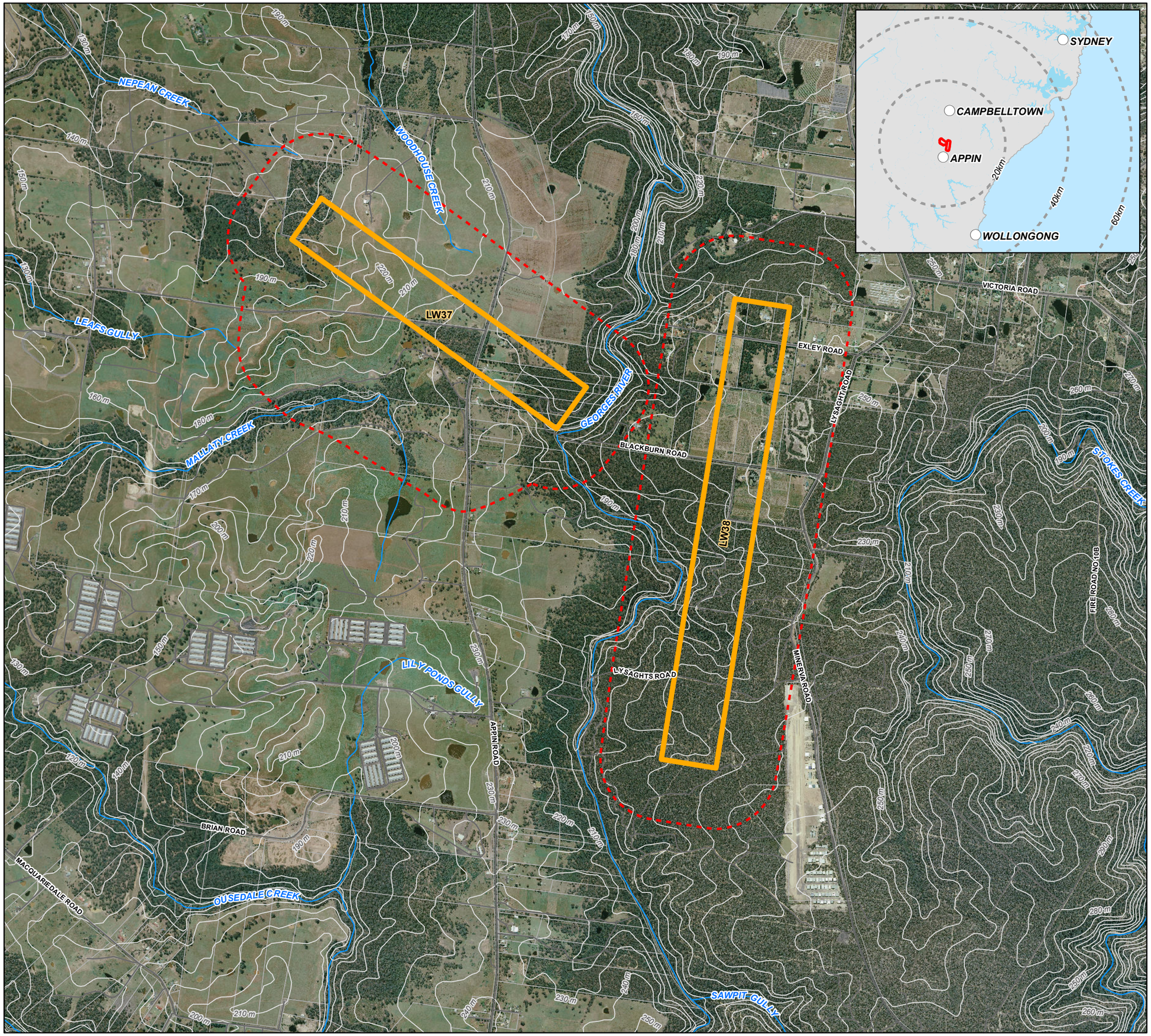
Specific focus will be on threatened species, populations and their habitats; endangered ecological communities; and groundwater dependent ecological communities, as shown in **Figure 2** and **Figure 3** (MSEC, 2013, Drawing 533-07).

1.4 DISTRIBUTION

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

- Department of Planning and Infrastructure (DP&I)
- NSW Trade and Investment - Division of Resources and Energy (DRE)
- OEH
- DPI Fisheries

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



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West Cliff Area 5 Study Areas (LW37 and 38)

Legend

- Study Area
- Local Roads (LPI)
- 10m Contours (LPI)
- Watercourses (LPI)
- Cadastre (LPI)
- West Cliff LW 37 and 38 (BHPBIC 2013)

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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 NSW/ACT Pty Ltd (WOL)
Date: 14/03/2013
Coordinate System: GDA 1994 MGA Zone 56
Project: 112054-01
Map: G1002_WCA5_ExtractionPlan.mxd 03

Aerial imagery supplied by BHPBIC (2007 and 2009)

2 STATUTORY REQUIREMENTS

Extraction of coal from Longwalls 37 and 38 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 licences 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 workings on both 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 5 (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	Section 4 Section 7
(b) a detailed description of the measures that would be implemented to remediate predicted impacts.	
Condition 2 – Schedule 6	
The Proponent shall ensure that the management plans required 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 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;	Section 6
(d) a program to monitor and report on the:	
- impacts and environmental performance of the project;	Section 8
- effectiveness of any management measures (see c above);	

Project Approval Condition	*Relevant BMP Section*
(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 10
(f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Section 9
(g) a protocol for managing and reporting any: - incidents; - complaints; - non-compliances with statutory requirements; and - exceedances of the impact assessment criteria and/or performance criteria; and	Section 10
(h) a protocol for periodic review of the plan.	

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 conforms to the requirements of the relevant legislation and guidelines under the following acts:

- (Federal) *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 apply to BHPBIC's operations in West Cliff Area 5:

- Mining Leases as per **Table 2.2** – West Cliff Leases, Licences and other Reference Documents.
- 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.environment.nsw.gov.au/poeo.
- West Cliff Mining Operations Plan (MOP) July 2007 to June 2014.
- All relevant OH&S and HSEC approvals.
- Any additional leases, licences of approvals resulting from the BSO Approval.

Table 2.2 – West Cliff Leases, Licences and other Reference Documents

Mining Lease - Document Number	Issue Date	Expiry Date/ Anniversary Date
CCL 724	4 July1991	26 October 2011 (renewal pending)
Part CCL 767	29 October 1991	September 2010 (renewal pending)
CCL 381	24 October 1991	23 October 2012 (renewal pending)
ML 1678	27 September 2012	26 September 2033
MPL 200	13 January 1982	13 January 2024
MPL 201	13 January 1982	13 January 2024

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 37 and 38 Study Area.

Supplementary field surveys for terrestrial biodiversity, titled, *West Cliff Longwalls 37-38 Extraction Plan – Terrestrial Flora and Fauna Assessment* (Niche, 2013) (refer **Attachment A**) and aquatic biodiversity, titled, *West Cliff Longwalls 37 and 38 – Aquatic Flora and Fauna Assessment* (Cardno Ecology Lab, 2013) (refer **Attachment B**) were undertaken for the purposes of this Extraction Plan.

3.1 TERRESTRIAL BIODIVERSITY

A total of 142 plant species were recorded across the Study Area. Ten weed species were recorded, none of which were listed as noxious weeds requiring removal. The Flora species recorded in the Study Area are provided in **Figure 2** Niche (2013), included as **Attachment A**.

3.1.1 Vegetation Communities

Five vegetation communities have been mapped as occurring within the Study Area by previous investigations undertaken by Tozer et al, 2010 (*Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands*). Descriptions of each vegetation community have been included in **Table 3.1** .

Of the five vegetation communities previously mapped within the Study Area, three are equivalent to Threatened Ecological Communities (TECs):

- Cumberland Shale Sandstone Transition Forest is equivalent to Shale Sandstone Transition Forest (SSTF), which is listed as a TEC under TSC Act and EPBC Act.
- Cumberland Shale Plains Woodland, which is equivalent to Cumberland Plain Woodland (CPW), which is listed as a Critically Endangered Ecological Community under the TSC Act and EPBC Act.
- Cumberland Shale Hills Woodland is equivalent to CPW, which is listed as a Critically Endangered Ecological Community under the TSC Act and EPBC Act.

Table 3.1 describes the communities present and their conservation status. Further descriptions of the vegetation communities are detailed in Niche (2013), located at **Attachment A**.

Table 3.1 – Vegetation community descriptions within the study area

Vegetation Community	Description	Conservation status	Area within Locality (ha)	Area within Study Area (ha)
Cumberland Shale Plains Woodland	Cumberland Shale Plains Woodlands, an Eucalypt woodland with an open shrub layer and grassy groundcover. It occurs on clay-loam soils derived from Wianamatta shale and is restricted to the Cumberland Plain, western Sydney. Dominant trees include: Eucalyptus moluccana, E. tereticornis. Shrubs: Bursaria spinosa. Climbers: Glycine tabacina, G. clandestina. Groundcover: Dichondra repens, Cheilanthes sieberi, Aristida vagans, Microlaena stipoides, Themeda australis, Brunoniella australis, Desmodium gunnii, Opercularia diphylla, Wahlenbergia gracilis, Dichelachne micrantha, Paspalidium distans, Eragrostis leptostachya, Lomandra filiformis, L. multiflora, Dianella longifolia, Oxalis perennans, Euchiton sphaericus, Goodenia hederacea, Aristida ramosa, Arthropodium milleflorum, Austrodanthonia tenuior, Cymbopogon refractus and Echinopogon caespitosus.	**NSW:** Critically Endangered **Commonwealth:** Critically Endangered	245.47	1.09
Cumberland Shale Hills Woodland	An Eucalypt woodland with an open shrub layer and grassy groundcover, restricted to clay-loam soils derived from Wianamatta Shale on the southern half of the Cumberland Plain, western Sydney. Cumberland Shale Hills Woodland is closely related to Cumberland Shale Plains Woodland (GW p29) but typically occurs on steeper and more undulating terrain. It is found from 50 – 350m ASL in areas receiving 750 – 900 mm mean annual rainfall. Trees: Acacia implexa, Eucalyptus moluccana, E. tereticornis. Shrubs: Bursaria spinosa, Rubus parvifolius. Climbers: Clematis glycinoides, Glycine tabacina. Groundcover: Dichondra repens, Brunoniella australis, Desmodium gunnii, Aristida ramosa, Microlaena stipoides, Carex inversa, Themeda australis, Cyperus gracilis,Dichelachne micrantha, Asperula conferta, Oxalis perennans, Cheilanthes sieberi, Desmodium brachypodum, Sporobolus creber, Wahlenbergia gracilis.	**NSW:** Critically Endangered **Commonwealth:** Critically Endangered	432.30	2.00
Hinterland Sandstone Gully Forrest	An open Eucalypt forest, dominated by Angophora costata, Corymbia gummifera, Banksia serrata and Eucalyptus piperita in the canopy. An abundant sclerophyll shrub stratum is dominated by Persoonia linearis, P. levis, Phyllanthus hirtellus, Leptospermum trinervium, Lomatia silaifolia, Banksia spinulosa, Platysace linearifolia, Ceratopetalum gummiferum, Acacia ulicifolia and Acacia terminalis. The groundcover is dominated by sedges, with the following species occurring Entolasia stricta, Pteridium esculentum, Dianella caerulea, Smilax glyciphylla, Xanthosia pilosa, Lomandra longifolia, Lepidosperma laterale and Lomandra obliqua. Hinterland Sandstone Gully Forest occurs on lower slopes of dry sandstone gullies up to 600m ASL where average annual rainfall ranges from 850 to 1300 mm.	**NSW:** Not Listed **Commonwealth:** Not Listed	5695.14	31.00

Vegetation Community	Description	Conservation status	Area within Locality (ha)	Area within Study Area (ha)
Sydney Hinterland Transition Woodland	Described by Tozer et al. (2010) as an Eucalypt woodland with an open understorey of sclerophyll shrubs, sedges, forbs and grasses. Dominant trees: Corymbia gummifera, Eucalyptus punctata, Angophora costata and Syncarpia glomulifera. Shrubs: Phyllanthus hirtellus, Persoonia linearis, Leptospermum trinervium, Acacia ulicifolia, Persoonia levis, Acacia linifolia, Banksia spinulosa and Pimelea linifolia. Groundcover: Entolasia stricta, Lomandra obliqua, Pomax umbellata, Themeda australis, Lomandra multiflora, Lepidosperma laterale, Dianella revoluta, Austrostipa pubescens and Goodenia hederacea. This vegetation shares similar characteristic and diagnostic species with Shale Sandstone Transition Forest. Vegetation assessed during the survey consisted of species that resembled that of SHTW.	**NSW:** Not Listed **Commonwealth:** Not Listed	3006.37	265.53
Cumberland Shale Sandstone Transition Forrest	Described by Tozer et al. (2010) as an Eucalypt forest or woodland with a mixed understorey of sclerophyll shrubs and grasses. Dominant canopy species: Eucalyptus crebra, Eucalyptus fibrosa, Allocasuarina littoralis and Eucalyptus punctata. Dominant shrubs: Persoonia linearis, Bursaria spinosa, Ozothamnus diosmifolius and Hibbertia aspera. Groundcover: Lepidosperma laterale, Cheilanthes sieberi, Aristida vagans, Pratia purpurascens, Microlaena stipoides, Entolasia stricta, Lomandra multiflora, Themeda australis, Panicum simile, Echinopogon caespitosus, Pomax umbellata, Dichondra spp., Billardiera scandens and Opercularia diphylla. This plant community is equivalent to Shale Sandstone Transition Forest, an EEC listed under both the TSC and EPBC Acts.	**NSW:** Endangered **Commonwealth:** Endangered	2624.34	78.29

3.1.2 Threatened Ecological Communities

Two TECs (SSTF and CPW) have been previously mapped within the Study Area as described above in **Section 3.1.1**. Both TECs were recorded away from areas that are more likely to be susceptible to subsidence impacts as identified by MSEC (2013), being the riparian zones and the edges of the Georges River valley (Niche, 2013).

3.1.3 Threatened Flora

One threatened flora species was recorded during the current field survey: *Grevillea parviflora* subsp. *Parviflora,* which was located throughout the Dharawal State Conservation Area, Crown Land and common along transmission lines in the Study Area. The population within the State Conservation Area was extensive and would consist of thousands of individuals. The species was recorded within Sydney Hinterland Transition Woodland and was dominant in the understorey. This species was also recorded by FloraSearch (2009) (Niche, 2013).

A total of 31 threatened flora, as listed by the TSC Act and/or the EPBC Act, were considered in this assessment (refer to **Attachment A**).

Persoonia hirsuta has previously been recorded within the Study Area (OEH 2013). The recorded location is above Longwall 38. However, this species was not recorded during the current survey. No other threatened flora species have been previously recorded in the Study Area.

The locations of those threatened flora species recorded during the field survey are illustrated in **Figure 2**.

Thirteen threatened flora species have potential habitat within the Study Area (Niche, 2013), all of which have a moderate to high likelihood of occurrence within the Study Area, as follows:

- *Acacia bynoeana*
- *Acacia pubescens*
- *Callistemon linearifolius*
- *Epacris purpurascens var. purpurascens*
- *Grevillea parviflora ssp. parviflora*
- *Leucopogon exolasius*
- *Melaleuca deanei*
- *Persoonia bargoensis*
- *Persoonia hirsuta*
- *Persoonia nutans*
- *Pimelea spicata*
- *Pomaderris brunnea*
- *Pultenaea aristata*

These species are considered further in the impact assessment (refer to **Section 4.1**).

3.1.4 Threatened Fauna

One threatened fauna species was recorded in the Study Area and immediate surrounds. The Glossy Black Cockatoo was recorded in the Study Area to the east of Longwall 37. **Figure 3** shows known occurrences of threatened species in the locality. Fauna recorded during the field survey includes: two amphibians, 24 birds, six mammals and three reptiles, with one threatened fauna species – Glossy Black Cockatoo, recorded during the field survey (Niche, 2013). When combined with the results of the Biosphere (2009) survey, nine amphibians, 41 birds, 17 mammals and seven reptiles have been recorded in total.

A total of 59 threatened fauna have previously been recorded (Atlas of NSW Wildlife) or are predicted to have habitat (EPBC Act) within 10 km of the Study Area (refer to **Attachment A**, Appendix 3). After considering the habitat present within the Study Area and the results of the field survey and previous studies, 43 of these threatened fauna were considered to have a moderate likelihood of occurrence within the Study Area (Niche, 2013).

The following threatened fauna species have been previously recorded in the Study Area (OEH, 2013): Scarlet Robin, Varied Sittella, Little Lorikeet, Little Eagle, Grey-headed Flying Fox and Koala.

The Spotted-tail Quoll was previously recorded immediately outside of the Study Area to the south of Longwall 38 (OEH, 2013). Potential habitat for the Spotted-tail Quoll occurs within the Study Area along the Georges River.

No threatened amphibians were recorded during the current survey or previous surveys in the Study Area by FloraSearch (2009). Potential habitat occurs along the Georges River for Red-crowned Toadlet, Giant Burrowing Frog, Littlejohn's Treefrog, and Green and Golden Bell Frog.

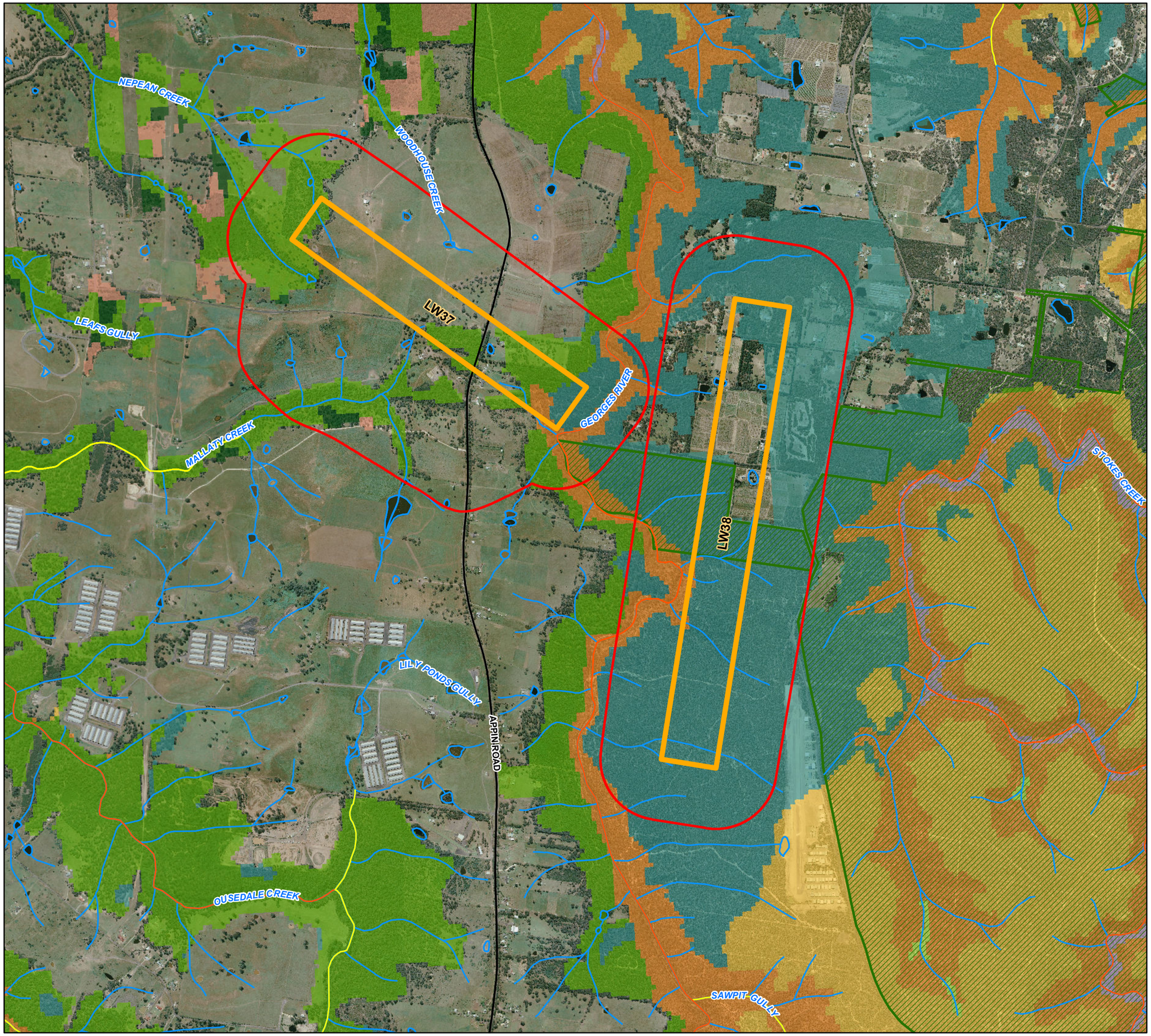
Sufficient hollows, rock crevices and outcrops were located along the Georges River and provide habitat for threatened microbats including: Eastern False Pipistrelle, Large-eared Pied Bat, Eastern Bentwing-bat and Little Bentwing-bat (Niche, 2013).

3.1.5 State Environmental Planning Policy 44 - Koala Habitat Protection

State Environmental Planning Policy 44 - Koala Habitat Protection (SEPP 44) aims to encourage the conservation and management of areas of natural vegetation that provide potential habitat for koalas.

SEPP 44 applies to land within the Wollondilly LGA. Under this policy, a determination of 'potential' and 'core' habitat must be defined at the site of development. The determination is based on previous koala records, Eucalypt species present, condition of the site, presence and quality of adjoining vegetation, and size of the area.

The proposal is unlikely to cause fragmentation to koalas potentially occupying the area, or a loss of habitat features (Niche, 2013).



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Native Vegetation Plan

WESTCLIFF AREA 5
LW 37 and 38

Legend

- Study Area
- Major Roads (LPI)
- Watercourse (MSEC, 2013)
- 3rd Order Watercourse (MSEC, 2013)
- 4th Order Watercourse (MSEC, 2013)
- West Cliff LW 37 and 38 (BHPBIC 2013)
- NPWS Reserve (LPI)

Native Vegetation (SCIVI, 2013)

- Coastal Sandstone Ridgetop Woodland
- Coastal Upland Swamp
- Cumberland Shale Hills Woodland
- Cumberland Shale Plains Woodland
- Cumberland Shale Sandstone Transition Forest
- Hinterland Sandstone Gully Forest
- Sandstone Riparian Scrub
- Sydney Hinterland Transition Woodland

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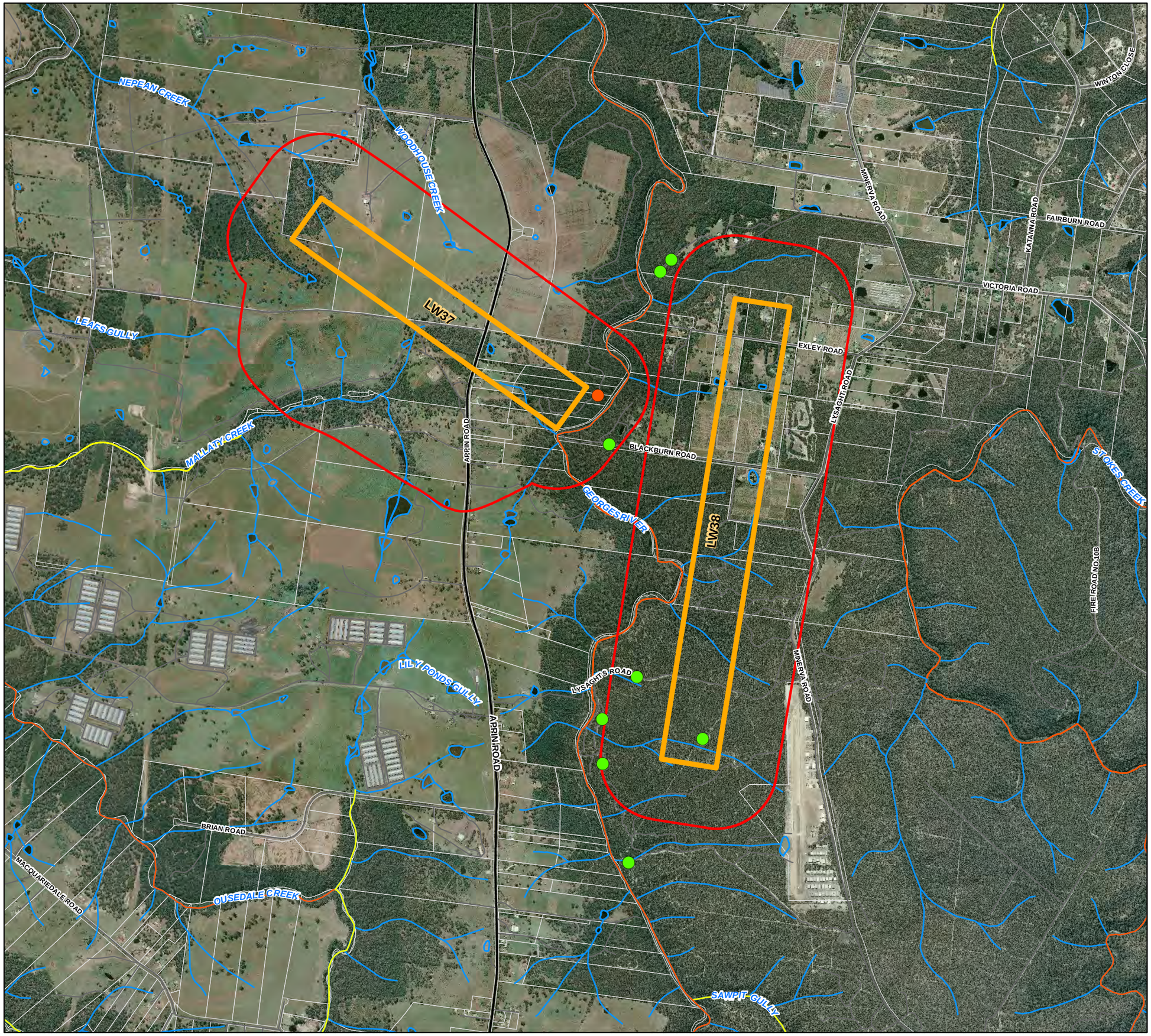
Scale 1:20,000 (at A3)

FIGURE 2

Metres
0 250 500 750 1,000

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 30/05/2013
Coordinate System: GDA 1994 MGA Zone 56
Project: 112054-01
Map: G1008_NativeVegetationMapping.mxd 01



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Flora & Fauna Occurences

WESTCLIFF AREA 5
LW 37 and 38

Legend

- Study Area
- Major Roads (LPI)
- Watercourse (MSEC, 2013)
- 3rd Order Watercourse (MSEC, 2013)
- 4th Order Watercourse (MSEC, 2013)
- West Cliff LW 37 and 38 (BHPBIC 2013)

Threatened Biodiversity (Niche, 2013)

- Fauna (Glossy Black Cockatoo)
- Flora (Grevillea parviflora)

N
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Scale 1:20,000 (at A3)

FIGURE 3

Metres
0 250 500 750 1,000

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 30/05/2013
Coordinate System: GDA 1994 MGA Zone 56
Project: 112054-01
Map: G1009_FloraFaunaSites.mxd 01

Aerial imagery supplied by BHPBIC (2007 and 2009)

3.2 AQUATIC BIODIVERSITY

3.2.1 The Georges River

The section of the Georges River within the Study Area comprises a series of pools and rockbars, with the upstream sections characterised by long shallow pools connected by sections of shallow flow over bedrock (Cardno Ecology Lab, 2013). Downstream of the Study Area are deeper pools varying in length from 5 m to 337 m, with connecting flow through boulder fields (MSEC 2013). These pools are generally connected, but can become disconnected during dry weather with some drying up completely or partially (MSEC, 2013).

Rockbars along this section vary in length from 5 m to 80 m and are generally low with many being exposed during moderate flows. Licensed discharges from Appin and West Cliff Collieries are the main source of flow in this section of river, with recent flows averaging 0.3 ML/day and 4 ML/day respectively (MSEC 2013). The river also receives occasional inflows from Brennans Creek Dam when this overtops during large rainfall events.

The substratum comprises large areas of sandstone bedrock, accumulations of sand and silt within pools, as well as sections of boulder and cobble and some riffle sections. There are also several dense beds of aquatic macrophytes and accumulations of woody debris within the river (Cardno Ecology Lab, 2013) The aquatic habitat of the Study Area is comparable with that in GR1 and GR2 as established by Bioanalysis (2009), (Cardno Ecology Lab, 2013).

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 B.** 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 ephemeral watercourses, which provide only limited aquatic habitat (Cardno Ecology Lab, 2012). The upper reaches of Mallaty Creek are subject to modified flow due to farm dams and mine-subsidence impacts (Bioanalysis, 2009).

After an extended dry period in May 2010, no water was observed at aquatic ecology monitoring Site 12 on Mallaty Creek (Cardno Ecology Lab, 2010). In November 2011, the aquatic habitat at this site consisted of two small pools with no observable flow, despite recent rainfall, reflecting the ephemeral nature of the watercourse (Cardno Ecology Lab, 2013).

The catchments of Woodhouse Creek and Nepean Creek have been developed as cattle pasture, so most of the native vegetation has been cleared and only thin bands of riparian vegetation remain (Cardno Ecology Lab, 2013).

3.2.3 Aquatic Vegetation

In-stream recording by Cardno Ecology Lab and in-stream and riparian zone observations made by Bioanalysis (2009) found at least 20 species of macrophytes in the reach of the Georges River, within and upstream of the Study Area, (Cardno Ecology Lab, 2013).

The Ecology Lab (2002a; 2005d; 2008d) noted that Cumbungi (*Typha spp*.) was the dominant in-stream macrophyte in the reach of the Georges River between its confluence with Brennans Creek and Marhynes Hole, but *Potamogeton tricarinatus* (synonym *sulcatus*), *Juncus usitatus, Isolepis prolifera* and various emergent grasses were also present (Cardno Ecology Lab, 2012). Cardno Ecology Lab (2013) found that Cumbungi (*Typha sp*.) spike

rush (*Juncus sp*.) and clubrush (*Isolepsis sp*.) were relatively abundant in the section of the Georges River within and adjacent to the Study Area.

Bioanalysis (2009) found that the emergent macrophytes, Tall Spikerush (*Eleocharis sphacelata*) and Cumbungi (*Typha orientalis*), and submerged macrophyte *Potamogeton sulcatus*, were relatively abundant at GR1 in spring 2008 and that a large stand of *Typha domingensis* was present at GR2 in autumn 2008 (Cardno Ecology Lab, 2013).

3.2.4 Aquatic Macroinvertebrates

Macroinvertebrate abundance can be used as an indicator of stream health. Several different sampling methods have been used, to collect macroinvertebrate data. The timed kick technique undertaken by Jarvis (1997) identified 122 taxa from 79 macroinvertebrate families at nine sites in the upper river on five occasions between 1995 and 1996 (Cardno Ecology Lab, 2013). Dytiscid beetles, a pollution tolerant taxon, dominated the fauna at six of the study sites and accounted for 40% of the animals sampled (Cardno Ecology Lab, 2013). Jarvis (1997) found that macroinvertebrate diversity and abundance increased downstream to Marhynes Hole but decreased below this location. The structure of assemblages at upstream sites differed from that found downstream, but it was not clear whether this was due to a change in altitude or water quality (Cardno Ecology Lab, 2013).

MPR (1999) used random dip net sweeps of riffle and pool edges to sample the aquatic macroinvertebrates occurring at 10 sites up and downstream of Marhnyes Hole in the Georges River. Sampling was conducted once with Coleopteran beetles the most common taxa recorded (Cardno Ecology Lab, 2013).

AUSRIVAS sampling in the Georges River adjacent to and upstream of The Study Area identified a total of 117 taxa since 2002 (Cardno Ecology Lab, 2013), with differences occurring in the overall health of the macroinvertebrate fauna along the Georges River as illustrated in **Table 3.2** . The taxa identified are detailed in **Attachment B**.

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

Date	Site	Taxa Observed	AUSRIVAS Condition
May 2007	1	17	B
	2	18	B
	3	17	B
	4	21	B
	5	18	B
	6	19	B
	7	27	A
	8	-	-
	9	-	-

Date	Site	Taxa Observed	AUSRIVAS Condition
	10	25	B
	11	20	B
	12	20	A
May 2008 (Upstream of Study Area)	GR1-1	5 per site	C
	GR1-2	9 per site	C
September 2008	1	18	B
	2	22	B
	3	19	B
	4	25	B
	5	24	B
	6	25	B
	7	22	A
	8	20	B
	9	25	B
	10	31	A
	11	23	A
	12	25	A
December 2008	GR2-1	12 per site	C
	GR2-2	21 per site	B
May 2010	1	22	B
	2	24	B
	3	18	B
	4	21	B
	5	26	A
	6	14	C

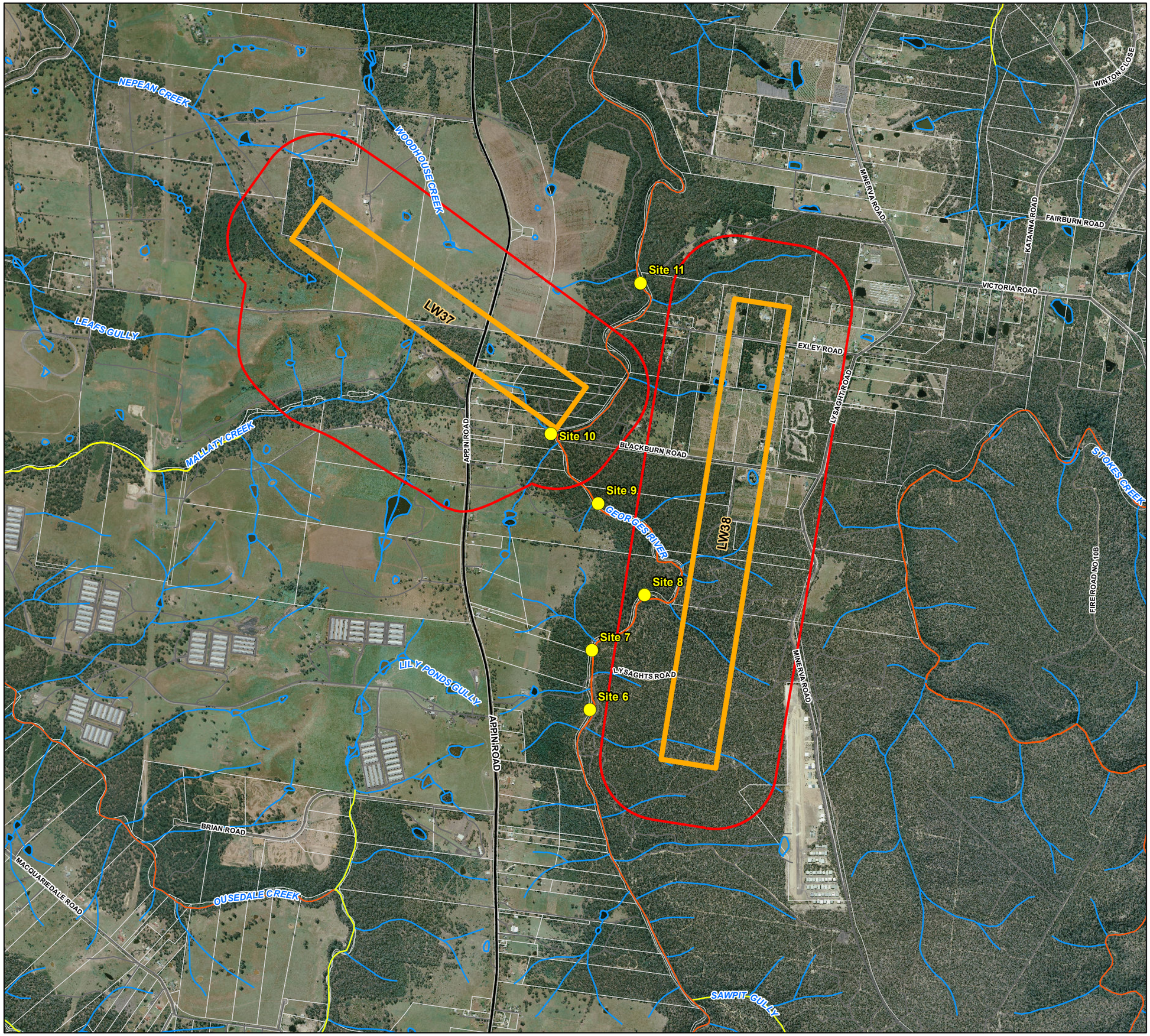
Date	Site	Taxa Observed	AUSRIVAS Condition
	7	21	B
	8	25	B
	9	24	A
	10	23	B
	11	19	B
	12	No water	No Water

3.2.5 Fish

A number of surveys have been undertaken in the stretch of the river adjacent to West Cliff Area 5 between March 2002 and November 2011 (Cardno Ecology Lab, 2013). These surveys recorded the following species:

- May 2002, March 2005 and September 2008:
  - Long-finned eel
  - Eastern gambusia
  - Fire-tailed gudgeon,
- May 2010:
  - Eastern gambusia
  - Fire-tailed gudgeon
- November 2011:
  - Long-finned eel
  - Eastern gambusia
  - Fire-tailed gudgeon
  - Coxs's gudgeon (*Gobiomorphus coxii*)
  - Lake's carp gudgeon (*Hypseleotris sp. 5*)
  - Freshwater crayfish (*Family Parastacidae*) (observed)
  - Freshwater shrimp (*Family Atyidae*) (observed)
  - Flathead gudgeon was the only species recorded in Mallaty Creek (The Ecology Lab 2003).

Liverpool Weir along with a further 77 barriers to fish passage on the Georges River upstream of Liverpool, including road culverts, weirs, piped sections and levees has resulted in the fish fauna of the Study Area being much less diverse than anticipated (Cardno Ecology Lab, 2013). These barriers to upstream migration are likely to have resulted in species that migrate between freshwater and the sea to breed becoming locally extinct (Cardno Ecology Lab, 2013). Further detail about where each of these fish species has been observed is provided in **Attachment B**.



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ILLAWARRA COAL

Ecology Watercourse Monitoring Locations

WESTCLIFF AREA 5
LW 37 and 38

Legend

- Study Area
- Aquatic Ecology Sampling Sites (Cardno Ecology Lab, May 2012
- Major Roads (LPI)
- Watercourse (MSEC, 2013)
- 3rd Order Watercourse (MSEC, 2013)
- 4th Order Watercourse (MSEC, 2013)
- West Cliff LW 37 and 38 (BHPBIC 2013)

N
W E
S

Scale 1:20,000 (at A3)

FIGURE 4

Metres
0 250 500 750 1,000

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 28/05/2013
Coordinate System: GDA 1994 MGA Zone 56
Project: 112054-01
Map: G1007_EcologyWatercourseMonitoringLocations.mxd 01

Aerial imagery supplied by BHPBIC (2007 and 2009)

3.2.6 Threatened Species

A database search by Cardno Ecology Lab (2013) indicates that the following threatened aquatic species or their habitats could potentially occur in the Study Area:

- Adams emerald dragonfly (*Archaeophya adamsi*)
- Sydney hawk dragonfly (*Austrocordulia leonardi*)
- Macquarie perch (*Macquaria australasica*).

All three species are listed as Endangered under the FM Act and the Macquarie perch is also listed as Endangered under the EPBC Act (Cardno Ecology Lab, 2013). Cardno Ecology Lab (2013) considers that given the characteristics of the Study Area it is possible, but unlikely that there is a viable local population of Sydney hawk dragonfly. Furthermore, the section of the Georges River within the vicinity of West Cliff Area 5 does not contain appropriate riffle habitat for the Adam's emerald dragonfly and it is therefore, unlikely to be present.

There are no records of Macquarie perch occurring in the upper Georges River in the vicinity of West Cliff Area 5, despite the extensive fish surveys undertaken. Cardno Ecology Lab (2013) consider that the presence of numerous barriers to fish passage in the Upper Georges River suggests that Macquarie perch are unlikely to be present in the reach of the Georges River adjacent to West Cliff Area 5.

3.2.7 Protected Species

There have been sightings of platypuses, which are a protected species in the upper Georges River and its tributary streams (Grant 2002; Grant et al. 2008). Additionally, there is also a record of a platypus from the section of the Georges River that flows through the West Cliff Area 5 domain (Cardno Ecology Lab, 2013).

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 37 and 38 Study Area. The maximum predicted subsidence, upsidence and closure are outlined in **Table 4.1**.

Table 4.1 – Maximum Predicted Subsidence Effects for Georges River, Mallaty and Nepean Creeks (MSEC, 2013)

Feature	Subsidence (mm)	Upsidence (mm)	Closure (mm)	Tilt (mm/m)
Georges River	**100**	**190**	**220**	**0.9**
Mallaty Creek	**1125**	**675**	**725**	**4.9**
Nepean Creek	**850**	**130**	**75**	**3.9**

4.1.2 Subsidence Impacts

Subsidence impacts on natural features as identified in MSEC (2013) are summarised in the Land Management Plan. Additionally, a summary of these impact predictions that could have environmental consequences for terrestrial biodiversity are provided in **Table 4.2** below.

Table 4.2 – Predicted Impacts to Natural Surface Features as a Result of Subsidence for Longwalls 37 and 38 (MSEC, 2013)

Natural Surface Feature	Predicted Impacts Due to Subsidence
Georges River	• Fracturing of rockbars and the stream bed where the subsidence movements are predicted to be highest • Changes in grade of drainage lines are considered small in comparison to natural grades. This is unlikely to result in significant increases in ponding or flooding, although some very localised impacts may occur • Diversion of surface water flows where fracturing coincides with a water controlling feature e.g. roc bar.
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 or flooding, although some very localised impacts may occur • Some compressive buckling and dilation of the uppermost bedrock could occur. However, the natural surface soil beds would limit exposure of fracturing at the surface and any minor occurrences are likely to be filled with the natural soils during subsequent flow events.
Cliffs	• Possible for rock falls from cliffs • Low risk of cliff failures as there is no longwall mining directly beneath cliffs.
Rocky Outcrops	• Fracturing is possible to a small percentage of rock outcrops where located directly above Longwalls.
Steep Slopes	• Minor cracking at the tops of steep slopes where the longwall mines directly beneath steep slopes.

The majority of the Study Area comprises open pasture grasslands, woodland and forest, which are unlikely to be impacted by subsidence related impacts.

Flora and fauna can potentially be impacted by subsidence within the alignments of streams. Flora could be adversely affected by the emission of gas at the surface; and habitats can be affected by the fracturing of bedrock and the cracking of soils (MSEC, 2013).

Other impacts on cliff and steep slope stability are difficult to assess based on predicted ground movements, as it is dependent on a number of factors that are difficult to quantify. According to MSEC (2013), based on the history of mining at West Cliff, Appin and Tower Collieries, it is possible that isolated rock falls could occur as a result of the extraction of the proposed longwalls. However, it is not expected, that any large cliff instabilities would occur as a result of the extraction, as the longwalls are not proposed to be extracted directly beneath the cliffs. This prediction is also supported by the results of previous mining in the Southern Coalfield. Based on the results of past mining it would be expected that the incidence of impacts on cliffs and the rock outcrops in the Study Area would also be small if the actual movements exceeded those predicted.

The majority of the steep slopes along the Georges River valley and associated tributaries are not directly mined beneath by the proposed longwalls. It is likely, therefore, that only minor cracking would occur near the tops of these steep slopes. Impacts from slope instability are unlikely to impact terrestrial flora and fauna except for small areas of any cracking. Impacts on watercourses within the Study Area are discussed at **Section 4.2.2** below.

4.1.3 Environmental Consequences

Table 4.3 compares the potential consequences as determined in the BSO EA to the residual risk determined by Niche (2013) for the Longwalls 37 and 38 Study Area. Where residual risk differs from that within the BSO EA the reason for the difference is provided.

Potential impacts as assessed by Niche (2013) are largely consistent with those outlined in the BSO EA. Generally the risks are lower in the Longwalls 37 and 38 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.

Table 4.3 – 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	Riparian vegetation • Localised minor floristic changes	Impacts to riparian vegetation are unlikely, and if they occur, are likely to be localised minor floristic changes.
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. Water habitats: • Impacts to water habitat unlikely to result in impacts to fauna.	Open pasture grasslands, woodland and forest habitat makes up the majority of the Study Area, which is unlikely to be impacted by subsidence related impacts. Micro-habitat features such as tree hollows and exfoliating bark are unlikely to be impacted. Fracturing and cracking of the surface may result in the formation of pitfall traps which may cause harm to some fauna. However, given the remediation measures proposed, and the low likelihood of occurrence, impacts to fauna as a result of surface cracking are likely to be negligible.

Potential impact assessed	Level of impact according to FloraSearch (2009), Biosphere (2009) and BSO EA	Level of impacts based on Current Survey
Threatened flora	No significant impacts on threatened flora species predicted.	Threatened flora species are not likely to be significantly impacted
Threatened fauna	No significant impacts on threatened fauna species predicted.	Threatened fauna species are not likely to be significantly impact.
Koala habitat	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.	The proposal is unlikely to cause fragmentation or loss of habitat suitable for koalas.
Spread of amphibian Chytrid Fungus and impacts on frog species	NA	Subsidence is unlikely to result in the introduction of disease, including the spread of *amphibian chytrid fungus*.
Infection of Native Plants by *Phytophthora cinnamomi*	NA	Subsidence is unlikely to result in the introduction of disease, including the spread of *Phytophthora cinnamomi*.

4.2 AQUATIC BIODIVERSITY

4.2.1 Subsidence Effects

Refer to **Section 4.1.1**

4.2.2 Subsidence Impacts

The proposed longwalls do not mine directly beneath the Georges River, with Longwall 37 being a minimum of 20 m from the centreline of the Georges River; and Longwall 38 a minimum distance of 45 m (MSEC, 2013) (refer to **Figure 1**). In addition to the Georges River, the other creeks within the Study Area are:

- Mallaty Creek and its tributaries (MSEC reference numbers MC3, MC4 and MC5)
- Nepean Creek and its tributaries (MSEC reference numbers NC3 and NC5)
- Woodhouse Creek and
- Tributaries of the Georges River (MSEC reference numbers GR101, GR102, GR103, GR104, GR105, GR107, GR108, GR108A, GR109, GR110, GR112, GR114, GR114A, GR117 and GR119.

A summary of the predicted impacts on the physio-chemical attributes of the major watercourses within the proposed Longwall 37 and 38 layouts is provided in **Table 4.4** below. These predictions indicate that there will be no significant impacts on the physico-chemical features of the Georges River. Increased levels of ponding and flooding and fracturing of the river bed may occur, but these impacts are anticipated to be short-lived, minor and localised (Cardno Ecology Lab, 2013). The impacts will be no more than negligible and are thus consistent with the Subsidence Impact Performance Measures for the Georges River and other watercourses specified in the Project Approval for the BSO EA (Cardno Ecology Lab, 2013).

Table 4.4 – Predicted impacts on physico-chemical attributes of the major watercourses subject to the extraction of Longwalls 37 and 38

Watercourse	Attribute	Predicted Impacts
Georges River	Surface water level.	No measurable impacts are expected due to vertical subsidence movements because the vertical movements resulting from extraction of the LWs 37 and 38 would be small relative to the natural grade along the river.
	Ponding, flooding and scouring of stream banks.	These impacts are unlikely, because the maximum predicted tilts along the river are small relative to the average natural grade. The impacts on scouring are expected to be minimal due to the sandstone river bed.
	Change in stream alignment.	Unlikely to be any significant change, because of the very small size of the predicted changes in the cross-bed gradients relative to the natural gradients. Impacts on stream alignment would be minor compared to changes in the river depth and width that occur during high flows.
	Bedrock and surface flows.	There is unlikely to be significant diversion of surface flow because LWs 37 and 38 would be at least 50 m away from most rockbars and riffles and maximum closures of 220 mm are predicted. Fracturing of the river bed may occur within 400 metres of the proposed longwalls, but this would not cause significant diversion of surface flows. Natural flow diversions have been observed along sections of the Georges River which have not been affected by mining. The extraction of the proposed longwalls could increase the current rate of surface water flow diversions in the river (MSEC 2013).
	Groundwater inflows.	Induction of ferruginous springs is unlikely, but if it does occur it could lead to a reduction in dissolved oxygen (DO) levels at their emergence point if their flow rate exceeds 0.1 ML/day while at a time when flows in the river are <0.3 ML/day (i.e. <15% probability). The reduction in DO levels is unlikely to have a significant impact unless the flow rate of the springs exceeds 0.1 ML/day when flows in the river are less than 0.3 ML/day.
	Water quality.	The effects on water quality would depend on the relative volume of sub-surface flow diversions and surface flows. In general, sub-bed diversions would maintain and may slightly increase ecotoxic concentrations of Zinc. There will be no significant effect on the pH (between 8.0 and 9.5) of the Georges River due to the extraction of the proposed longwalls. Emerging water is unlikely to exceed national guidelines for DO where less than one third of flow is diverted. Only where one third or more of the flow is diverted would DO exceed guidelines. If all flow was diverted the emerging water would have reduced levels of DO.
Drainage Lines	Ponding, flooding and scouring of stream banks.	Significant increases are unlikely, but there could be minor localised increases in ponding and flooding at some points along the drainage lines.
	Creek beds and bedrock.	Fracturing, bulking and dilation may occur in the uppermost bedrock. This is unlikely to be seen in creeks with alluvial beds. Over time the fractures will be in-filled by deposits during flow events. In areas of drainage lines with exposed bedrock, some surface water flows may be diverted into underlying strata and drainage of pools may occur during low flow periods. Water will re-emerge downstream, so net loss of water from the catchments is likely.
	Water quality.	Significant impacts resulting from the formation of springs are unlikely.

4.2.3 Environmental Consequences

Table 4.5 compares the potential impacts as determined in the BSO EA to the impacts determined by Cardno Ecology Lab (2013) for the Longwalls 37 and 38 Study Area, based on the revised MSEC (2013) predictions and subsequent environmental consequences. Where residual risk differs from the BSO EA the reason for the difference is provided.

The potential impacts of subsidence on aquatic ecology predicated to occur during extraction of Longwalls 37 and 38 is concluded to be similar to the predicted impacts based on the BSO EA layout.

Table 4.5 – Comparison of potential environmental consequences of subsidence on aquatic ecology between the proposed Longwall 37 and 38 layout and the approved BSO EA layout

Component of Aquatic Ecology	Potential Impacts predicted from BSO EA	Revised Potential Impacts based on the Longwall 37 & 38 layout
Aquatic Habitat	Georges River – Isolated instances of fracturing of bed rock and iron staining, transient increases in water quality parameters, such as iron, transient gas emissions in some pools.	Impacts to aquatic habitat, if any, due to isolated fracturing of the river bed or increases in the rate of natural surface water flow diversions are expected to be negligible. Gas emissions could occur and if they do, they could result in a temporary and localised reduction in DO levels, such effects are expected to result in a negligible impact to aquatic habitat. Minor localised iron staining is not expected to result in changes in water quality and should not therefore affect the quality of aquatic habitat.
	Drainage lines – reduced water levels in pools and persistence of inter-pool flow, isolated iron staining, increases in water quality parameters, such as iron, and transient emissions of gas	Minor, localised increases in the level of ponding or flooding may occur. These could result in minor, localised increases in the longitudinal connectivity of aquatic habitats. Fracturing of bedrock may lead to diversion of surface flows and drainage of pools during low flow periods. This would result in localised reductions in small areas of pool habitat. Owing to the ephemeral nature of these drainage lines, and the relatively poor quality of ephemeral habitat, such effects would be negligible in a local and regional context. Localised development or enhancement of iron staining is not expected to result in more than minor changes in water quality, so there should be no effects on the quality of aquatic habitat. Gas emissions could occur and if they do, there could be a reduction in DO levels and a decline in the quality of aquatic habitat, when water is present in these streams. These effects are expected to be negligible.
Riparian vegetation	Unlikely that stream water level changes or strata gas emissions resulting from mine subsidence would have an adverse effect on the ecological role of riparian vegetation.	Localised, minor fracturing of bedrock could have a minor, localised impact on riparian vegetation. Gas emissions could occur; however, no associated impacts on riparian vegetation are expected.
Aquatic macrophytes	Georges River – As significant fracturing leading to more than localised surface flow loss is unlikely to occur, mining is unlikely to have a significant impact on the composition or distribution of macrophytes.	As impacts on aquatic habitats would be minor, isolated and in some cases transient, the effects on composition and distribution of macrophytes would be negligible to minor.
	Drainage lines – As significant fracturing and more than localised surface flow diversions are unlikely and aquatic	Impacts on the aquatic flora that may inhabit these ephemeral watercourses are unlikely to be

Component of Aquatic Ecology	Potential Impacts predicted from BSO EA	Revised Potential Impacts based on the Longwall 37 & 38 layout
	macrophytes are not abundant in these ephemeral, degraded streams, mining would not have a significant impact on the composition or distribution of macrophytes.	detectable, because of the large variability in natural flows and low abundance of the plants.
Aquatic macroinvertebrates	Georges River – Reduction in DO levels associated with gas emissions and iron staining that coincided with low flow conditions could have a measurable impact on macroinvertebrates. As impacts on water quality are expected to be minor, short-lived and localised, it is unlikely that there would be significant effects on macroinvertebrates.	As per the Part 3A layout. Minor changes in the distribution of 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 this reach of the river.
	Drainage Lines – 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 would perish as a result of desiccation and/or predation. Drainage of pools after river bed or rockbar 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 would be difficult to detect, because of the degraded nature of these streams.	Impacts on the aquatic macroinvertebrates that may periodically inhabit these ephemeral watercourses resulting from diversion of flows are unlikely to be detectable because of the large variability in natural flows and degraded nature of the streams.
Fish	Georges River – As impacts on water quality are expected to be minor, temporary and localised and fish are highly mobile, it is unlikely that fish populations would be significantly adversely affected by the small areas of habitat potentially impacted by mining.	As per Part 3A layout.
	Drainage lines – Potential habitat for fish and fish assemblages may be impacted if fracturing and loss of water occurs. Freshwater eels, may be able to relocate to nearby pools, but most species would perish as a result of desiccation and/or predation. Drainage of pools may also result in a temporary barrier to fish passage. Despite the above, it is unlikely that localised loss of fish would have a significant impact on the size of fish populations.	As per Part 3A layout.
Threatened Species	Macquarie perch have recently been recorded in the Georges River, approximately 15 km downstream of West Cliff Area 5. As loss of habitat not expected to occur in this area and changes in water quality are expected to be localised, transient and unlikely to have adverse effects, mining would not have a significant effect on Macquarie perch populations.	As per Part 3A layout.

5 PERFORMANCE MEASURES AND INDICATORS

The BSO Approval provides Subsidence Impact Performance Measures (*Schedule 3).* **Table 5.1** below 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)	
Georges 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 over at least 80% of the stream length subject to vertical subsidence >20 mm. No subsidence impact or environmental consequence greater than minor.
Other watercourses	No greater subsidence impact or environmental consequences than predicted in the EA and PPR.
Land (Condition 1 Schedule 3)	
Dharawal State Conservation Area	Negligible environmental consequences.
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	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 Longwall 37 and 38 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 the mining of Longwalls 37 and 38, monitoring and recording will be undertaken prior to mining, throughout the extraction and at the completion of extraction and associated 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 OEH and other relevant stakeholders (refer **Section 7**).

If the subsidence impact performance measures are exceeded, BHPBIC will notify DP&I, OEH, DRE 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 37 and 38 Subsidence Monitoring Program.

The monitoring program outlined below will be implemented to monitor the impacts of subsidence effects on biodiversity within the Longwalls 37 and 38 Study Area. As subsidence effects are predicted to be small in magnitude the monitoring program outlined below reflects the magnitude of these expected impacts. Further details are provided in the Subsidence Monitoring Program located at Annex B of the Extraction Plan.

6.1.1 Terrestrial Biodiversity

The magnitude of subsidence effects on biodiversity values is predicted to be small.

Monitoring will focus on detecting significant changes to vegetation communities and fauna habitat present within the Longwalls 37 and 38 Study Area and will aim to ensure complete coverage across the Study Area.

Subsidence effects are unlikely to have a significant impact on any threatened flora or fauna species (Niche, 2013). However, impacts may lead to the alteration of habitat and the alteration of the natural flow regimes of rivers, stream, floodplains and wetlands following longwall mining (Niche, 2013).

Visual inspections of vegetation communities within the Longwalls 37 and 38 Study Area will be undertaken as a part of routine landscape and water monitoring programs. Targeted inspection by a qualified ecologist will follow should vegetation health changes be observed.

Monitoring will focus on detecting significant changes to vegetation communities and fauna habitat present within the Longwalls 37 and 38 Study Area and will aim to ensure complete coverage across the Study Area.

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)?

Areas of impact or any subsidence effects will be mapped and documented using digital photography. Where a significant visual impact is detected 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.

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 Correct Management Actions (CMAs) that may be required.

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

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

6.1.2 Aquatic Biodiversity

Monitoring of aquatic biodiversity as identified by Cardno Ecology Lab (2013) would monitor 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.

Monitoring would be undertaken at:

- Sites 9, 10 and 11 on the Georges River situated upstream, adjacent and downstream of the south-eastern end of Longwall 37, respectively; and
- Sites 6 and 8 on the Georges River situated upstream and adjacent to Longwall 38, respectively.

Monitoring has already been undertaken at the above sites, with Site 6 having been monitored on six occasions since May 2002, Sites 8 and 9 on four occasions since May 2007 and Sites 10 and 11 on two occasions, in May 2010 and November 2011 (Cardno Ecology Lab 2013). These sites were also visited in November 2013.

Baseline data is available for all the sites except Site 13. Cardno Ecology Lab (2013) do not recommend further monitoring at Site 13, as it is downstream of Site 11, which in turn is downstream of Longwalls 37 and 38. Potential impacts would be expected to diminish moving downstream, and as such, Site 11 would be expected to be at a greater risk of any impact compared with Site 13. Cardno Ecology Lab (2013) recommends that future monitoring focus on the spring period and that another baseline survey is undertaken at the above sites in spring 2013. Further monitoring would be conducted once during the mining of each longwall and on two occasions after the completion of mining (Cardno Ecology Lab, 2013).

No monitoring is proposed for the drainage lines due to their ephemeral nature and limited value as aquatic habitat.

Indicators of aquatic ecology would be comprised of:

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

The condition of aquatic habitat at each site would also be monitored.

The monitoring program would build on the current monitoring program in place for West Cliff Longwalls 29 to 36.

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; and whether CMAs are 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 TARP (refer **Table 7.1**).

Monitoring results will be made publicly available in accordance with BSO Approval *Conditions 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 field crews and other BHPBIC staff and contractors are required to access surface areas as a part of monitoring programs, the following mitigation measures shall be adhered to:

- Mitigation measures contained within the BSO EA should be implemented (especially with regards to the spread of weeds and other pathogens).
- All remediation works must take appropriate measures to minimise environmental impacts. This includes avoiding the spread of Chytrid Fungus by following the NPWS guidelines.
- In addition to these measures, and to prevent the spread of weed species into areas of native vegetation, BHPBIC staff and contractors will 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.
- All BHPBIC staff and contractors accessing the Longwalls 37 and 38 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.
- Any surface cracking within woodland or forested areas assessed to result in significant fauna entrapment should be mitigated as soon as possible.

7.1.2 Management Measures

As detailed in **Section 6.1.1** 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 more intensive management measures, 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, and sourced from local stock.

7.2 AQUATIC BIODIVERSITY

7.2.1 Mitigation Strategies

The potential impacts of the extraction of Longwalls 37 and 38 on aquatic habitats and biota in the Georges River are anticipated to be negligible and would be further minimised through:

- The adoption of a mine layout that does not involve undermining the river and setting Longwalls 37 and 38 at least 20 m and 45 m back respectively from the centreline of the Georges 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 37 and 38 through ongoing monitoring and timely implementation of appropriate remediation works.

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 related subsidence. Standard management measures include photographic records capture and the continuation of the approved monitoring program.

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

Should the impacts of the extraction of Longwalls 37 and 38 on aquatic habitats and biota in the Georges River be greater than predicted, the following contingency measures would be implemented:

- Reviewing the mine layout and the appropriate offset distances from the Georges River
- Implementing stream remediation measures, such as grouting, in areas where fracturing of controlling rockbars and/or the 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 Georges River.

If these management strategies prove ineffectual, appropriate offset and compensatory measures would be implemented (Cardno Ecology Lab, 2013).

7.3 TARPS

Table 7.1 shows the Longwalls 37 and 38 Biodiversity Trigger Action Response Plan (TARP)**.**

Table 7.1 – West Cliff Longwalls 37 and 38 Trigger Action Response Plan (TARP)

Monitoring	Trigger	Action
Aquatic Biodiversity		
Pool water level, connectivity of pools and habitat changes **Longwall 37**: • Site 9 • Site 10 and • Site 11 **Longwall 38:** • Site 3 and • Site 8 General observations of the mining area. Refer **Figure 4**	***Level 1 **** • Reduction of aquatic habitat for 1 season	• Continue monitoring program • Report trigger to key stakeholders • Summarise impacts and report in the End of Panel Report and AEMR
	Level 2 * • Reduction of aquatic habitat for 2 seasons	• *Actions as stated for Level 1* • Review monitoring program • Review impacts against the Performance Measures • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Level 3 * • Reduction of aquatic habitat for >2 seasons or complete loss of habitat	• *Actions as stated for Level 2* • Notify DoPI, DPI, 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 • Issue CMA report within 1 month of works completion • 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. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Exceeding Performance Measures • Subsidence impacts or environmental consequences greater than minor • More than negligible environmental consequences in respect of threatened species, threatened populations, or endangered ecological communities	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predications based on outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful

Monitoring	Trigger	Action
Terrestrial Biodiversity		
General observation of active mining areas including: **Cliffs** • GR-CL01 and GR-CL02 **Steep slopes** **Georges River** – including pools and rockbars • GR-RB42 • GR-RB43 • GR-RB44 • GR-RB45 • GR-RB47 • GR-RB48 • GR-RB49 • GR-RB51 • GR-RB52 • GR-RB53 • GR-RB54 • GR-RB55 • GR-RB56a • GR-RB56b • GR-RB57 • GR-RB59 • GR-RB60 • GR-RB61 • GR-RB62 • GR-RB63 • GR-RB64 • GR-RB65 • GR-RB66 • GR-RB67	***Level 1*** * • Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that naturally regenerates within the monitoring period	• Continue monitoring program • Report trigger to key stakeholders • Summarise impacts and report in the End of Panel Report and AEMR
	Level 2 * • Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that does not regenerate within the monitoring period	• Actions as stated for Level 1 • Review monitoring program • Review impacts against the Performance Measures • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved *<u>Note:</u> CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Level 3 * • Vegetation impacted by mining that is not responding to CMAs	• Actions as stated for Level 2 • Notify DoPI, DPI, 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 • Issue CMA report within 1 month of works completion • 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. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Exceeding Performance Measures • Subsidence impacts or environmental consequences greater than minor • More than negligible environmental consequences in respect of threatened species, threatened populations, or endangered ecological communities	• Actions as stated for Level 3 • Investigate reasons for the exceedance • Update future predications based on 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. These TARPs relate to West Cliff Area 5 Longwalls 37 and 38.

8 CONTINGENCY AND RESPONSE PLANS

8.1 CONTINGENCY PLAN

In the event the Subsidence Performance Measures detailed in **Section 5** of this BMP are considered to have been 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 immediately.
- Notify relevant stakeholders soon as practicable.
- Notify relevant agencies and specialists as soon as practicable.
- Conduct site visits with stakeholders as required.
- Contract specialists to investigate and report on changes identified.
- Provide incident report to relevant agencies within seven days.
- Establish weekly monitoring until stabilised.
- Monthly updates from specialists on investigation process.
- Inform relevant agencies and stakeholders of results of investigation within one week of completion.
- Develop site Corrective Management Action (CMA) in consultation with key stakeholders if required within one month, (pending stakeholder availability) and seek approvals.
- Implement CMA as agreed with stakeholders following approvals.
- Conduct initial follow up monitoring and reporting within two months of CMA completion.
- Review Management Plan within three months.
- 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 DP&I 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 (refer **Section 10.4**).

9 INCIDENTS, COMPLAINTS, EXCEEDANCES AND NON-CONFORMANCES

9.1 INCIDENTS

BHPBIC will notify the DP&I and any other relevant agencies of any incident associated with the Bulli Seam Operations as soon as practicable after BHPBIC becomes aware of the incident. BHPBIC will provide the DP&I and any relevant agencies with a detailed report on the incident within seven days of confirmation of any event.

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 the community and BHPBIC staff.
- 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 West Cliff Mine. 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 DP&I.

10 PLAN ADMINISTRATION

This BMP will be administered in accordance with the requirements of the West Cliff 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 West Cliff Area 5 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.

Responsibilities for environmental management of West Cliff Area 5 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 and seek appropriate approvals for any proposed amendments.
- 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 in accordance with the BMP. Maintain records required by 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, assess improvement ideas submitted and implement if considered appropriate.
- Arrange for the implementation of 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 within the BMP.
- Participate in any other 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 provisions 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 operations manuals.

It shall be 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 (incl. 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 site management and other key site personnel, assess the performance of the mine 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.

11 REFERENCES

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Attachment A – West Cliff Longwalls 37 and 38 Terrestrial Flora and Fauna Assessment (Niche, 2013)

niche
Environment and Heritage

Westcliff Longwalls 37-38 Extraction Plan

TERRESTRIAL FLORA AND FAUNA ASSESSMENT

Prepared for BHP Billiton Illawarra Coal

DOCUMENT CONTROL

Business Unit	Niche Environment and Heritage		
Project No.	1197		
Document Description	Terrestrial ecology assessment for the extraction of West Cliff Longwalls 37-38 within West Cliff Area 5. This report will accompany the Extraction Plan for the underground mining of the longwalls.		
	Name	**Signed**	**Date**
Supervising Manager(s)	Frank Lemckert		29 May 2013

Person managing this document	**Person(s) writing this document**
Luke Baker	Luke Baker

Internal Review	**Name**
20/05/2013	Nathan Smith
External Review	
21/05/2013	Gary Brassington (BHPBIC) Danyil Skora (Cardno)

Document Status	**Date**
Final	29/05/2013

Prepared for:	**Organisation**
	BHP Billiton Illawarra Coal PO Box 514, Unanderra, NSW 2526

Front Cover Photograph: Pool along Georges River to the north of the Study Area.

EXECUTIVE SUMMARY

Niche Environment and Heritage (Niche) has been commissioned by BHP Billiton Illawarra Coal (BHPBIC) to undertake an assessment of the ecological constraints and potential impacts associated with the extraction of Bulli Seam Coal from longwalls 37-38. The longwalls occur within West Cliff Area 5, located near Appin NSW. The proposal is part of the Bulli Seam Operations Project (BSOP).

Approval of the BSOP was granted on 22 December 2011 under Part 3A of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act). Consent conditions relating to this approval require BHPBIC to submit an Extraction Plan to manage potential subsidence effects, impacts and environmental consequences associated with proposed coal extraction activities. A terrestrial ecology impact assessment is required as part of the Extraction Plan to support the mining of Longwalls 37-38 within West Cliff Area 5 mining domain.

The Study Area has been subject to previous ecological survey and assessment conducted in 2009 as part of the BSOP. The current assessment focused on landscape features that may be sensitive to impacts of subsidence from longwall extraction. It contains a thorough review of the previous assessments, habitat assessment and targeted threatened flora survey. The natural surface features which are sensitive to subsidence movements, including significant natural features that may be subjected to far-field or valley related movements, have been identified by MSEC (2012) as the Georges River, drainage lines, creeks, rock outcrops, cliffs, and steep slopes.

Mine subsidence

The findings from the MSEC (2012) report form the basis on which the potential impacts to threatened biodiversity have been assessed in this report.

The MSEC (2012) report provided important conclusions that are relevant to this study, including:

- It is unlikely that there would be any significant increases in the levels of ponding, flooding, or scouring of the river banks resulting from the extraction of the proposed longwalls. It is possible, that there could be some localised small increased levels of ponding or flooding where the predicted maximum tilts coincide with existing pools, steps or cascades along the river, however, any changes are not expected to result in a significant impact.
- Minor fracturing could occur along the Georges River and drainage lines as a result of the extraction of the proposed longwalls. Where this fracturing coincides with a pool water level controlling feature (e.g. rockbar) this could result in some flow diversion.
- It is possible that minor fractures could occur up to 400 metres from the proposed longwalls.
- It is possible that there could be very localised areas along the drainage lines which could experience a small increase in the levels of ponding and flooding. However,

any changes are expected to be minor and not result in a significant impact on the drainage lines.

- It is unlikely that there would be any net loss of water from the catchment.
- Based on the previous experience of mining beneath drainage lines in the Southern Coalfield, the incidence of fracturing in the drainage lines within the Study Area is expected to be low and unlikely to result in any significant loss of surface water flows.
- Large cliff instabilities are unlikely to occur as a result of the extraction of the longwalls.
- Some fracturing of the rock outcrops predominantly where the rock outcrops are located above the existing and proposed longwalls and, where the rock is marginally stable, could then result in instabilities. Previous experience in the Southern Coalfield indicates that the percentage of rock outcrops that are likely to be impacted by mining is very small.
- It is likely that only minor cracking would occur near the tops of steep slopes.

Assessment of impacts to threatened biodiversity

Potential impacts on threatened biodiversity were assessed under the requirements of the EP&A Act and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This requires that Assessments of Significance under both Acts (Seven Part Tests in NSW and Significant Impact Criteria for the Commonwealth) are conducted for threatened biodiversity that are known or likely to occur in the Study Area. Threatened biodiversity (species, populations and ecological communities) are listed in the relevant schedules of the NSW *Threatened Species Conservation Act 1995* (TSC Act) and the EPBC Act.

NSW and/or Commonwealth Assessments of Significance were conducted for threatened biodiversity with known and potential habitat within the Study Area and where an impact due to subsidence was possible. Habitats likely to be impacted by subsidence are those associated with ground water (such as riparian vegetation), rock overhangs, surface rock and watercourses. Ridgeline and woodland dependent biodiversity are unlikely to be significantly impacted by subsidence mechanisms.

Threatened ecological communities

Of the five vegetation communities mapped within the Study Area (Tozer 2010), two align to Threatened Ecological Communities (TECs) as follows:

- Cumberland Shale Sandstone Transition Forest, is equivalent to Shale Sandstone Transition Forest (SSTF), which is listed as a TEC under both the TSC and EPBC Acts.
- Cumberland Shale Plains Woodland, is equivalent to Cumberland Plain Woodland (CPW) which is listed as critically endangered under both the TSC and EPBC Acts.

Vegetation communities which are not located within the riparian zones of watercourses in the Study Area, or are not dependent on alluvial soils, are unlikely to be significantly impacted by subsidence due to underground mining.

Ground-water dependant and riparian vegetation may experience some minor floristic changes as a result of changes in the distribution and availability of surface water or near surface groundwater, as a result of subsidence. However, this is likely to be minor in occurrence.

Dieback of riparian vegetation as a result of strata gas emissions associated with subsidence is unlikely. Based on previous experience in the Southern Coalfields, such impacts are rare, small in nature and unlikely to cause long-term adverse changes to native vegetation.

The magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in shale/sandstone transition soils and clay soils (FloraSearch 2009). SSTF occurs on shale/sandstone transition soil and CPW on clay soils.

Mining in the Study Area is unlikely to result in any physical landscape changes which may impact SSTF or CPW. This assessment concludes that SSTF and CPW are unlikely to be significantly impacted by the proposal.

Threatened flora

On the basis of a moderate to high likelihood of occurrence in the Study Area and the potential for impact due to subsidence, NSW and/or Commonwealth Assessments of Significance were conducted for the following six threatened flora: *Epacris purpurascens* var. *purpurascens, Grevillea parviflora* subsp. *parviflora, Leucopogon exolasius, Melaleuca deanei, Pomaderris brunnea* and *Pultenaea aristata. Grevillea parviflora* subsp. *parviflora* was recorded in the Study Area. These Assessments of Significance concluded that the proposal is unlikely to have a significant impact on any threatened flora as listed on the TSC and/or EPBC Acts.

Threatened fauna

On the basis of a moderate to high likelihood of occurrence in the Study Area and the potential for impact due to subsidence, NSW and/or Commonwealth Assessments of Significance were carried out for 15 threatened fauna, including:

- **Amphibians** - Green and Golden Bell Frog, Littlejohn's Tree Frog, Giant Burrowing Frog, and Red-crowned Toadlet.
- **Mammals** - Spotted-tailed Quoll, Eastern False Pipistrelle, Eastern Freetail Bat, Grey-headed Flying-fox, Large-eared Pied Bat, Eastern Bent-wing Bat, Large-footed Myotis, Yellow-bellied Sheathtail-bat, Greater Broad-nosed Bat
- **Reptiles** - Broad-headed Snake and Rosenberg's Goanna.

The Assessments of Significance concluded that the proposal is unlikely to have a significant impact on any threatened fauna.

SEPP No. 44 – Koala Habitat

It is highly unlikely any State Environmental Planning Policy (SEPP) No. 44 Koala Habitat will be impacted by the proposal. The proposal is unlikely to cause fragmentation to koalas potentially occupying the area, nor a loss of habitat features.

Amelioration measures

It is recommended the following be included in the environmental monitoring program for the project:

- ❒ Monitoring should be conducted for as long as impacts could occur or (as appropriate).
- ❒ In the event that monitoring does reveal impacts, mitigation measures should be considered to minimise these.
- ❒ The implementation of any mitigation measures should include monitoring to confirm the success of any implemented measures.
- ❒ All remediation works must take appropriate measures to minimise environmental impacts.
- ❒ Any surface cracking within woodland or forested areas should be mitigated as soon as possible should fauna entrapment be considered an issue.

GLOSSARY AND ABBREVIATIONS

Subject site: the area to be directly affected by the proposal.

Study Area: the subject site and any additional areas which may potentially be affected by the proposal, either directly or indirectly.

Direct impacts: those that directly affect the habitat and/or individual plants and animals and cannot be avoided or mitigated.

Indirect impacts: those that affect species, populations or ecological communities in a manner other than through direct loss or disturbance. These can usually be avoided or mitigated.

Flora and fauna of conservation significance: threatened species or populations listed on the schedules of the TSC Act and/or listed as matters of National Environmental Significance (NES) under the EPBC Act.

Local population: the population of a particular threatened species that occurs in the locality.

Locality: the area within 10 km of the Study Area.

Local occurrence: refers to the distribution of an ecological community within the Study Area and continuous with it.

Matters of NES: matters of national environmental significance.

BSOP: Bulli Seam Operations Project.

OEH: Office of Environment and Heritage.

SEWPaC: Department of Sustainability, Environment, Water, Populations and Communities.

TEC: Threatened ecological community as listed on the TSC and or EPBC Acts. Includes: vulnerable, endangered and critically endangered ecological communities.

Threatened biodiversity: Threatened species, populations and ecological communities as listed on the TSC and/or EPBC Acts.

TSC Act: NSW *Threatened Species Conservation Act 1995*

EPBC Act: Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

EP&A Act: NSW *Environmental Planning and Assessment Act 1979*

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1 INTRODUCTION

Niche Environment and Heritage (Niche) has been commissioned by BHP Billiton Illawarra Coal (BHPBIC) to undertake an assessment of the ecological constraints and potential impacts associated with the extraction of Bulli Seam Coal from Longwalls 37-38. The longwalls occur within the West Cliff Area 5 domain, located near Appin NSW. The proposal is part of the Bulli Seam Operations Project (BSOP).

Approval of the BSOP was granted on 22 December 2011 under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act). Consent conditions relating to this approval require BHPBIC to submit an Extraction Plan to manage potential subsidence effects, impacts and environmental consequences associated with proposed coal extraction activities. A terrestrial ecology impact report is required as part of the Extraction Plan to support the mining of Longwalls 37-38 within the West Cliff Area 5 mining domain.

This document constitutes the terrestrial ecological assessment for the Longwall 37-38 Extraction Plan.

1.1 Project description

The project involves the extraction of coal from the Bulli Seam using longwall mining techniques. The coal will be extracted from proposed Longwalls 37 and 38 (Figure 1) within the West Cliff Area 5 mining domain.

Mine subsidence is a consequence of longwall mining. Subsidence predictions for Longwalls 37-38 were investigated, and reported by MSEC (2012) (Section 1.4).

1.2 Report objectives

The primary objective of this report is to describe and assess ecological values within the Study Area and surrounds and determine whether the proposal is likely to have a significant impact on threatened biodiversity. A description of likely impacts from the proposal and consideration of mitigation measures is also provided.

The approach of this assessment includes the following:

- Undertake a background review of relevant literature, mapping and databases.
- Conduct a field survey using recognised methods to assess the ecological values of the site and address identified data gaps.
- Describe the ecological values of the site in regard to flora, fauna and vegetation communities.
- Describe the potential ecological impacts of the proposal.
- Assess impacts on threatened biodiversity as listed on the *Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- Provide recommendations on measures to ameliorate impacts, including strategies to avoid, mitigate and rehabilitate.

1.3 Study Area context

The Study Area occurs within Consolidated Coal Lease 767, which is located within Wollondilly and Campbelltown Local Government Areas (LGA). The Study Area is defined as the surface area that is likely to be affected by the proposed mining of Longwalls 37 and 38 at West Cliff. The extent of the Study Area is consistent with that provided in MSEC (2012), which has been calculated by combining the areas bounded by the following limits:

- A 35 degree angle of draw line from the proposed extents of Longwalls 37 and 38.
- The predicted limit of vertical subsidence, taken as the predicted 20 mm subsidence contour resulting from the extraction of the proposed Longwalls 37 and 38 (Figure 2).
- Any features sensitive to far field movements, including potential horizontal and valley related movements, resulting from the extraction of Longwalls 37 and 38.

The topography of the Study Area mostly consists of gentle undulating slopes, with a steep sandstone valley forming the banks of the Georges River. The Study Area consists of Hawkesbury Sandstone and Wianamatta Shale derived soils.

The Georges River is located between Longwalls 37 and 38. Longwall 37 occurs immediately to the west of the River, and Longwall 38 runs parallel to the east.

Native vegetation occurs along the riparian areas of the Georges River, and along the tops of the valley. The vegetation provides fauna connectivity along the River to conservation reserves including: Dharawal State Conservation Area and National Park, Sydney Catchment Authority Special Areas, Heathcote National Park and the Royal National Park.

The area above Longwall 37 consists mainly of rural residential development, with scattered patches of woodland and isolated trees. Towards the centre of Longwall 37, the Bulli Appin Road crosses running north to south. Native vegetation borders the western end of the longwall along the Georges River.

The Nepean River occurs approximately 1km to the east of Longwall 37.

Nepean Creek is located within the far eastern corner of Longwall 37. Nepean Creek flows into to the Nepean River further downstream.

The area above Longwall 38 is situated predominantly within an area supporting native vegetation, with some rural residential land occurring towards the northern end of the longwall. The Dharawal State Conservation Area occurs toward the centre and south of the longwall.

Other watercourses within the Study Area include: Mallaty Creek and its tributaries, Woodhouse Creek, and various tributaries of the Georges River.

Wedderburn Airport occurs approximately 500 m to the east of Longwall 38.

1.4 Predicted mine subsidence

Subsidence predictions for Longwalls 37-38 were investigated and reported by MSEC (2012).

The natural surface features which are sensitive to subsidence movements have been identified by MSEC and include the following: Georges River, drainage lines, creeks, rock outcrops, cliffs, steep slopes.

These features provide important habitat for terrestrial ecological values and therefore a detailed consideration of the potential effects of subsidence on these features is warranted in order to accurately assess any potential impacts and consequences.

An assessment of the impacts to water quality associated with the proposal was investigated and reported by Ecoengineers (2013).

A summary of the predicted impacts (MSEC 2012, Ecoengineers 2013) that the proposal will have on these features is described below.

1.4.1 Georges River

The only river within the Study Area is the Georges River. The proposed longwalls do not directly mine beneath the Georges River.

The following have been predicted based on the MSEC (2012) report:

- The changes in water level due to vertical subsidence movements resulting from the extraction of the proposed longwalls are not expected to result in any measurable impact.
- It is unlikely that there would be any significant increases in the levels of ponding, flooding, or scouring of the river banks resulting from the extraction of the proposed longwalls. It is possible, that there could be some localised small increased levels of ponding or flooding where the predicted maximum tilts coincide with existing pools, steps or cascades along the river. However, any changes are not expected to result in a significant impact.
- The potential impacts of the changes in the stream alignment are expected to be minor when compared to the changes in the river depth and width that occur during times of high flow in the river.
- The potential impacts of scouring are also likely to be minimal due to the nature of the sandstone river bed.
- Minor fracturing could occur along the Georges River as a result of the extraction of the proposed longwalls. While it is possible for fracturing to occur anywhere along the river, the most likely areas are the stretch of the Georges River adjacent to and approximately parallel with the longwall 38 tailgate and the stretch of the Georges River adjacent to the longwall 35 maingate. Where this fracturing coincides with a pool water level controlling feature (e.g. rockbar) this could result in some flow diversion.
- It is possible that minor fractures could occur up to 400 metres from the proposed longwalls.

1.4.2 Creeks and drainage Lines

Creeks that have been identified within the Study Area include:

- Mallaty Creek and its tributaries;
- Nepean Creek and its tributaries;
- Woodhouse Creek, and

- Various tributaries of the Georges River.

The following have been predicted based on the MSEC (2012) report:

- Significant increases in the levels of ponding, flooding or scouring are unlikely.
- It is possible that there could be localised areas along the drainage lines which could experience a small increase in the levels of ponding and flooding. However, any changes are expected to be minor and not result in a significant impact on the drainage lines.
- Some fracturing, bulking and dilation would occur in the uppermost bedrock based on the distribution of conventional tensile and compressive strains.
- It is possible that some compressive buckling and dilation of the uppermost bedrock could occur along the alignments of Mallaty Creek and, to a lesser extent, along the alignments of Nepean Creek and the tributaries within the Study Area.
- It is unlikely that there would be any net loss of water from the catchment.
- The drainage lines are ephemeral and so water typically flows during and for periods of time after each rain event. In times of low flow, however, some of the water could be diverted into the dilated strata below the beds and this could affect the quality and quantity of the water flowing in the drainage lines. It is unlikely, however, that this would result in a significant impact on the overall quantity and quality of water flowing from the catchment.
- Based on the previous experience of mining beneath drainage lines in the Southern Coalfield, the incidence of fracturing in the drainage lines within the Study Area is expected to be low and unlikely to result in any significant loss of surface water flows.

1.4.3 Water quality

Ecoengineers (2013) did not predict any significant impacts to water quality arising from the proposal. Whilst it is stated that the proposal may cause fracturing of rockbars and inducement of ferruginous springs or exacerbate pre-existing ones, any impact to water quality would be mitigated by the controlled release of water from Brennans Creek Dam at West Cliff Colliery.

The watercourses to the West of the Study Area are strongly ephemeral in nature with ongoing agricultural land use, and it is unlikely there would be any significant impact to water quality resulting from the formation of springs in these streams over and above current anthropological effects (The Ecology Lab, 2007).

1.4.4 Cliffs

The cliffs within the Study Area are generally located within the valley of the Georges River and associated tributaries. There are also rock outcrops which are located along the Georges River. Cliffs are not located above the proposed longwalls.

The likelihood of cliff instabilities within the Study Area have been assessed by MSEC (2012) using case studies where previous longwall mining has occurred close to but not directly beneath cliffs. Based on the history of mining at Appin and Tower Collieries, it is possible that isolated rock falls could occur as a result of the extraction of the proposed longwalls.

It is not expected, however, that any large cliff instabilities would occur as a result of the extraction of the longwalls, as the longwalls are not proposed to be extracted directly beneath the cliffs.

1.4.5 Rock outcrops

The extraction of the proposed longwalls is likely to result in some fracturing of the rock outcrops predominantly where the rock outcrops are located above the existing and proposed longwalls. Where the rock is marginally stable this could then result in instabilities. Previous experience in the Southern Coalfield indicates that the percentage of rock outcrops that are likely to be impacted by mining is very small.

Based on this experience, it would be expected that the incidence of impacts on the rock outcrops in the Study Area would still be small if the actual movements exceeded those predicted.

1.4.6 Steep slopes

The majority of the steep slopes along the Georges River valley and associated tributaries are not directly mined beneath by the proposed longwalls. It is likely, therefore, that only minor cracking would occur near the tops of these steep slopes.

2 LITERATURE REVIEW

2.1 Literature and database review

Literature and data sources reviewed included:

- MSEC (2012) BHP Billiton Illawarra Coal West Cliff Colliery – Longwalls 37 and 38 Subsidence Predictions and Impact Assessments for the Natural Features and Surface Infrastructure in Support of the Extraction Plan;
- Ecoengineers (2013) Assessment of Water Quality Effects and Water Quality Monitoring Plan, West Cliff Colliery longwalls 37 and 38 Extraction Plan, prepared for BHPBIC;
- Cardno Ecology Lab (2013) West Cliff Longwalls 37-38 Aquatic Flora and Fauna Assessment, prepared for BHPBIC;
- Biosphere Environmental Consultants (2009) Illawarra Coal Bulli Seam Operations Project Terrestrial Flora Assessment, prepared for BHPBIC;
- FloraSearch (2009) Illawarra Coal Bulli Seam Operations Project Terrestrial Flora Assessment, prepared for BHP Billiton Illawarra Coal;
- Niche (2011) Ecological Assessment of Three Goaf Gas Extraction Well Sites, one MRD Drilling Site and One Gas Extraction Plant above Longwall 37;
- Native Vegetation of Southeast NSW (Tozer *et al* 2010);
- DECC (2008) Threatened Species Profiles Database, NSW Department of Environment and Climate Change (now OEH);
- OEH Atlas of NSW Wildlife (accessed May 2013); and
- The EPBC Act Protected Matters Search Tool (accessed May 2013).

2.1.1 FloraSearch (2009) Bulli Seam Operations Project Terrestrial Flora Assessment

FloraSearch (2009) conducted a flora survey of the BSOP during 2008 to 2009, and assessed the likely impacts of the BSOP on the flora of the Study Area.

Conclusions from FloraSearch (2009) relevant to the current Study Area include the following:

- Mine subsidence impacts on riparian vegetation are expected to be similar to those experienced elsewhere in the Southern Coalfield at similar depths of cover, that is, localised dieback that is temporary and limited in its extent.
- Recovery of riparian vegetation from dieback following subsidence-induced hydrological changes has been observed in the Woronora catchment. Similarly, recovery of riparian vegetation from dieback due to strata gas emissions has been documented in the Cataract River near Appin.
- Cracking may alter, at a local scale, the movement of water in plateau and hillslope areas. However, the magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in these

areas and is unlikely to have any biologically significant effect on the vegetation communities in these areas due to soil moisture change.

- The impacts of surface cracking as the result of systematic subsidence movements is expected to be isolated and of a minor nature due to the relatively low magnitudes of the predicted strains and the relatively high depths of cover for all areas of TECs.
- The magnitude of the predicted subsidence effects is considered to be too small to influence the hydrological processes in areas supporting TECs, such that it is unlikely there would be any biologically significant effect on TECs in the Study Area due to soil moisture change. Consequently, it is unlikely that the TECs would be adversely affected by mine subsidence.
- Potential impacts of rock falls on threatened flora are considered most likely to be small.
- *Grevillea parviflora* subsp. *parviflora* was recorded and abundant in the eastern parts of the West Cliff Area 5 domain, where it is widespread in Dharawal SCA and the Tharawal Local Aboriginal Land Council (LALC) areas.
- It is unlikely the proposal will result in a significant impact to any threatened flora species or TEC.

2.1.2 Biosphere Environmental Consultants (2009) Bulli Seam Operations Project Terrestrial Fauna Assessment

Biosphere Environmental (2009) conducted a fauna survey of the BSOP during 2008 to 2009, and assessed the likely impacts of the BSOP on the fauna and fauna habitat of the Study Area.

Conclusions from Biosphere Environmental (2009) relevant to the current Study Area include the following:

- Many of the terrestrial fauna species are known to utilise a range of habitats, or are mobile allowing them to move to alternative habitat in response to changes in stream flows or water levels. For species that are likely to utilise small pools rather than large bodies of water (e.g. frogs), a number of small pools that create micro-habitat are expected to remain which hold water even during periods of persistent low flows.
- The predicted effects of subsidence on fauna habitats are minimal and it is considered unlikely that subsidence resulting from the BSOP would have any real effect on koala habitat.
- The potential impacts of subsidence associated with the BSOP are unlikely to cause any changes to connectivity of habitats within the project area.
- Within Appin Area 5, three threatened fauna species were recorded: Spotted-tailed Quoll, Grey-headed Flying Fox and Koala. The Spotted-tailed Quoll was recorded dead along a roadside.

- Given the predicted low incidence of rock falls (MSEC, 2009), it is considered unlikely that rock falls or other instabilities at the surface resulting from mine subsidence would threaten the viability of any individual species population.
- Subsidence is unlikely to result in a significant impact to any threatened fauna species in the Study Area.

3 METHODS

3.1 Field survey methodology

The Study Area was investigated by two ecologists on the 3rd December 2012, and by one ecologist on the 15th and 17th April 2013.

The Study Area had been subject to extensive surveys as detailed in Biosphere (2009) and FloraSearch (2009). As such, this investigation has utilised the results of these surveys, and focused on areas of habitat likely to be susceptible to subsidence, such as watercourses, ridgelines and riparian areas.

The current survey has relied upon existing vegetation mapping and vegetation plots which were conducted as part of the FloraSearch (2009) survey. To complement the existing data, 35 rapid data plots (RDPs) were conducted as part of the current survey. RDPs involved recording dominant species in the near vicinity, along with key attributes such as vegetation height and canopy cover. RDPs were focused on vegetation within proximity to watercourses and ridgetops. RDPs were used to confirm the presence of TECs within proximity to areas of subsidence.

General traverses were conducted between plot sites which yielded data such as the presence of threatened plant species.

3.1.1 Fauna assessment

Previous targeted fauna surveys within the Study Area are extensive.

Biosphere (2009) conducted targeted fauna surveys in March/April/May 2008 (autumn), September/October 2008 (spring) and March/April/May 2009 (autumn). Details of the survey effort are provided in Table 1.

Given the extensive fauna survey, a habitat assessment was conducted within the Study Area, along with a targeted search for Spotted Tail Quoll latrine sites and threatened amphibians and microbats. Two songmeter recording devises were used during the current field survey to detect amphibian and microbat species.

Opportunist rock rolling, bird surveys and herpetological searches were conducted during the field survey.

Habitat characteristics and parameters that were assessed included:

- physical aspects of the site such as climate (desktop), geology, soils, slope, elevation, drainage and aspect;
- floristic composition, structure and age;
- vegetation condition (Niche use a measure of 'ecosystem resilience' as a function of disturbance);
- composition of ground layer (bare earth, litter etc.); and
- presence and relative abundance of key habitat features (e.g. tree hollows, large logs, exfoliating rock, flowering resources, aquatic features).

The previous and current survey effort has been provided in Table 1.

Table 1. Survey effort

Survey task	FloraSearch (2009)	Biosphere Environmental (2009)	Niche current survey
Quadrat sampling	Six plots within Study Area. Quadrat plot number 49-53 and 61.	-	-
Random meander	Random meanders along Georges River. Random meander numbers 9-11.	-	Random meander along Georges River and drainage lines in Study Area.
Rapid data plot	Five RDPs in Study Area. RDP numbers 18-22.	-	35 RDPs across the Study Area.
Anabat detectors (two consecutive nights)	-	Sites: 8, 10, 20, T9, T10 and T20.	Two songmeters
Hair tubes (ground) (minimum four nights)	-	At least 5 large ground hair tubes at Sites 8, 10 and 20	-
Hair tubes (arboreal) (minimum four nights)	-	At least 5 large ground hair tubes at sites 8, 10 and 20	-
Spotlighting (2 person hours per site)	-	Sites: 8, 10, 20, T9, T10	-
Diurnal herpetological searches	-	Up to 1 person hour per site on two days at sites 8, 10, 20, T9, T10 and T20.	Opportunistic during course of survey. Approximately 20 minutes per 3 days
Nocturnal amphibian searches	-	Up to 1 person hour per site on two days at sites 8, 10, 20, T9, T10 and T20.	Use of two songmeter for two nights.
Bird surveys	-	30-minutes on two days at sites 8, 10, 20, T9, T10 and T20.	Opportunistic during course of survey. Approximately 20 minutes per 3 days.
Call playback	-	Up to 20 minutes at site 10, 20, T9, T10 for two nights	-
Elliott A traps	-	20 Elliott A traps at sites 8, 10 and 20 for a minimum of four nights. 25 Elliott A traps at sites 8, 10 and 20 for five nights.	-
Elliott B traps	-	5 Elliott B traps at sites 8, 10 and 20 for a minimum of four nights.	-
Arboreal Elliott traps	-	5 arboreal Elliott traps at Sites 8, 10 and 20 for a minimum of four nights.	-
Standard cage traps	-	5 traps at sites 8, 10 and 20 for a minimum of four nights.	-
Platypus surveys	-	Up to 6 hours of observation at Sites 20.	-
Opportunistic observations	-	Ad lib across the Study Area.	Ad lib across the Study Area.
Tracks and traces	-	Ad lib or when engaged in other activities above.	Ad lib or when engaged in other activities above.

3.2 Threatened flora and fauna likelihood of occurrence

A list of subject threatened flora and fauna within the locality (10 kilometre radius) was determined from database searches (OEH Atlas of NSW Wildlife and EPBC Act Protected Matters Search Tool). The list of potentially impacted (affected) species is determined from consideration of this list. In order to adequately determine the relevant level of assessment to apply to subject species, further analysis of the likelihood of those species occurring within the Study Area was completed.

Five categories for 'likelihood of occurrence' (Table 2) were attributed to species after consideration of criteria such as known records, presence or absence of important habitat features on the subject site, results of the field surveys and professional judgement. This process was completed on an individual species basis.

Species considered further in formal assessments of significance pursuant to relevant legislation were those in the 'Known' to 'Moderate' categories and where impacts for the species could reasonably occur from the development (refer to the outcomes of the affected species analysis in Section 5).

Table 2. Likelihood of occurrence criteria

Likelihood rating	Threatened flora criteria	Threatened and migratory fauna criteria
Known	The species was observed within the Study Area.	The species was observed within the Study Area.
High	It is likely that a species inhabits or utilises habitat within the Study Area.	It is likely that a species inhabits or utilises habitat within the Study Area.
Moderate	Potential habitat for a species occurs on the site. Adequate field survey would determine if there is a 'high' or 'low' likelihood of occurrence for the species within the Study Area.	Potential habitat for a species occurs on the site and the species may occasionally utilise that habitat. Species unlikely to be wholly dependent on the habitat present within the Study Area.
Low	It is unlikely that the species inhabits the Study Area.	It is unlikely that the species inhabits the Study Area. If present at the site the species would likely be a transient visitor. The site contains only very common habitat for this species which the species would not rely on for its on-going local existence.
None	The habitat within the Study Area is unsuitable for the species.	The habitat within the Study Area is unsuitable for the species.

3.3 Limitations

This assessment has utilised the results of targeted survey undertaken within the Study Area by Flora Search (2009) and Biosphere Environmental (2009) as part of the Bulli Seam Operations Project. As such, no targeted trapping fauna surveys were conducted for this assessment. Habitat-based assessments are considered a conservative method of assessing threatened fauna, as presence is determined on the basis of the presence of suitable habitat, not observations of species from the Study Area.

Existing vegetation mapping has been utilised. Areas which are likely to be susceptible to subsidence, for example along riparian areas, were surveyed using RDPs to compliment the plots conducted during the FloraSearch (2009) survey. Large scale validation of the existing vegetation mapping was not considered necessary for this assessment.

This report has replied upon the results of the MSEC (2012), Ecoengineers (2013) and experience in the Southern Coalfield to determine potential impacts to flora and fauna.

4 RESULTS

4.1 Flora and native vegetation

A total of 142 plant species were recorded across the Study Area. Ten weed species were recorded. None of the weed species recorded during the current survey are listed as noxious weeds for the Campbelltown City Council. Flora species recorded in the Study Area are provided in Table 8.

4.2 Vegetation community alignment and description

Vegetation in the Study Area has been mapped as part of Native Vegetation of the South East vegetation mapping project (Tozer 2010) (Figure 4).

Five vegetation communities have been mapped occurring within the Study Area. Descriptions of each vegetation community have been included in Table 3.

Of the five vegetation communities previously mapped within the Study Area, three are equivalent to Threatened Ecological Communities (TECs):

- Cumberland Shale Sandstone Transition Forest is equivalent to Shale Sandstone Transition Forest (SSTF), which is listed as a TEC under TSC Act and EPBC Act.
- Cumberland Shale Plains Woodland which is equivalent to Cumberland Plain Woodland (CPW), which is listed as a Critically Endangered Ecological Community under the TSC Act and EPBC Act.
- Cumberland Shale Hills Woodland is equivalent to CPW, which is listed as a Critically Endangered Ecological Community under the TSC Act and EPBC Act.

Table 3. Vegetation community descriptions of the Study Area

Vegetation community	Description	Conservation status[1]	Area within Locality (ha)	Area within Study Area (ha)
South East NSW (SCIVI) mapping project (Tozer 2010)				
Cumberland Shale Plains Woodland	Cumberland Shale Plains Woodlands, an Eucalypt woodland with an open shrub layer and grassy groundcover. It occurs on clay-loam soils derived from Wianamatta shale and is restricted to the Cumberland Plain, western Sydney. Dominant trees include: *Eucalyptus moluccana, E. tereticornis.* Shrubs: *Bursaria spinosa. Climbers: Glycine tabacina, G. clandestina.* Groundcover: *Dichondra repens, Cheilanthes sieberi, Aristida vagans, Microlaena stipoides, Themeda australis, Brunoniella australis, Desmodium gunnii, Opercularia diphylla, Wahlenbergia gracilis, Dichelachne micrantha, Paspalidium distans, Eragrostis leptostachya, Lomandra filiformis, L. multiflora, Dianella longifolia, Oxalis perennans, Euchiton sphaericus, Goodenia hederacea, Aristida ramosa, Arthropodium milleflorum, Austrodanthonia tenuior, Cymbopogon refractus* and *Echinopogon caespitosus.*	**NSW:** Critically Endangered **Commonwealth:** Critically Endangered	245.47	1.09
Cumberland Shale Hills Woodland	An Eucalypt woodland with an open shrub layer and grassy groundcover, restricted to clay-loam soils derived from Wianamatta Shale on the southern half of the Cumberland Plain, western Sydney. Cumberland Shale Hills Woodland is closely related to Cumberland Shale Plains Woodland (GW p29) but typically occurs on steeper and more undulating terrain. It is found from 50 – 350m ASL in areas receiving 750 – 900 mm mean annual rainfall. Trees: *Acacia implexa, Eucalyptus moluccana, E. tereticornis. Shrubs: Bursaria spinosa, Rubus parvifolius.* Climbers*: Clematis glycinoides, Glycine tabacina.* Groundcover*: Dichondra repens, Brunoniella australis, Desmodium gunnii, Aristida ramosa, Microlaena stipoides, Carex inversa, Themeda australis, Cyperus gracilis, Dichelachne micrantha, Asperula conferta, Oxalis perennans, Cheilanthes sieberi, Desmodium brachypodum, Sporobolus creber, Wahlenbergia gracilis.*	**NSW:** Critically Endangered **Commonwealth:** Critically Endangered	432.30	2.00
Hinterland Sandstone Gully Forest	An open Eucalypt forest, dominated by *Angophora costata, Corymbia gummifera, Banksia serrata* and *Eucalyptus piperita* in the canopy. An abundant sclerophyll shrub stratum is dominated by *Persoonia linearis, P. levis, Phyllanthus hirtellus, Leptospermum trinervium, Lomatia silaifolia, Banksia spinulosa, Platysace linearifolia, Ceratopetalum gummiferum, Acacia ulicifolia* and *Acacia terminalis*. The groundcover is dominated by sedges, with the following species occurring *Entolasia stricta, Pteridium esculentum, Dianella caerulea, Smilax glyciphylla, Xanthosia pilosa, Lomandra longifolia, Lepidosperma laterale* and *Lomandra obliqua.* Hinterland Sandstone Gully Forest occurs on lower slopes of dry sandstone gullies up to 600m ASL where average annual rainfall ranges from 850 to 1300mm.	**NSW:** Not listed **Commonwealth:** Not listed	5695.14	31.00
Sydney Hinterland Transition Woodland	Described by Tozer et al. (2010) as an Eucalypt woodland with an open understorey of sclerophyll shrubs, sedges, forbs and grasses. Dominant trees: *Corymbia gummifera, Eucalyptus punctata, Angophora costata* and *Syncarpia glomulifera.* Shrubs: *Phyllanthus hirtellus, Persoonia linearis, Leptospermum trinervium, Acacia ulicifolia, Persoonia levis, Acacia linifolia, Banksia spinulosa* and *Pimelea linifolia.* Groundcover: *Entolasia stricta, Lomandra obliqua, Pomax umbellata, Themeda australis, Lomandra multiflora, Lepidosperma laterale, Dianella revoluta, Austrostipa pubescens* and *Goodenia hederacea.* This vegetation shares similar characteristic and diagnostic species with Shale Sandstone Transition Forest. Vegetation assessed during the survey consisted of species that resembled that of SHTW.	**NSW:** Not listed **Commonwealth:** Not listed	3006.37	265.53

[1] NSW – *Threatened Species Conservation Act* 1995. Commonwealth – *Environment Protection and Biodiversity Conservation Act* 1999.

Vegetation community	Description	Conservation status[1]	Area within Locality (ha)	Area within Study Area (ha)
Cumberland Shale Sandstone Transition Forest	Described by Tozer et al. (2010) as an Eucalypt forest or woodland with a mixed understorey of sclerophyll shrubs and grasses. Dominant canopy species: *Eucalyptus crebra, Eucalyptus fibrosa, Allocasuarina littoralis* and *Eucalyptus punctata*. Dominant shrubs: *Persoonia linearis, Bursaria spinosa, Ozothamnus diosmifolius* and *Hibbertia aspera*. Groundcover: *Lepidosperma laterale, Cheilanthes sieberi, Aristida vagans, Pratia purpurascens, Microlaena stipoides, Entolasia stricta, Lomandra multiflora, Themeda australis, Panicum simile, Echinopogon caespitosus, Pomax umbellata, Dichondra spp., Billardiera scandens* and *Opercularia diphylla.* This plant community is equivalent to Shale Sandstone Transition Forest, an EEC listed under both the TSC and EPBC Acts.	**NSW:** Endangered **Commonwealth:** Endangered	2624.34	78.29
		TOTAL	12003.70	377.91

4.2.1 Vegetation mapping validation

Vegetation in the Study Area was surveyed by FloraSearch (2009). The survey confirmed the broad results of Tozer (2010) through the compilation of quadrats and random meanders. The current survey has relied upon the existing vegetation mapping, and confirmed the presence/absence of TECs along the riparian zones which may be susceptible to subsidence. This report does not aim to provide a detailed quantitative assessment of vegetation condition across the Study Area similar to those generated by methodologies such as Biometric (Gibbons et al., 2008) or BioBanking (DECC, 2008). Such detailed assessment is not necessary for this assessment.

Native vegetation condition varies widely across the Study Area according to land use history.

Most of the vegetation to the west of the Study Area above Longwall 37 consisted of SSTF in various conditions, and extensive areas of exotic pasture.

Dominant species recorded in SSTF include: *Eucalyptus crebra, Eucalyptus fibrosa, Eucalyptus punctata* and *Allocasuarina littoralis*. Dominant shrubs include: *Acacia decurrens, Bursaria spinosa, Ozothamnus diosmifolius* and *Persoonia linearis*. Groundcover included: *Aristida vagans, Cheilanthes sieberi, Dichondra repens, Echinopogon caespitosus, Lomandra multiflora, Microlaena stipoides, Panicum simile, Pomax umbellata, Pratia purpurascens,* and *Themeda australis*.

SSTF recorded along the western ridgeline of the Georges River was observed to be in the best condition with all strata layers intact. SSTF in this area integrated with Sydney Hinterland Transition Woodland and Hinterland Sandstone Gully Forest further downslope toward the Georges River.

SSTF has been mapped along the banks of ephemeral watercourses in the Study Area. Watercourses include: Mallaty Creek, Nepean Creek and tributaries of the Georges River. SSTF along Mallaty Creek and Nepean Creek were observed to be in a poor condition due to previous clearing and weed invasion.

Within the pasture lands, stands of Eucalypts occur as paddocks trees. It is likely that some of these trees may qualify as SSTF. These stands are located away from areas susceptible to subsidence such as ridgelines and watercourses (further discussed in Section 5.1) and were therefore not surveyed in detail.

Pasture lands in the Study Area consisted predominantly of exotic species including: *Eragrostis curvula, Hypochaeris radicata, Paspalum dilatatum, Pennisetum clandestinum, Phytolacca octandra, Plantago lanceolata, Senecio madagascariensis, Setaria gracilis, Sporobolus creber, Tagetes minuta, Trifolium repens* and *Verbena bonariensis.* Native species included: *Aristida ramosa, Aristida vagans, Cynodon dactylon, Eragrostis brownii, Poa sieberiana* and *Themeda australis.* The pasture is used for grazing. Horses, goats and cows were present in the paddocks during the current survey.

Toward the east of the Study Area, Sydney Hinterland Transition Woodland dominates. The community occurs on the gentle slopes and flat terrain toward the Georges River and integrates into Hinterland Sandstone Gully Forest. A large portion of this community is land owned by the Tharawal LALC. The vegetation is considered to be in good condition with high resilience.

Very small patches of Cumberland Shale Plains Woodland have been mapped to the west of the Study Area. These remnants have mostly lost their understorey shrub layer and have a highly modified ground cover layer with low native species diversity and abundant weeds. Their condition and resilience are considered to be low to moderate (FloraSearch 2009).

Potential impacts to native vegetation are discussed in Section 5.1.

4.2.2 Threatened ecological communities

Two EECs (SSTF and CPW) have been previously mapped within the Study Area as described above in Section 4.2.

Both EECs are recorded away from the riparian zones and edges of the Georges River valley which may be susceptible to subsidence impacts.

No Upland Swamps were recorded in the Study Area.

Potential impacts to TECs are discussed in Section 5.2.

4.2.3 Threatened flora

A total of 31 subject threatened flora, as listed on the TSC and/or EPBC Acts, were considered in this assessment (Appendix 1). This list was derived from the database searches outlined in Section 2.1.

One threatened flora species was recorded during the current field survey: *Grevillea parviflora* subsp. *parviflora* was located throughout the Dharawal State Conservation Area, Crown Land and common along transmission lines in the Study Area. The population within the State Conservation Area was extensive and would consist of thousands of individuals. The species was recorded within Sydney Hinterland Transition Woodland and was dominant in the understorey. This species was also recorded by FloraSearch (2009).

Persoonia hirsuta has previously been recorded within the Study Area (OEH 2013). The record is above Longwall 38. It was not recorded during the current survey. It was also recorded within Sydney Hinterland Transition Woodland.

No other threatened flora species have been previously recorded in the Study Area.

Threatened flora records within the locality are illustrated in Figure 5.

The locations of those threatened flora species recorded during the field survey are illustrated in Figure 7.

Thirteen threatened flora species have potential habitat within the Study Area. Species include: *Acacia bynoeana, Acacia pubescens, Callistemon linearifolius, Epacris purpurascens var. purpurascens, Grevillea parviflora ssp. parviflora, Leucopogon exolasius, Melaleuca deanei, Persoonia bargoensis, Persoonia hirsuta, Persoonia nutans, Pimelea spicata, Pomaderris brunnea,* and *Pultenaea aristata.* These species have been given a moderate to high likelihood of occurrence within the Study Area. These species are considered further for impact assessment in Section 5.3.

4.3 Fauna

Fauna recorded during the field survey includes: two amphibians, 24 birds, six mammals and three reptiles. One threatened fauna species – Glossy Black Cockatoo was recorded during the field survey.

When combined with the result of the Biosphere (2009) survey, nine amphibians, 41 birds, 17 mammals and seven reptiles were recorded.

The fauna observations are provided in Appendix 3.

4.4 Fauna habitat

Fauna habitat within the Study Area is broadly dependant on vegetation type and topography with specific structural features also important in determining the presence and distribution of fauna. Species from different fauna guilds may have specific habitat requirements that are represented in only one, or many, of the identified vegetation types.

The following distinct habitat types and features have been identified and are referred to throughout this report:

- ❒ Woodland/Forest;
- ❒ Pasture/Paddocks;
- ❒ Creeks and drainage lines;
- ❒ Sandstone outcrops, overhangs and caves; and,
- ❒ Important microhabitat features.

4.4.1 Woodland/forest

Sandstone vegetation communities and transitional shale sandstone communities occupy a large portion of the Study Area. The communities range from dry shrubby woodland and open woodland along ridge tops and exposed slopes to gully forest and riparian vegetation associated with creeklines.

Woodland and Forest habitats provide a wide range of food and shelter for vertebrate fauna. Myrtaceaeous trees, mostly Eucalypt species, generally dominate the upper canopy in these areas and supply direct (foliage, nectar, exudates) and indirect food (arthropods) for a range of vertebrates, particularly birds and arboreal mammals.

Dense under storey and shrub vegetation was common in parts of the Study Area, particularly along the Georges River. These areas provide important habitat for a range of species. These include small birds and ground-dwelling mammals.

4.4.2 Pasture/paddocks

The pasture and paddocks which occupy most of the Study Area to the west of the Georges River provide little habitat for native fauna. The pasture and paddocks provide some foraging habitat for opportunistic species.

4.4.3 Creeks and drainage Lines

Watercourses within the Study Area include: Georges River, Mallaty Creek and its tributaries, Nepean Creek and its tributaries, Woodhouse Creek, and various tributaries of the Georges River. Habitat features associated with these creeks and drainage lines include: emergent vegetation, riffles, pools, sandy substrate and rocks.

Creek lines are important to particular frogs and reptiles including threatened species, with water facilitating the breeding cycle of most frogs. In addition, many terrestrial species rely upon streams of the Study Area for drinking. The character of drainage lines depends on their size, slope and catchment area with small ephemeral streams important breeding and sheltering habitat for some species and larger permanent streams preferred by others.

The other watercourses are ephemeral and provide only limited aquatic habitat (Cardno Ecology Lab 2013). Most of the riparian vegetation along these areas has been removed through historic clearing, only leaving thin bands of vegetation. These ephemeral creeks provide limited habitat for threatened amphibians due to lack of habitat features. After heavy rainfall the ephemeral creeks are likely to provide pools and flow which would be suitable for amphibians.

4.4.4 Sandstone outcrops, overhangs and caves

Sandstone outcrops, overhangs and small caves occur throughout the Study Area along the Georges River. This habitat feature is of particular importance to reptile and bat species. Threatened reptiles that may utilise such a feature include the threatened Broad-headed Snake.

The Brush-tailed rock wallaby and Spotted-tail Quoll utilise rock outcrops. Potential habitat exists for both these species along the Georges River.

Caves and overhangs provide habitat for Micro-bats, including threatened species – Eastern False Pipistrelle, Large-eared Pied Bat, Eastern Bentwing-bat and Little Bentwing-bat.

4.4.5 Microhabitat features

Other habitat features that occur across the Study Area include micro habitat features such as:

- Hollow bearing trees;
- Mature trees;
- Woody debris;
- Termite mounds;
- Leaf litter; and,
- Exfoliating bark.

4.5 Threatened fauna

A total of 59 subject threatened fauna have previously been recorded (Atlas of NSW Wildlife) or are predicted to have habitat (EPBC Act) within 10 km of the Study Area (Appendix 1). After considering the habitat present within the Study Area and the results of the field survey and previous studies, 43 of these threatened fauna were considered to have a moderate likelihood of occurrence within the Study Area.

One threatened fauna species was recorded during the current survey. The Glossy Black Cockatoo was recorded in the Study Area to the east of Longwall 37.

The following threatened fauna species have been previously recorded in the Study Area (OEH 2013): Koala, Scarlet Robin, Varied Sittella, Little Lorikeet, Little Eagle, Grey-headed Flying Fox and Koala.

The Spotted-tail Quoll was previously recorded immediately outside of the Study Area to the south of Longwall 38 (OEH 2013). Potential habitat for the Spotted-tail Quoll occurs within the Study Area along the Georges River. Habitat such as fallen hollow logs, dense vegetation and rock outcrops were observed. Within home ranges of the Spotted-tail Quoll, Quolls establish 'latrines' where they regularly defecate and scent mark. The latrine sites are typically found on exposed rocks or flat top boulders (often indicated by patches of dead moss or lichen) along creeks or on rock outcrops and/or large ground logs, exposed rock at the base of cliffs or sometimes on exposed ground adjacent to tracks. No latrine sites were identified in the Study Area during the current field survey.

No threatened amphibians were recorded during the current survey or previous surveys in the Study Area by FloraSearch (2009). Potential habitat occurs along the Georges River for Red-crowned Toadlet, Giant Burrowing Frog, Littlejohn's Treefrog, and Green and Golden Bell Frog.

Sufficient hollows, rock crevices and outcrops were located along the Georges River and provide habitat for threatened microbats: Eastern False Pipistrelle, Large-eared Pied Bat, Eastern Bentwing-bat and Little Bentwing-bat.

An assessment of the potential impacts of the proposal on these threatened fauna species is provided in Section 5.4.

5 IMPACT ASSESSMENT

5.1 Affected ecological communities

Vegetation communities which are independent of ground-water are unlikely to be impacted by subsidence due to underground mining. This accounts for most of the woodland and forest communities in Table 3.

Riparian vegetation is generally not mapped as discrete vegetation communities; rather these areas display structural and floristic variation within their composite community in response to more frequent contact with the local water table. Riparian vegetation may be impacted by subsidence through water diversion, cracking of bedrock or the release of strata gas.

In the Southern Coalfield, impacts to riparian vegetation as a result of subsidence are minor in occurrence. Previous examples of impacts include: dieback of riparian vegetation as a result of subsidence which occurred nearby Cataract River during the 1990s (Eco Logical Australia, 2004 in TEC 1997), and small localised changes to riparian vegetation along a Section of the Waratah Rivulet (HC 2007). Strata gas emissions association with subsidence are temporary (generally less than 12 months), and therefore are unlikely to cause long-term adverse changes to the habitat of threatened riparian species (FloraSearch 2009).

Impacts to riparian vegetation associated with the proposal are unlikely, and if occurred, are likely to be localised minor floristic changes.

Impacts to vegetation communities are unlikely to result in a significant impact based on the following:

- MSEC (2012) and Ecoengineers (2013) do not predict any large scale subsidence impacts nor gas emissions from the proposal likely to impact riparian vegetation (Section 1.4).
- Previous impacts to vegetation as a result of subsidence in the Southern Coalfield are isolated and minor.
- The Georges River is unlikely to experience loss of water or large scale hydrological impacts (MSEC 2012). Therefore, it is unlikely that riparian vegetation will be impacted.
- The magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in shale/sandstone transition soils and clay soils (FloraSearch 2009). Therefore, it is unlikely there would be any biologically significant effects on the habitats of threatened shale sandstone transition and clay species, due to soil moisture change.
- Surface cracking as a result of subsidence movements is expected to be isolated and minor.
- In alluvial environments mine subsidence has some potential to affect threatened plant species through changes in hydrology impacting on individual plants or groups of plants. However, impacts to hydrology and flow are likely to be minor and localised (MSEC 2012).

- Strata gas release has the potential to result in vegetation die back near the points of emission. Such events are rare and affect relatively small areas (e.g. 0.12 hectares in one documented case on the Cataract River near Appin, FloraSearch 2009). The vegetation in the affected area subsequently recovered through assisted and natural regeneration.
- The vegetation along the Georges River is mapped as Hinterland Sandstone Gully Forest, which is not listed as an EEC.
- Small patches of degraded SSTF were recorded along the banks of some ephemeral watercourses (Woodhouse and Mallaty) to the west of the Study Area near Longwall 37, however these watercourses are ephemeral and experience periods of dryness and inundation. It is unlikely that subsidence would impact on vegetation along the ephemeral watercourses.
- Much of the vegetation along watercourses to the west of the Study Area is currently impacted by grazing and previous clearing.
- Ridgetop, woodland and paddock vegetation is unlikely to be impacted by subsidence. Some cracking may be observed in the soil, however it is unlikely to result in a significant impact to vegetation composition.

5.2 Affected threatened ecological communities

SSTF and CPW have been mapped within the Study Area (Tozer et al 2010). Location descriptions for these communities are provided in Section 4.2.2.

SSTF and CPW within the Study Area are unlikely to be significantly impacted by subsidence based on the following:

- SSTF occurs in shale/sandstone transition soils, and CPW occurs in clay soils. The magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in such soils (FloraSearch 2009).
- The predicted subsidence impacts are likely to be minor and isolated. It is unlikely there would be any biologically significant effect on species within shale sandstone transition soils or clay soils due to soil moisture change.
- Surface cracking as a result of subsidence movements is expected to be isolated and minor.
- SSTF was observed along the banks of the ephemeral watercourses (Woodhouse and Mallaty) to the west of the Study Area. The condition of SSTF in this part of the Study Area was in a modified condition, due to weed invasion, previous clearing and current agricultural practises. Given the watercourses in the west of the Study Area are ephemeral, SSTF in this area currently experiences periods of dryness and inundation. It is unlikely that subsidence would impact on vegetation along the ephemeral watercourses.
- Very small patches of Cumberland Shale Plains Woodland have been mapped to the west of the Study Area away from watercourses and ridgelines. It is highly unlikely that CPW would be significantly impacted by subsidence.
- The majority of the SSTF in the Study Area is located away from the watercourses, and therefore are unlikely to experience significant impacts associated with subsidence.

- Approximately 78.29 hectares of SSTF has been mapped within the Study Area. Approximately 264.34 hectares of SSTF has been mapped within the locality. SSTF within the Study Area therefore represents a relatively small portion of the extent of the community within the locality.
- Approximately 3.09 hectares of CPW has been mapped within the Study Area. Approximately 677.77 hectares of CPW has been mapped within the locality. CPW within the Study Area therefore represents a relatively small portion of the extent of the community within the locality.
- No Critical Habitat has been declared for SSTF and CPW within the Study Area.

Given the proposal is unlikely to result in any significant impact to SSTF or CPW, no Seven Part Tests or Assessment of Significance were carried out for any TEC. The proposal is unlikely to have a significance impact on any TEC.

5.3 Affected threatened flora

Fourteen threatened flora species have been determined to have a moderate to high likelihood of occurring within the Study Area (Table 4). However, not all of these species would have habitat potentially impacted by subsidence. As such, Seven-Part Tests and/or Assessments of Significance were conducted for species with potential habitat likely to be impacted by subsidence or species known to occur within the Study Area.

Subsidence may impact those species which occur along watercourses, riparian zones, and alluvial soils.

The magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in shale/sandstone transition soils and clay soils (FloraSearch 2009). It is unlikely there would be any biologically significant effect on the habitats of threatened shale sandstone transition and clay species due to soil moisture change. Furthermore, surface cracking of soils as a result of subsidence movements is expected to be isolated and minor. As such, Seven Part Tests and/or Assessments of Significance were not required for the following species: *Acacia bynoeana, Acacia pubescens, Callistemon linearifolius, Persoonia bargoensis, Persoonia hirsuta, Persoonia nutans* and *Pimelea spicata*.

Threatened flora associated with ground water dependent habitats, such as riparian vegetation and alluvial soils may be subject to subsidence impacts. Threatened flora which may occur within, or in close proximity to riparian vegetation, include: *Epacris purpurascens* var. *purpurascens, Leucopogon exolasius, Melaleuca Deanei, Pomaderris brunnea* and *Pultenaea aristata*. Most of these species rely on the alluvial soils found along the Georges River in the Study Area.

Seven Part Tests and/or Assessments of Significance were carried out for those species listed in Table 4. The assessments are provided in Appendix 4 and 5.

The assessments concluded that the proposal is unlikely to have a significant impact on any threatened flora species, based on the following:

- There is a low likelihood of impacts to the threatened species as a result of subsidence;

- Large area of potential habitat for the species within the Study Area and locality will not be impacted by subsidence;
- Records of the species occur within Heathcote National Park, Dharawal Conservation reserves and protection within the Sydney Metropolitan Catchment Areas;
- Subsidence is unlikely to impact on known pollination and dispersal mechanisms of the species;
- The magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in shale/sandstone transition soils and clay soils (FloraSearch 2009);
- Surface cracking as a result of subsidence movements is expected to be isolated and minor;
- In alluvial environments mine subsidence has some potential to affect threatened plant species through changes in hydrology impacting on individual plants or groups of plants. However, impacts to hydrology and flow are likely to be minor and localised (MSEC 2012);
- Strata gas release has the potential to result in vegetation die back near the points of emission. Such events are rare and affect relatively small areas;
- With the exception of *Grevillea parviflora* subsp. *parviflora* (which does not occur along riparian zones and alluvial soils), no other threatened flora species was recorded during the current and previous surveys; and
- No critical habitat is known to occur within the Study Area.

Table 4. Affected threatened flora species

Species	EPBC Act	TSC Act	Likelihood of Occurrence	Potential to be impacted by subsidence	Seven Part Test outcome	Assessment of Significance outcome
Epacris purpurascens var. *purpurascens*	-	V	Moderate	Yes. Creek line habitat may be impacted by subsidence mechanisms.	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Grevillea parviflora subsp.. *parviflora*	V	V	Known	No. Ridge line vegetation communities are unlikely to be altered by subsidence impacts. However, has been previously recorded in Study Area.	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Leucopogon exolasius	V	V	Moderate	Yes. Creek line habitat may be impacted by subsidence mechanisms.	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Melaleuca deanei	V	V	Moderate	Yes. Creek line habitat may be impacted by subsidence mechanisms. Previously recorded in Dharawal Conservation Area.	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Pomaderris brunnea	V	V	Moderate	Yes. Creek line habitat may be impacted by subsidence mechanisms.	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Pultenaea aristata	V	V	Moderate	Yes. Creek line habitat may be impacted by subsidence mechanisms.	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**

5.4 Potential impacts to fauna

Subsidence may have a direct impact on known and potential habitat for threatened fauna such as creeks, drainage lines, rock overhangs, rocky outcrops, cliffs, crevices, and riparian vegetation. Predicted impacts to these habitats are discussed in detail in Section 1.4. All impact assessments have been based on the upper limit of subsidence impacts predicted by MSEC (2012). This ensures a conservative approach towards potential impacts on ecological values.

Open pasture grasslands, woodland and forest habitat types make up the majority of the Study Area. These habitat types are unlikely to be impacted by subsidence related impacts. Microhabitat features such as tree hollows and exfoliating bark are also unlikely to be impacted.

Fracturing and cracking of the surface may result in the form of pitfall traps which may cause harm to some fauna. Given the remediation measures proposed, and the low likelihood of occurrence, impacts to fauna as a result of surface cracking are likely to be negligible.

The proposed longwall layout has been set back from the Georges River, and as such, habitats within this area are unlikely to be subject to the full range of subsidence related movements. Minor cracking and localised changes to ponding may occur in Georges River, which may cause very small microhabitat impacts, however given the likelihood of this occurring and the extensive habitat available along the creek, impacts to fauna would be negligible.

Water quality may be impacted through erosion and loss of soil materials into watercourses as well as some changes to water quality which can impact amphibious fauna and riparian vegetation. However changes to water quality are considered to not be significant (Ecoengineers 2012).

Impacts on cliff lines and rock outcrops within the Study Area are likely to be minimal. No large scale cliff collapses of slope failures are predicted. Small rock outcrops are expected to experience minor impacts. Although rock falls may alter roosting or sheltering habitat for a range of species, new habitat for these species are likely to be created. Rock falls do have the potential to harm or cause mortality to species that reside under rock overhangs. Given the minimal occurrence of rock falls and collapses predicted, the likelihood of this is low.

5.5 Potential impacts to threatened fauna

Forty-two threatened fauna have been determined to have a moderate to high likelihood of occurrence within the Study Area. However, not all of these species have habitat potentially impacted by subsidence. As such, Seven-Part Tests and Assessments of Significance were conducted for species with potential habitat likely to be impacted by subsidence. Seven-Part Tests and/or Assessments of Significance were also conducted for threatened fauna that are known or have a high likelihood of occurrence in the Study Area.

Seven-Part Tests and/or Assessments of Significance were not required for species which relied upon woodland environments, microhabitat features such as hollow bearing trees,

logs, or had no limiting habitat features in the Study Area. Assessments were not required for the following species:

- **Birds:** Fork-tailed Swift, Gang-gang Cockatoo, Glossy Black-cockatoo, Spotted Harrier, Brown Treecreeper, Varied Sittella, Latham's Snipe, Little Lorikeet, Little Eagle, White-throated Needletail, Swift Parrot, Hooded Robin, Rainbow Bee-eater, Black-faced Monarch, Satin Flycatcher, Turquoise Parrot, Barking Owl, Powerful Owl, Scarlet Robin, Flame Robin, Eastern Ground Parrot, and Speckled Warbler.
- **Mammals:** Eastern Pygmy-possum, Koala, Yellow-bellied Glider, Squirrel Glider and New Holland Mouse.

Seven-Part Tests and Assessments of Significance were conducted for 15 threatened fauna species. These species have been identified in Table 5 and assessments have been provided in Appendix 4 and 5. These species utilise rock outcrops, overhangs, surface rock, riparian vegetation and watercourses which may be impacted by subsidence. The assessments concluded that the proposal is unlikely to have a significant impact on threatened fauna species.

No threatened fauna species are unlikely to be impact by subsidence due to the following:

- Limiting habitat is unlikely to be impacted by subsidence;
- Potential habitat is abundant;
- No limiting resources are likely to be impacted;
- The proposal is unlikely to result in death or injury;
- Most of the species listed above are mobile and unlikely to rely only on the habitat within the Study Area; and,
- No important populations of the species have been recorded in the Study Area.

Table 5: Affected threatened fauna

Common name	EPBC Act	TSC Act	Likelihood of occurrence	Potential to be impacted by subsidence	Seven Part Test outcome	Assessment of Significance outcome
Green and Golden Bell Frog	V	E	Moderate	Yes, potential habitat impacted. Potential impacts include: changes to flow regimes, loss of surface flow and deep pools and hydrological changes	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Littlejohn's Tree Frog	V	V	Moderate	Yes, potential habitat impacted. Potential impacts include: changes to flow regimes, loss of surface flow and deep pools and hydrological changes	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Giant Burrowing Frog	V	V	Moderate	Yes, potential habitat impacted. Potential impacts include: changes to flow regimes, loss of surface flow and deep pools and hydrological changes	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Red-crowned Toadlet	-	V	High	Yes, potential habitat impacted. Potential impacts include: changes to flow regimes, loss of surface flow and deep pools and hydrological changes	Significant impact on species: **Not Likely**	Assessment not required
Spotted-tailed Quoll (southeastern mainland)	E	V	Moderate-High	Yes, potentially impacted. Potential impacts include: death or injury as result of rock fall or collapse, possible changes in availability of breeding and roosting habitat, potential loss of prey species within creeks and ridge lines.	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Eastern False Pipistrelle	-	V	Moderate	Yes, potentially impacted. Potential impacts include: rock fall or collapse, possible changes in availability of breeding and roosting habitat.	Significant impact on species: **Not Likely**	Assessment not required
Eastern Freetail Bat	-	V	Moderate	Yes, potentially impacted. Potential impacts include: rock fall or collapse, possible changes in availability of breeding and roosting habitat.	Significant impact on species: **Not Likely**	Assessment not required
Grey-headed Flying-fox	V	V	Known	No. Potential impacts are unlikely. Subsidence mechanisms unlikely to alter potential habitat.	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Large-eared Pied Bat	V	V	Moderate	Yes, potentially impacted. Potential impacts include: rock fall or collapse, possible changes in availability of breeding and roosting habitat.	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Eastern Bent-wing Bat	-	V	High	Yes, potentially impacted. Potential impacts include: rock fall or collapse, possible changes in availability of breeding and roosting habitat.	Significant impact on species: **Not Likely**	Assessment not required
Large-footed Myotis	-	V	Moderate	Yes, potentially impacted. Potential impacts include: rock fall or collapse, possible changes in availability of breeding and roosting habitat.	Significant impact on species: **Not Likely**	Assessment not required
Yellow-bellied Sheathtail-bat	-	V	Moderate	Yes, potentially impacted. Potential impacts include: rock fall or collapse, possible changes in availability of breeding and roosting habitat.	Significant impact on species: **Not Likely**	Assessment not required
Greater Broad-nosed Bat	-	V	Moderate	Yes, potentially impacted. Potential impacts include: rock fall or collapse, possible changes in availability of breeding and roosting habitat.	Significant impact on species: **Not Likely**	Assessment not required
Broad-headed Snake	V	E	Moderate	Yes, potentially impacted. Potential impacts include: rock fall or collapse, possible changes in availability of breeding and roosting habitat.	Significant impact on species: **Not Likely**	Significant impact on species: **Not Likely**
Rosenberg's Goanna	-	V	Moderate	Yes, potentially impacted. Potential impacts include: death or injury as result of rock fall or collapse, possible changes in availability of breeding and roosting habitat.	Significant impact on species: **Not Likely**	Assessment not required

5.5.1 SEPP No. 44 – koala habitat protection

State Environmental Planning Policy 44 (SEPP 44) aims to encourage the conservation and management of areas of natural vegetation that provide potential habitat for koalas.

SEPP 44 applies to land within the Wollondilly LGA. Under this policy, a determination of 'potential' and 'core' habitat must be defined at the site of development. The determination is based on previous koala records, Eucalypt species present, condition of the site, presence and quality of adjoining vegetation, and size of the area.

The proposal is unlikely to cause fragmentation to koalas potentially occupying the area, nor a loss of habitat features.

5.6 Key Threatening Processes

The Key Threatening Processes (KTPs) as listed on the TSC that are applicable to the project are discussed below. No KTPs listed under the EPBC Act are relevant to the proposal.

5.6.1 Alteration of habitat following subsidence due to longwall mining

Alteration of habitat following subsidence due to longwall mining is listed as a KTP under Schedule 3 of the TSC Act.

This is the most relevant KTP associated with the proposal.

Subsidence due to longwall mining has been recognised as causing habitat alteration, with species and ecological communities that depend on aquatic and semi-aquatic habitats being particularly susceptible to the impacts of subsidence. Consequently, alteration of habitat following subsidence due to longwall mining has been determined by the NSW Scientific Committee to constitute a Key Threatening Process (NSW Scientific Committee 2005).

A list of threatened species, populations and EECs potentially impacted by longwall mining is provided in the NSW Scientific Committee Final Determination for this KTP (NSW Scientific Committee 2005).

Flora of relevance to this assessment include: *Epacris purpurascens* var. *purpurascens, Leucopogon exolasius, Melaleuca deanei,* and *Pultenaea aristata.*

Fauna include: Eastern Pygmy Possum (*Cercartetus nanus*), Giant Burrowing Frog (*Heleioporus australiacus*), Black Bittern (*Ixobrychus flavicollis*), Littlejohn's Tree Frog (*Litoria Littlejohni*), Large-footed Myotis (*Myotis adversus*), Long-nosed Potoroo (*Potorous tridactylus*), Red-crowned Toadlet (*Pseudophryne australis*), Grey-headed Flying Fox (*Pteropus poliocephalus*) and Rosenberg's Goanna (*Varanus rosenbergi*).

SSTF has also been listed in the KTP and is relevant to the Study Area.

5.6.2 Alteration of the natural flow regimes of rivers, stream, floodplains and wetlands

Alteration of the natural flow regimes of rivers, stream, floodplains and wetlands is listed as a KTP under Schedule 3 of the TSC Act.

This is a relevant KTP associated with the proposal.

Alteration to natural flow regimes can occur through reducing or increasing flows, altering seasonality of flows, changing the frequency, duration, magnitude, timing, predictability and variability of flow events, altering surface and subsurface water levels and changing the rate of rise or fall of water levels. Based on the MSEC (2012) report, the proposal has the potential to cause some minor and isolated changes to the natural flows of watercourses in the Study Area.

5.7 Critical Habitat

No Critical Habitat to date has been declared for any ecological values within the Study Area under the TSC Act or EPBC Act. No Critical Habitat will be impacted by the proposal.

6 AMELIORATION MEASURES

It is recommended the following be included in the terrestrial ecology monitoring program for the project:

- Monitoring should be conducted for as long as impacts could occur or, where applicable, until a decision can be made about recovery.
- In the event that monitoring does reveal impacts, mitigation measures should be considered to minimise and negate emerging impacts.
- The implementation of any mitigation measures should include monitoring to confirm the success of any implemented measures.
- All remediation works must take appropriate measures to minimise environmental impacts. This includes avoiding the spread of Chytrid Fungus following the NPWS guidelines.
- Any surface cracking within woodland or forested areas assessed to result in significant fauna entrapment should be mitigated as soon as possible.

7 CONCLUSION

This report provides a terrestrial ecological assessment to address the potential impacts associated with the extraction of Bulli Seam Coal from Longwalls 37-38 within the West Cliff Area 5 domain.

The Study Area had been subject to previous ecological survey and assessments conducted in 2009 as part of the BSOP. The current assessment involved a thorough review of the previous assessments along with habitat assessment and targeted threatened flora survey, focusing on landscape features that may be sensitive to impacts of subsidence from longwall extraction.

The report concentrated on natural areas sensitive to subsidence, which included: Georges River, Mallaty Creek and its tributaries, Woodhouse Creek, various tributaries of the Georges River, cliffs, rock outcrops, steep slopes, and riparian vegetation.

Subsidence predictions detailed in MSEC (2012) were used as the basis to which the impact assessments for threatened flora, fauna and ecological communities have been assessed in this report.

Five vegetation communities have been previously mapped in the Study Area, three of which are equivalent to EECs:

- Cumberland Shale Sandstone Transition Forest is equivalent to Shale Sandstone Transition Forest, which is listed as an EEC under TSC Act and EPBC Act.
- Cumberland Shale Plains Woodland and Cumberland Shale Hills Woodland which are equivalent to Cumberland Plain Woodland listed as a Critically Endangered Ecological Community under the TSC Act and EPBC Act.

Vegetation communities which are not ground-water dependent are unlikely to be significantly impacted by subsidence due to underground mining.

The proposal is unlikely to result in any physical landscape changes which may impact SSTF or CPW. This assessment concludes that SSTF and CPW are unlikely to be significantly impacted by the proposal.

Fourteen threatened plant species have been determined to have a moderate to high likelihood of occurring within the Study Area. However, not all of these species would have habitat potentially impacted by subsidence. Seven-Part Tests and/or Assessments of Significance were conducted for species with potential habitat likely to be impacted by subsidence or species known to occur within the Study Area. Seven Part Tests and/or Assessments of Significance were conducted for the following species: *Epacris purpurascens* var. *purpurascens, Grevillea parviflora* subsp. *parviflora, Leucopogon exolasius, Melaleuca deanei, Pomaderris brunnea* and *Pultenaea aristata*.
The assessments concluded that the proposal is unlikely to have a significant impact on any threatened flora species.

Forty-three threatened fauna have been determined to have a moderate to high likelihood of occurrence within the Study Area. Seven-Part Tests and Assessments of Significance were conducted for species with potential habitat likely to be impacted by subsidence.

Seven-Part Tests and/or Assessments of Significance were carried out for the 15 threatened species including:

- **Amphibians,** including Green and Golden Bell Frog, Littlejohn's Tree Frog, Giant Burrowing Frog, and Red-crowned Toadlet.
- **Mammals,** including Spotted-tailed Quoll, Eastern False Pipistrelle, Eastern Freetail Bat, Grey-headed Flying-fox, Large-eared Pied Bat, Eastern Bent-wing Bat, Large-footed Myotis, Yellow-bellied Sheathtail-bat, Greater Broad-nosed Bat
- **Reptiles,** including Broad-headed Snake and Rosenberg's Goanna.

The assessments concluded that the proposal is unlikely to have a significant impact on any threatened fauna species.

No State Environmental Planning Policy (SEPP) No. 44 Koala Habitat will be impacted by the proposal.

The proposal would result in two KTPS: 'Alteration of habitat following subsidence due to longwall mining', and 'Alteration of the natural flow regimes of rivers, stream, floodplains and wetlands'.

No Critical Habitat would be impacted by the proposal.

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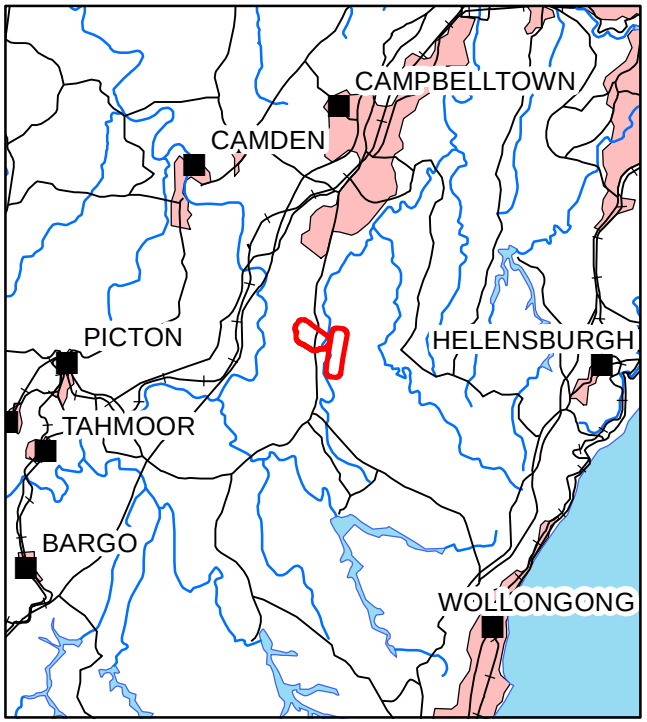
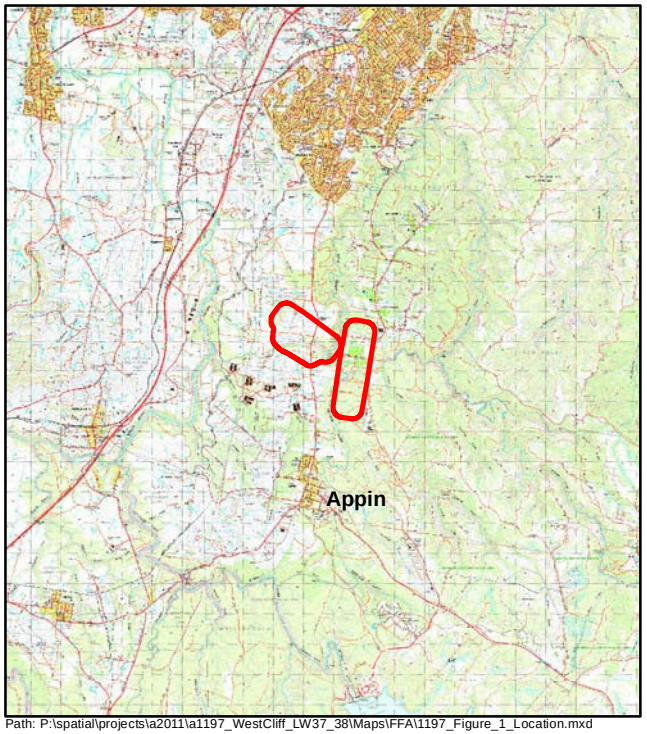
FIGURES





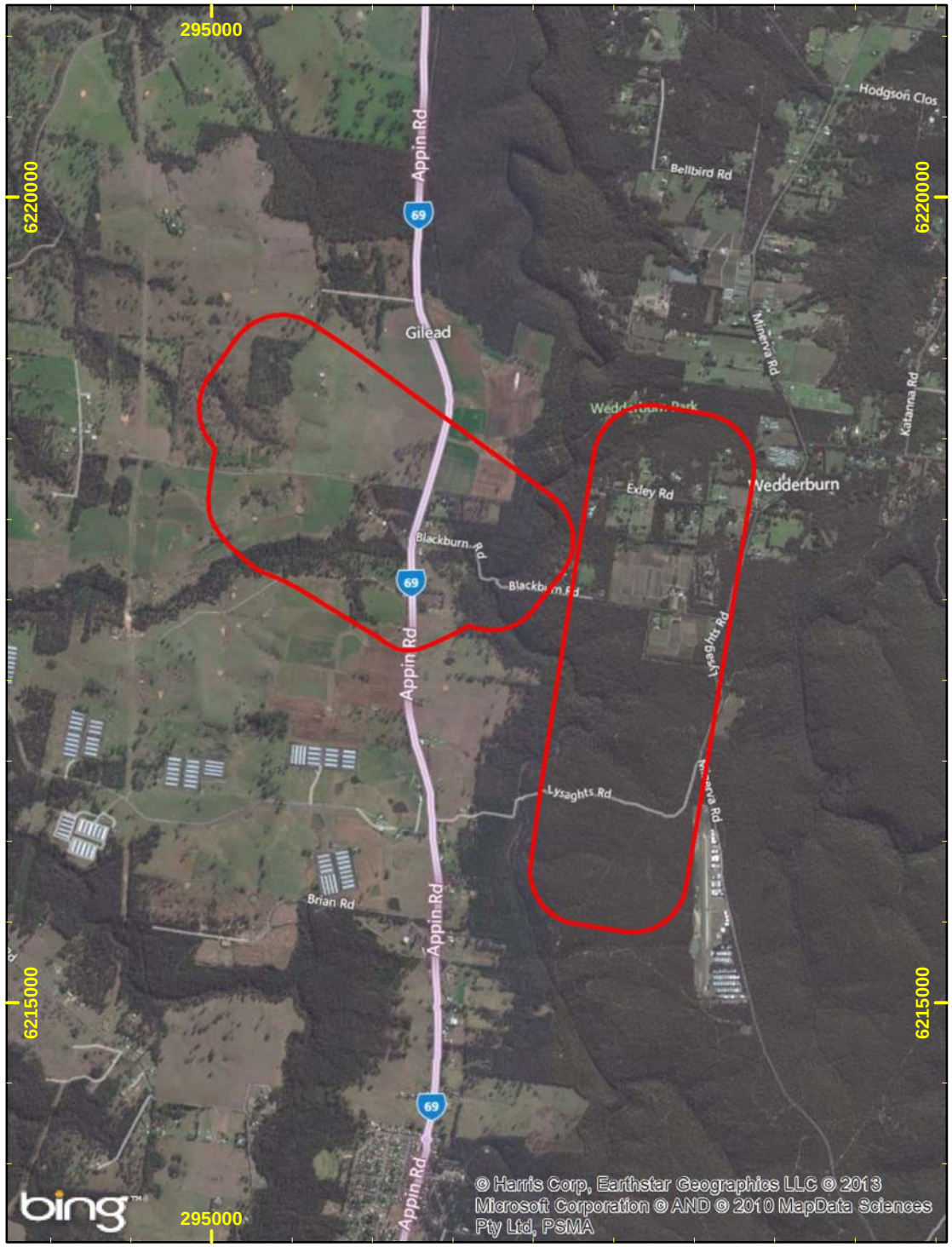


Figure 1: Location Map

1197 West Cliff LW 37-38
Extraction Plan
Terrestrial Ecology Report

Drawn by: EM
Project Mgr: LB
Date: 16/05/2013

Study Area

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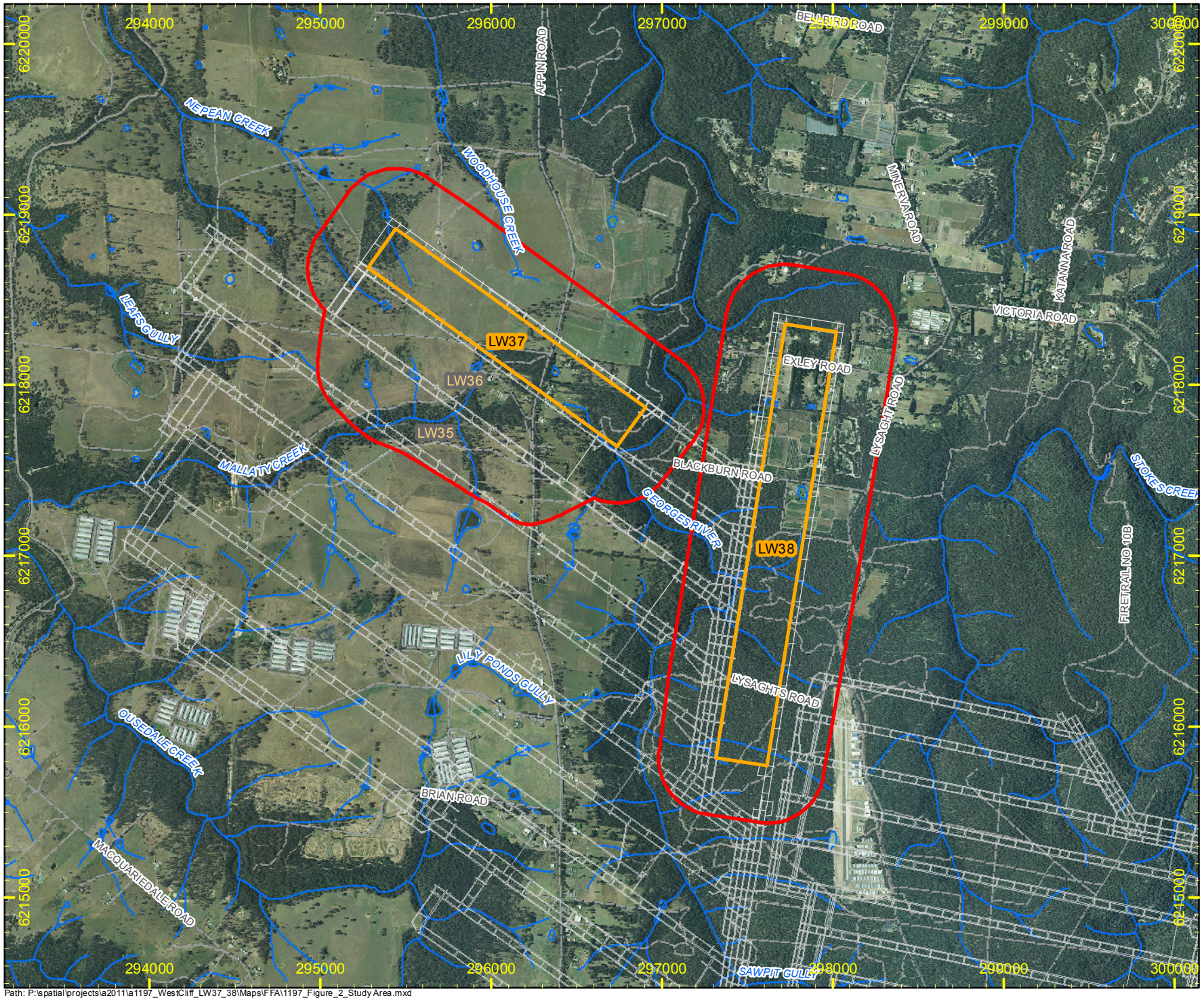

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Figure 2: Study Area

1197 West Cliff LW 37-38
Extraction Plan
Terrestrial Ecology Report

Drawn by: EM
Project Mgr: LB
Date: 24/05/2013

- Subject Area
- LW 37 and 38
- Mine workings
- Roads and Trails
- Watercourse

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(c) 2009 BHPBIC

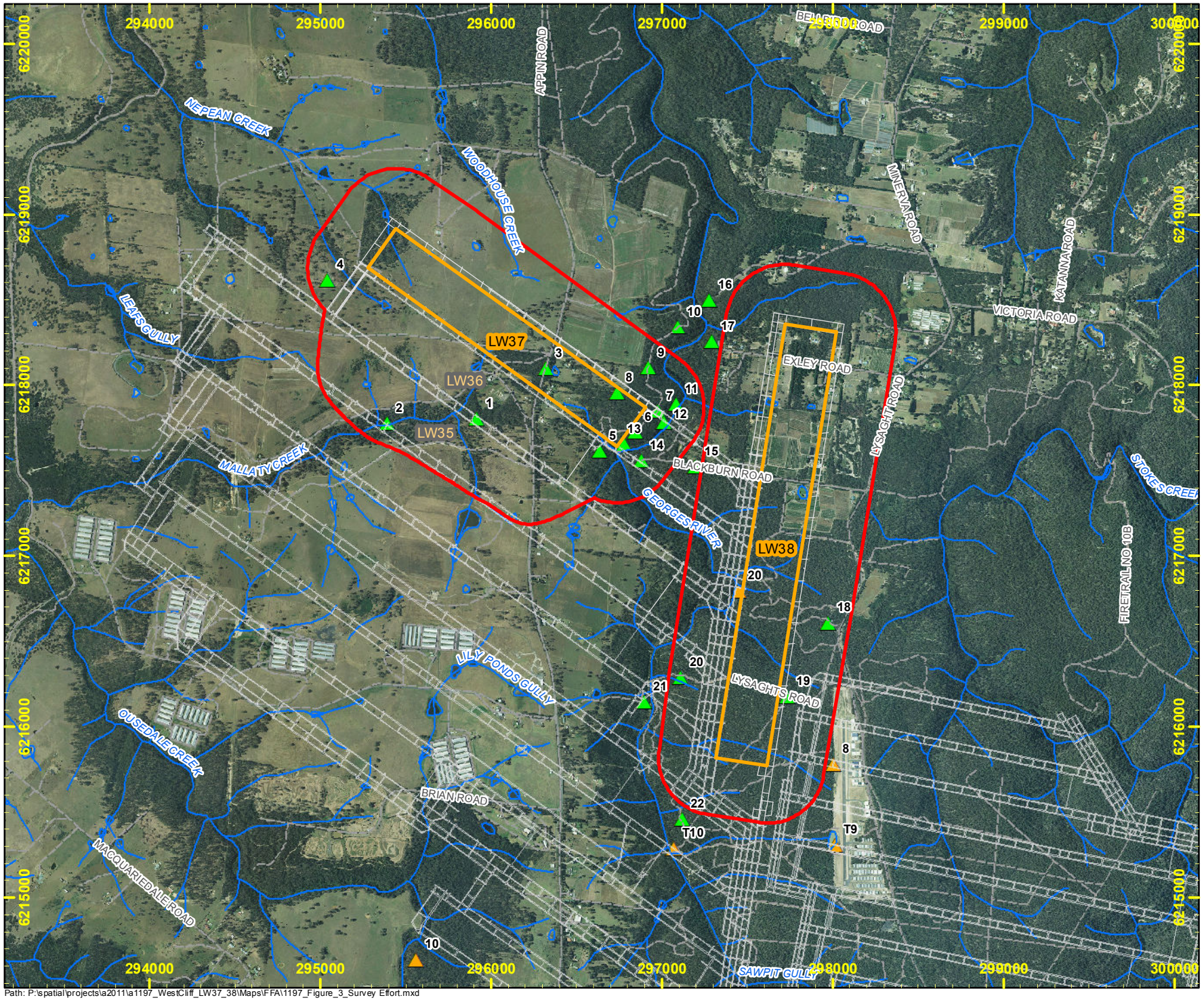

Figure 3: Survey Effort

1197 West Cliff LW 37-38
Extraction Plan
Terrestrial Ecology Report

Drawn by: EM
Project Mgr: LB
Date: 24/05/2013

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- Mine workings
- Roads and Trails
- Watercourse

Survey Locations

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- Biosphere Environmental (2009)

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Imagery:
(c) 2009 BHPBIC

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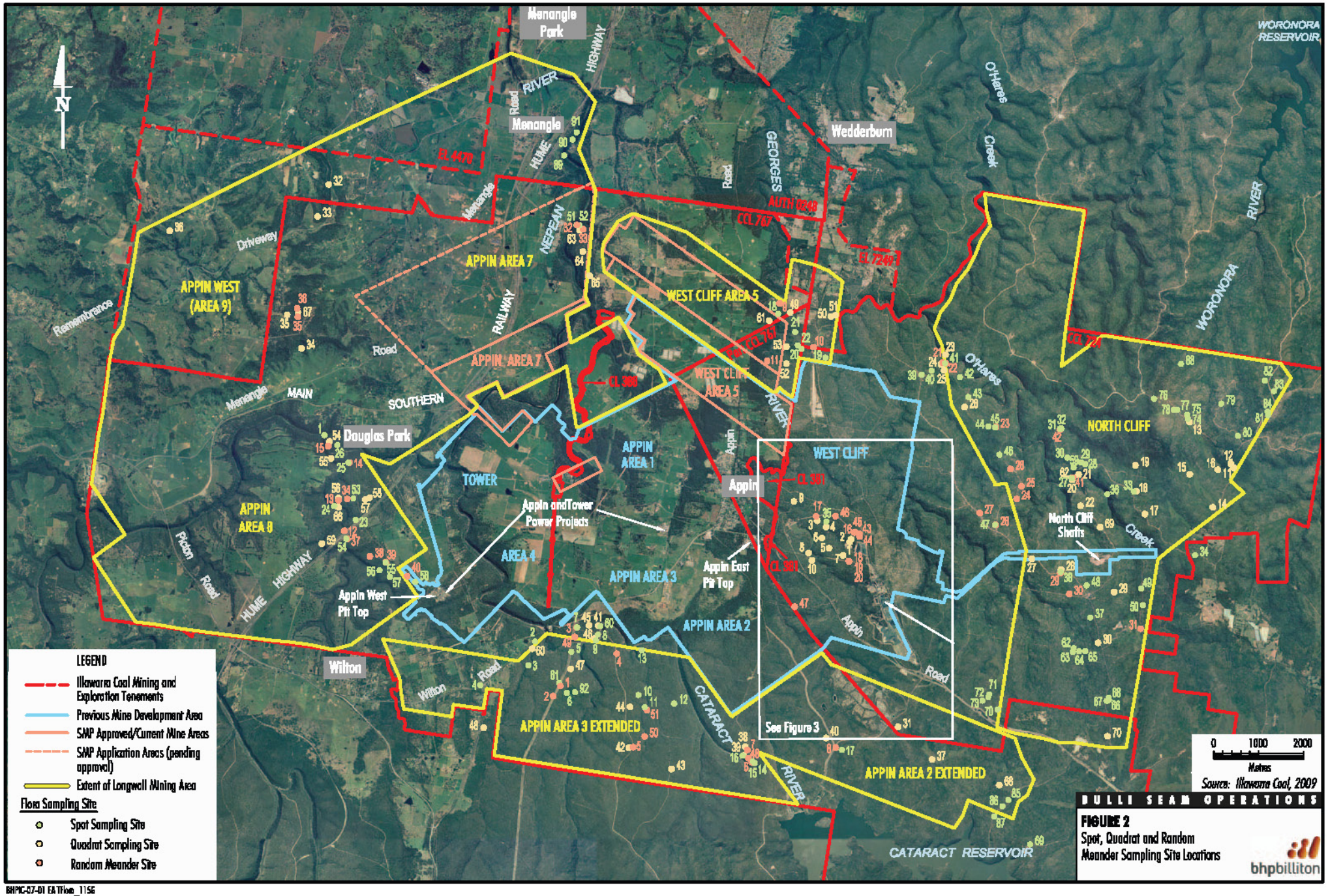
Figure 3b. Survey effort undertaken by FloraSearch (2009)



Source. FloraSearch (2009)

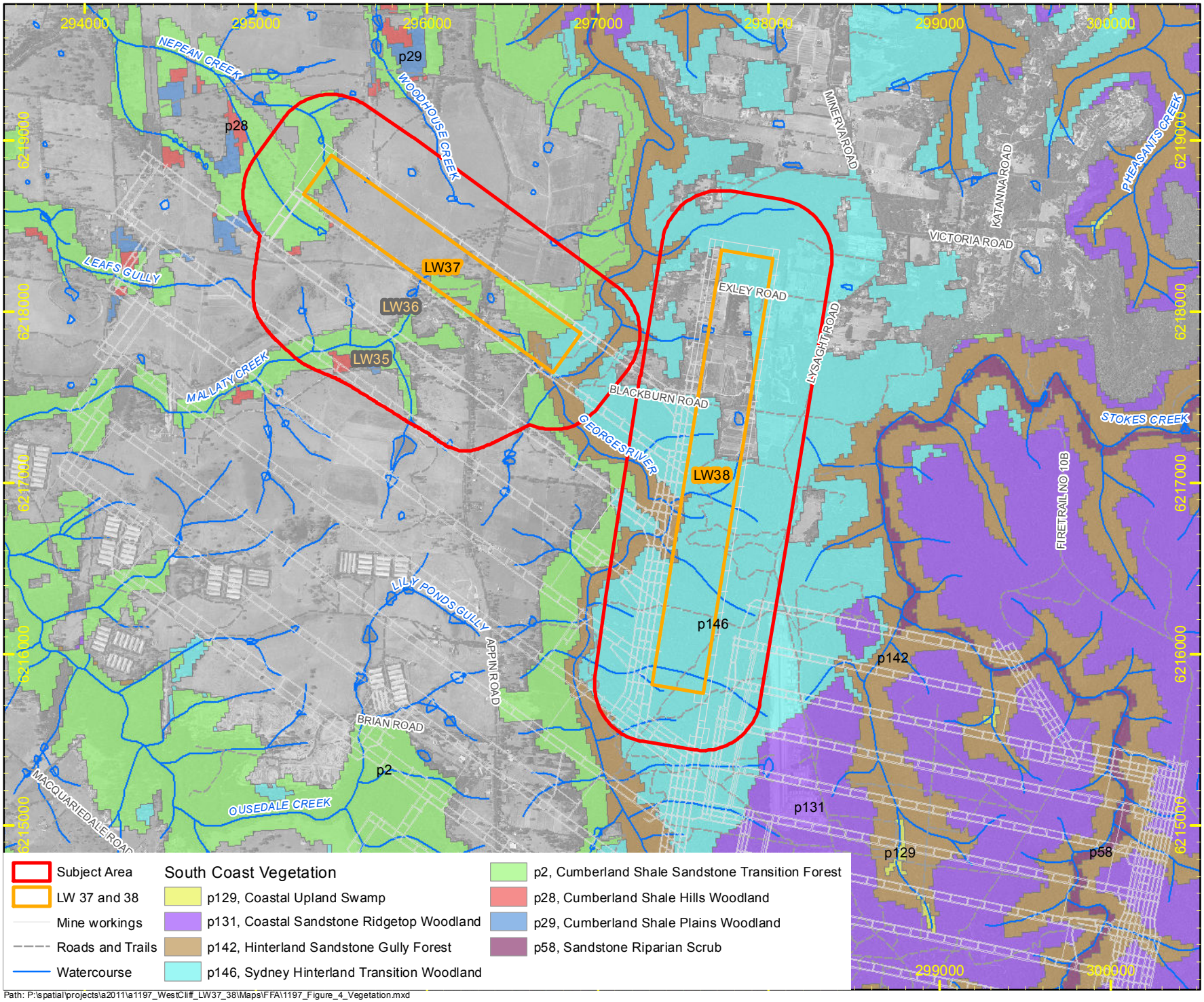


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Figure 4: Vegetation Communities

1197 West Cliff LW 37-38
Extraction Plan
Terrestrial Ecology Report

Drawn by: EM
Project Mgr: LB
Date: 24/05/2013

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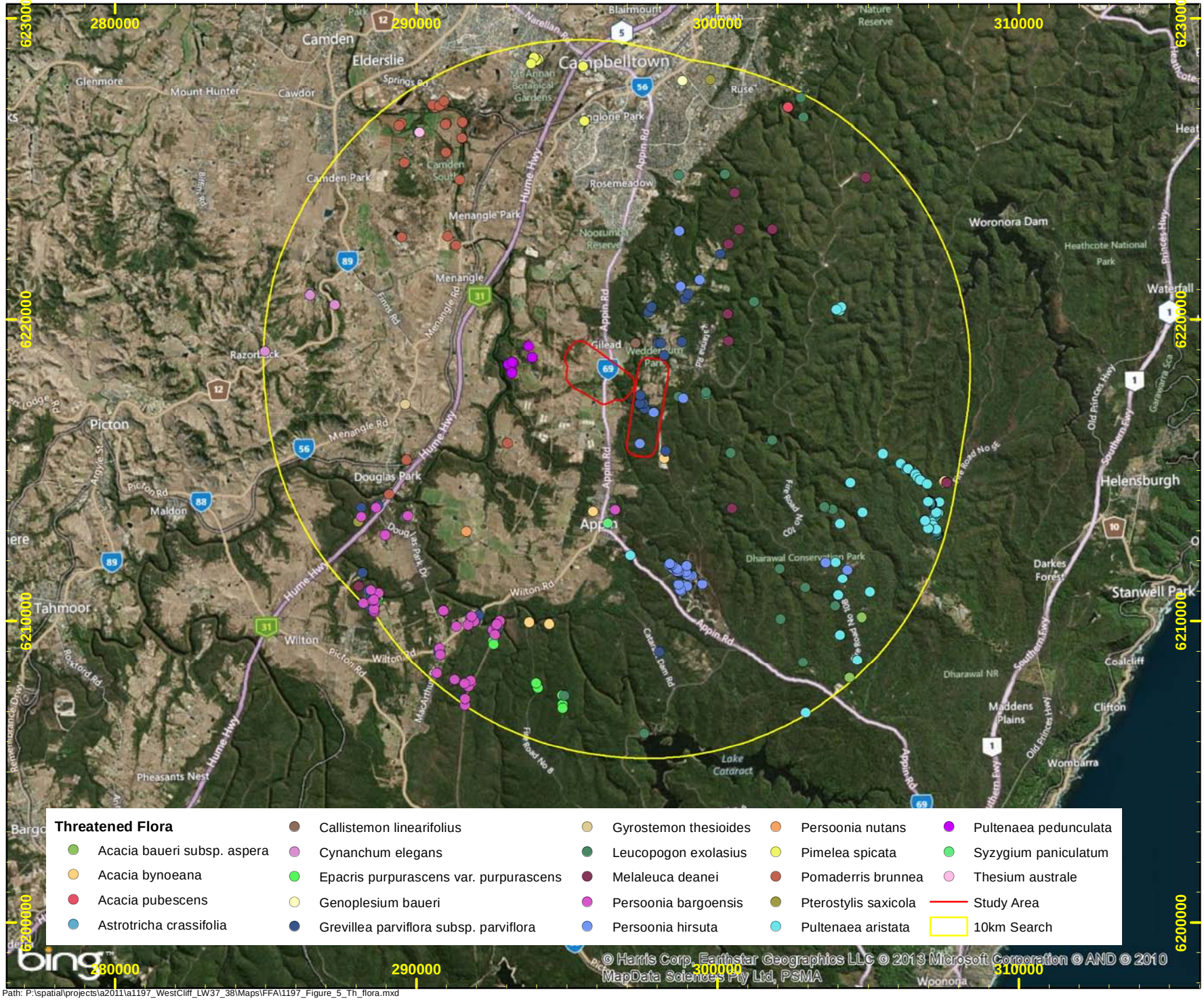

Figure 5: Threatened Flora

1197 West Cliff LW 37-38
Extraction Plan
Terrestrial Ecology Report

Drawn by: EM
Project Mgr: LB
Date: 16/05/2013

Source: Atlas of NSW Wildlife 16/5/2013

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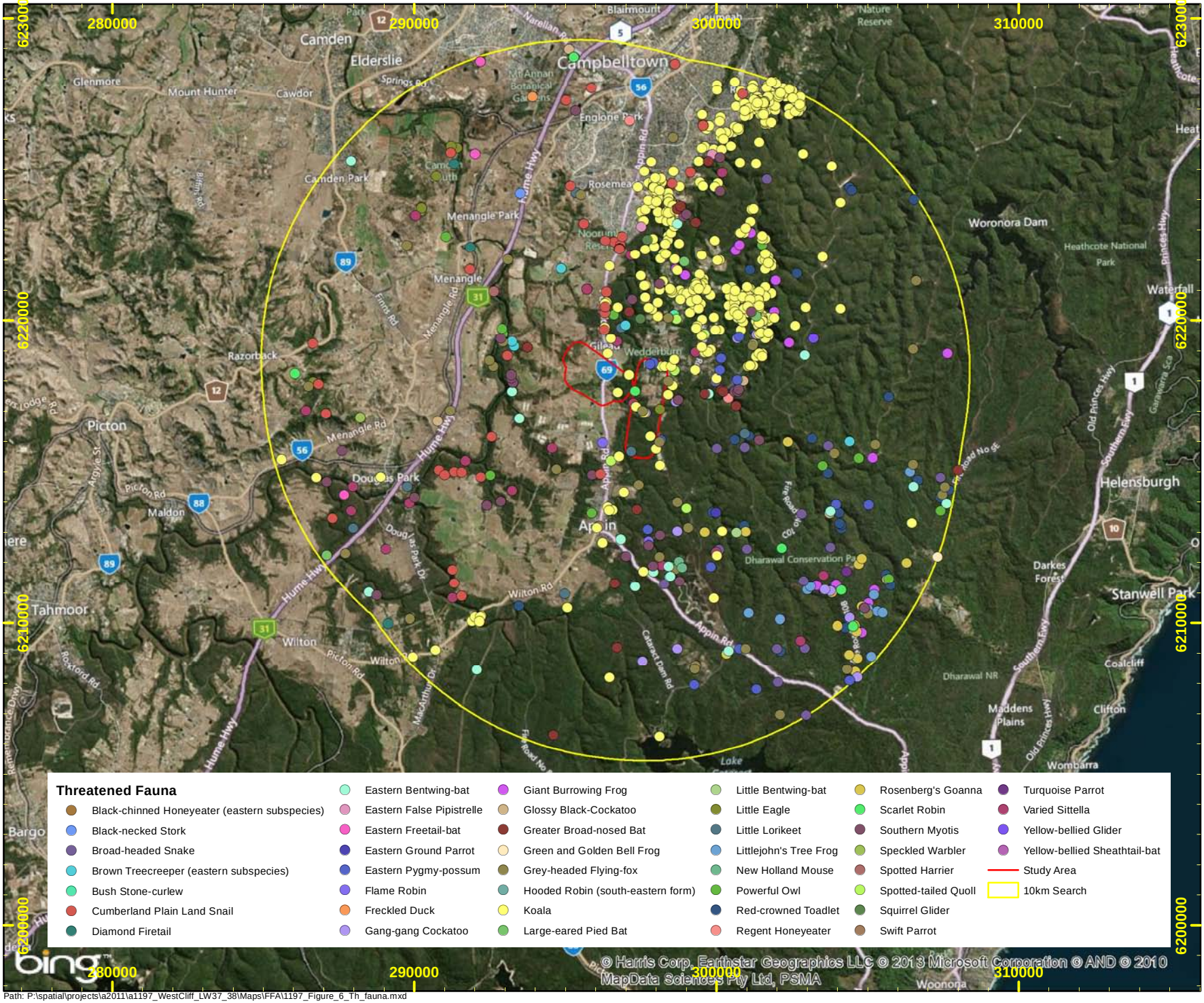

Threatened Fauna

- Black-chinned Honeyeater (eastern subspecies)
- Black-necked Stork
- Broad-headed Snake
- Brown Treecreeper (eastern subspecies)
- Bush Stone-curlew
- Cumberland Plain Land Snail
- Diamond Firetail
- Eastern Bentwing-bat
- Eastern False Pipistrelle
- Eastern Freetail-bat
- Eastern Ground Parrot
- Eastern Pygmy-possum
- Flame Robin
- Freckled Duck
- Gang-gang Cockatoo
- Giant Burrowing Frog
- Glossy Black-Cockatoo
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Hooded Robin (south-eastern form)
- Koala
- Large-eared Pied Bat
- Little Bentwing-bat
- Little Eagle
- Little Lorikeet
- Littlejohn's Tree Frog
- New Holland Mouse
- Powerful Owl
- Red-crowned Toadlet
- Regent Honeyeater
- Rosenberg's Goanna
- Scarlet Robin
- Southern Myotis
- Speckled Warbler
- Spotted Harrier
- Spotted-tailed Quoll
- Squirrel Glider
- Swift Parrot
- Turquoise Parrot
- Varied Sittella
- Yellow-bellied Glider
- Yellow-bellied Sheathtail-bat
- Study Area
- 10km Search

Figure 6: Threatened Fauna

1197 West Cliff LW 37-38
Extraction Plan
Terrestrial Ecology Report

Drawn by: EM
Project Mgr: LB
Date: 16/05/2013

Source: Atlas of NSW Wildlife 16/5/2013

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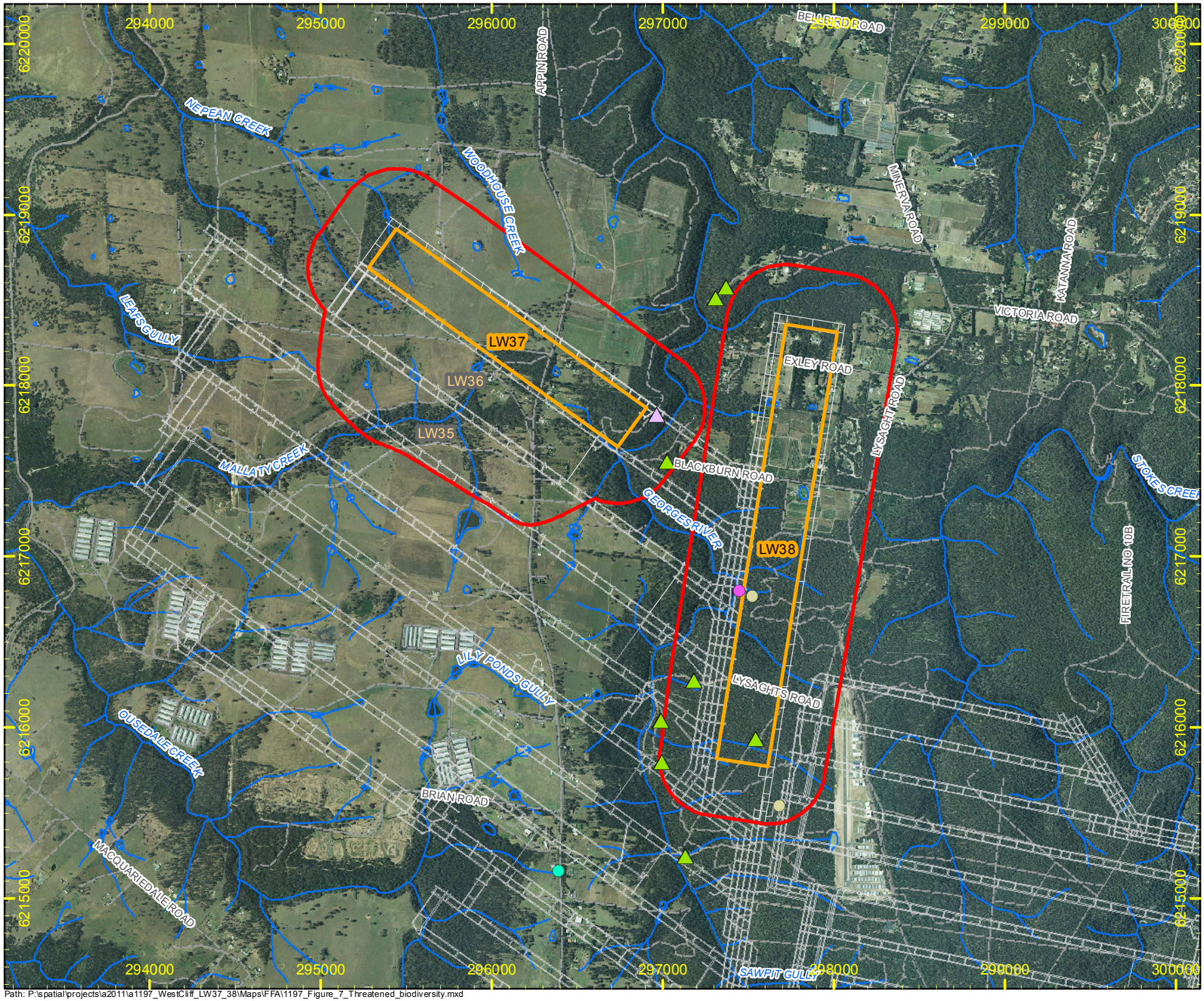

Figure 7: Threatened Biodiversity recorded during field survey and previous field survey

1197 West Cliff LW 37-38 Extraction Plan
Terrestrial Ecology Report

Drawn by: EM
Project Mgr: LB
Date: 24/05/2013

- Subject Area
- LW 37 and 38
- Mine workings
- Roads and Trails
- Watercourse

Niche (2013)
- Glossy Black Cockatoo
- Grevillea parviflora subsp. parviflora

Biosphere (2009)
- Grey-headed Flying-Fox
- Koala
- Spotted-tail Quoll

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Horizontal Datum:
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Imagery:
(c) 2009 BHPBIC

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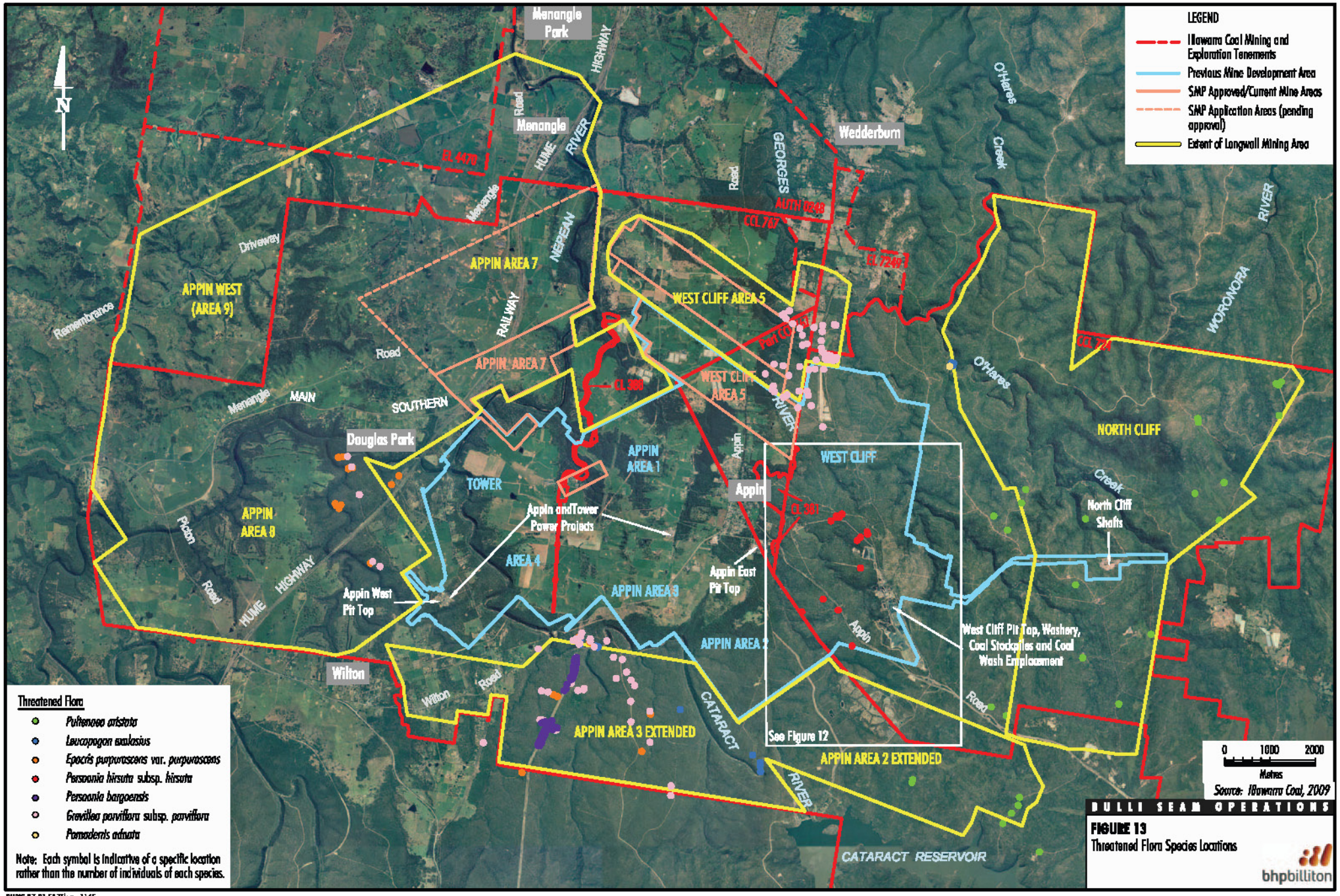
Figure 7b. Threatened flora recorded by FloraSearch (2009).



Source: FloraSearch (2009

APPENDICES

Appendix 1: Likelihood of occurrence of threatened flora and fauna within the Study Area

Table 6. Threatened flora likelihood table

Species	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
Acacia baueri subsp. *aspera*	-	V	Grows in low heath, often on exposed sandstone ridges. Occurs chiefly in the Blue Mountains, but also near Mount Keira and reported from Royal National Park.	Low
Acacia bynoeana	V	E	Grows mainly in heath and dry sclerophyll forest in sandy soils. Mainly south of Dora Creek-Morisset area to Berrima and the Illawarra region, west to the Blue Mountains, also recorded from near Kurri Kurri in the Hunter Valley and from Morton National Park.	High
Acacia pubescens	V	V	Concentrated around the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. Occurs on alluviums, shales and at the intergrade between shales and sandstones. The soils are characteristically gravely soils, often with ironstone. Grows in open woodland and forest, in a variety of plant communities, including Cooks River/ Castlereagh Ironbark Forest, Shale/ Gravel Transition Forest and Cumberland Plain Woodland.	Moderate
Allocasuarina glareicola	E	E	This species is restricted to a few small populations in and around Castlereagh, north-east of Penrith, NSW. The total range of the species is approximately 36 km².	Low
Asterolasia elegans	E	E	Occurs north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby local government areas. Also likely to occur in the western part of Gosford local government area. Known from only seven populations, only one of which is wholly within a conservation reserve. Occurs on Hawkesbury sandstone in sheltered forests on mid- to lower slopes and valleys, e.g. in or adjacent to gullies which support sheltered forest. The canopy at known sites includes *Syncarpia glomulifera* subsp. *glomulifera, Angophora costata, Eucalyptus piperita, Allocasuarina torulosa* and *Ceratopetalum gummiferum.*	Low
Astrotricha crassifolia	V	V	Occurs near Patonga (Gosford LGA), and in Royal NP and on the Woronora Plateau (Sutherland and Campbelltown LGAs). There is also a record from near Glen Davis (Lithgow LGA). Also in Victoria. Occurs in dry sclerophyll woodland on sandstone.	Low
Caladenia tessellata	V	E	The Tessellated Spider Orchid is found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil. Known from the Sydney area (old records), Wyong, Ulladulla and Braidwood in NSW. Populations in Kiama and Queanbeyan are presumed extinct.	Low
Callistemon linearifolius	-	V	Recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. Recorded in 2000 at Coalcliff in the northern Illawarra. For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River. The species was more widespread in the past, and there are currently only 5-6 populations remaining from the 22 populations historically recorded in the Sydney area. Three of the remaining populations are reserved in Ku-ring-gai Chase National Park, Lion Island Nature Reserve and Spectacle Island Nature Reserve. The species has also been recorded from Yengo National Park.	Moderate

Species	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
Cryptostylis hunteriana	V	V	Grows in swamp-heath on sandy soils, chiefly in coastal districts, south from the Gibraltar Range.	Low
Cynanchum elegans	E	E	Recorded from rainforest gullies scrub and steep slopes from the Gloucester district to the Wollongong area and inland to Mt Dangar.	Low
Epacris purpurascens var. *purpurascens*	-	V	Grows in sclerophyll forest, scrubs and swamps on sandstone from Gosford and Sydney districts.	Moderate
Eucalyptus benthamii	V	V	Occurs on the alluvial flats of the Nepean River and its tributaries. There are two major subpopulations: in the Kedumba Valley of the Blue Mountains National Park and at Bents Basin State Recreation Area. Several trees are scattered along the Nepean River around Camden and Cobbitty. At least five trees occur on the Nattai River in Nattai National Park. Requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Occurs in open forest. Associated species at the Bents Basin site include *Eucalyptus elata, E. baueriana, E. amplifolia, E. deanei* and *Angophora subvelutina.* Understorey species include *Bursaria spinosa, Pteridium esculentum* and a wide variety of agricultural weeds. The Kedumba Valley site *lists E. crebra, E. deanei, E. punctata, Leptospermum flavescens, Acacia filicifolia* and *Pteridium esculentum* among its associated species.	Low
Galium australe	-	E	Widespread in Victoria and is also found in South Australia and Tasmania. Once regarded as presumed extinct in NSW, this species is now known from the Towamba Valley near Bega, Lake Yarrunga near Kangaroo Valley, Cullendulla Creek Nature Reserve near Batemans Bay, Conjola National Park, Swan Lake near Swanhaven, and the Big Hole in Deua National Park. It was recorded historically from the Clyde River near Batemans Bay and the Mongarlowe area near Braidwood. The species also occurs beside Lake Windemere in the Australian Capital Territory at Jervis Bay. There is also an outlying record to the north from near Byabarra on the north coast. In NSW, the species grows in moist gullies of tall forest, *Eucalyptus tereticornis* forest, coastal Banksia shrubland, and *Allocasuarina nana* heathland. In other States the species is found in a range of near-coastal habitats, including sand dunes, sand spits, shrubland and woodland.	Low
Grevillea parviflora ssp. *parviflora*	V	V	Grows in heathy associations or shrubby woodland, in sandy or light clay soils usually over shale substrates. Occurs west and south of Sydney from west of Prospect (where now almost certainly extinct), Kemps Creek and lower Georges River south to Camden, Appin and Cordeaux Dam, with disjunct northern populations south of Putty and near Cessnock and Cooranbong, possibly also south of Moss Vale.	Known
Gyrostemon thesioides	-	E	Within NSW, has only ever been recorded at three sites, to the west 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 in Western Australia, South Australia, Victoria and Tasmania.	Low
Lepidium hyssopifolium	E	E	The species occurs in a variety of habitats including woodland with a grassy understorey and grassland. In NSW, there is a small population consisting near Bathurst, two populations near Bungendore, and one near Crookwell. Historical records also exist from near Armidale and possibly Cooma.	Low
Leucopogon exolasius	V	V	Grows in woodland on sandstone. Restricted to the Woronora and Grose Rivers and Stokes Creek, Royal National Park.	Moderate
Melaleuca deanei	V	V	Grows in wet heath on sandstone in coastal districts from Berowra to Nowra.	Moderate

Species	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
Pelargonium sp. Striatellum	E	E	Pelargonium sp. Striatellum (G.W.Carr 10345) is known to occur in New South Wales (NSW) and Victoria. The total number of individual plants is not known, as the vegetative mode of propagation makes it difficult to distinguish. The species is known to occur in habitat usually located just above the high water level of irregularly inundated or ephemeral lakes. During dry periods, the species is known to colonise exposed lake beds. It is not known if the species' rhizomes and/or soil seedbank persist through prolonged inundation or drought.	Low
Persoonia bargoensis	V	E	Occurs in woodland to dry sclerophyll forest, on sandstone and laterite. Restricted to the Bargo area; between Picton, Douglas Park, Yanderra, Cataract River and Thirlmere.	Moderate
Persoonia hirsuta	E	E	The Hairy Geebung is found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone.	High
Persoonia nutans	E	E	It occurs between Richmond, Macquarie Fields & East Hills, particularly near the Nepean and Georges Rivers. *Persoonia nutans* also occurs on Shale/Gravel Transition Forest and Cooks River Castlereagh Ironbark Forest.	Moderate
Pimelea curviflora subsp. *cuviflora*	V	V	Confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west. Former range extended south to the Parramatta River and Port Jackson region including Five Dock, Bellevue Hill and Manly. Occurs on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands. Has an inconspicuous cryptic habit as it is fine and scraggly and often grows amongst dense grasses and sedges	Low
Pimelea spicata	E	E	Once widespread on the Cumberland Plain, the Spiked Rice-flower occurs in two disjunct areas; the Cumberland Plain (Narellan, Marayong, Prospect Reservoir areas) and the Illawarra (Landsdowne to Shellharbour to northern Kiama). In both the Cumberland Plain and Illawarra environments this species is found on well-structured clay soils. On the inland Cumberland Plain sites it is associated with Grey Box and Ironbark. In the coastal Illawarra it occurs commonly in Coast Banksia open woodland with a better developed shrub and grass understorey. .	Moderate
Pomaderris brunnea	V	V	Brown Pomaderris grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines in association with *Eucalyptus amplifolia*, *Angophora floribunda*, *Acacia parramattensis, Bursaria spinosa* and *Kunzea ambigua*.	Moderate
Pterostylis saxicola	E	E	Restricted to western Sydney between Freemans Reach in the north and Picton in the south. 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.	Low
Pultenaea aristata	V	V	Grows in moist, dry sclerophyll woodland to heath on sandstone, specifically the drier areas of Upland Swamps. Restricted to the Woronora Plateau, a small area between Helensburgh, south of Sydney, and Mt Keira above	Moderate
Pultenaea pedunculata	-	E	In NSW it is known from the Sydney Basin Bioregion (Bankstown to Liverpool) and on the South Coast in the Southeast Corner Bioregion at Bournda. It was thought to be extinct in the Sydney, but has been found at two locations at Villawood and Prestons. At both these locations P. pedunculata occupies a very small area and is represented by a small number of individuals.	Low
Streblus pendulinus	E	-	Occurs from Cape York Peninsula to Milton, south-east New South Wales (NSW), as well as Norfolk Island. Outside of Australia, the species is found in Papua New Guinea, Micronesia, Vanuatu, New Caledonia, Fiji, Rapa and Hawaii. On the Australian mainland, is found in warmer rainforests, chiefly along watercourses. The altitudinal range is from near sea level to 800 m above sea level. The species grows in well developed rainforest, gallery forest and drier, more seasonal rainforest.	Low

Species	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
Syzygium paniculatum	V	E	The Magenta Lilly Pilly is 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	Low
Thelymitra sp. Kangaloon	CE	-	Recorded from shallow black peaty soil in coastal heath on sandstone. *Thelymitra sp. Kangaloon* is a terrestrial orchid endemic to New South Wales, and is known from three locations near Robertson in the Southern Highlands.	Low

Key: CE = Critically Endangered; E, E1 = Endangered; EP = Endangered Population; V = Vulnerable.

*Unless otherwise stated, descriptions have been taken from DEC (2005) threatened species profiles.

Table 7. Threatened fauna likelihood table

Latin name	Common name	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
Amphibians					
Litoria aurea	Green and Golden Bell Frog	V	E1	Inhabits marshes, dams and stream-sides, particularly those containing bullrushes (*Typha* spp.) or spikerushes (*Eleocharis* spp.). Optimum habitat includes water-bodies that are un-shaded, free of predatory fish such as Plague Minnow (*Gambusia holbrooki*), have a grassy area nearby and diurnal sheltering sites available.	Moderate
Litoria littlejohni	Littlejohn's Tree Frog	V	V	Occurs in wet and dry sclerophyll forests associated with sandstone outcrops between 280 and 1000 m on the eastern slopes of the Great Dividing Range (Barker, 1995). Prefers rock flowing streams, but individuals have also been collected from semi-permanent dams with some emergent vegetation. Forages both in the tree canopy and on the ground, and has been observed sheltering under rocks on high exposed ridges during summer. It is not known from coastal habitats.	Moderate
Heleioporus australiacus	Giant Burrowing Frog	V	V	Prefers hanging swamps on sandstone shelves adjacent to perennial non-flooding. Can also occur within shale outcrops within sandstone formations. In the southern part of its range can occur in wet and dry forests, montane sclerophyll woodland and montane riparian woodland. 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.	Moderate
Litoria raniformis	Growling Grass Frog	V	E	Usually found in or around permanent or ephemeral Black Box/Lignum/Nitre Goosefoot swamps, Lignum/Typha swamps and River Red Gum swamps or billabongs along floodplains and river valleys. They are also found in irrigated rice crops, particularly where there is no available natural habitat.	Low
Mixophyes balbus	Stuttering Frog	V	E	This species is usually associated with mountain streams, wet mountain forests and rainforests. It rarely wanders very far from the banks of permanent forest streams, although it will forage on nearby forest floors. Eggs are deposited in leaf litter on the banks of streams and are washed into the water during heavy rains (Barker, 1995).	Low
Pseudophryne australis	Red-crowned Toadlet	-	V	Occurs on wetter ridge tops and upper slopes of sandstone formations on which the predominant vegetation is dry open forests and heaths. This species typically breeds within small ephemeral creeks that feed into larger semi-perennial streams. After rain these creeks are characterised by a series of shallow pools lined by dense grasses, ferns and low shrubs (Thumm, 1997).	High
Birds					
Apus pacificus	Fork-tailed Swift	M	-	Almost exclusively aerial (Higgins, 1999).	Moderate

Latin name	Common name	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
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, 1990).	Low
Ardea ibis	Cattle Egret	M	-	Occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands (Marchant, 1990).	Low
Botaurus poiciloptilus	Australasian Bittern	-	V	The Australasian Bitterns is widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spikerushes (*Eleoacharis* spp.).	Low
Burhinus grallarius	Bush stone Curlew	-	CE	The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east it is either rare or extinct throughout its former range. Inhabits open forests and woodlands with a sparse grassy ground layer and fallen timber. Largely nocturnal, being especially active on moonlit nights.	Low
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, 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. It requires tree hollows in which to breed (Gibbons, 1997).	High
Calyptorhynchus lathami	Glossy Black-cockatoo	-	V	Inhabits forest with low nutrients, characteristically with key Allocasuarina species. Tends to prefer drier forest types with a middle stratum of Allocasuarina below Eucalyptus or Angophora. Often confined to remnant patches in hills and gullies. Breed in hollows stumps or limbs, either living or dead.	Known
Circus assimilis	Spotted Harrier	-	V	The Spotted Harrier occurs throughout the Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Individuals disperse widely in NSW and comprise a single population. Occurs in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrublands. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands.	Moderate

Latin name	Common name	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
Climacteris picumnus victoriae	Brown Treecreeper	-	V	Found in Eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked Eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and River Red Gum (*Eucalyptus camaldulensis*) Forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses.	High
Daphoenositta chrysoptera	Varied Sittella	-	V	Inhabit a wide variety of dry Eucalypt forests and woodlands, usually with either shrubby under storey 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 paperbarks or mature Eucalypts with hollows.	High
Dasynoris brachypterus	Eastern Bristlebird	E	E	Found in coastal woodlands, dense scrub and heathlands, particularly where it borders taller woodlands (Pizzey and Knight 1997).	Low
Ephippiorhynchus asiaticus	Black-necked Stork	-	E	Black-necked Stork is widespread in coastal and subcoastal northern and eastern Australia, south to central-eastern NSW. In NSW, the species becomes increasingly uncommon south of the Northern Rivers region, and rarely occurs south of Sydney. Found on shallow, permanent, freshwater terrestrial wetlands, and surrounding marginal vegetation, including swamps, floodplains, watercourses and billabongs, freshwater meadows, wet heathland, farm dams and shallow floodwaters, as well as extending into adjacent grasslands, paddocks and open savannah woodlands. They also forage within or around estuaries and along intertidal shorelines, such as saltmarshes, mudflats and sandflats, and mangrove vegetation.	Low
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
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.	Moderate
Haliaeetus leucogaster	White-bellied Sea-eagle	M	-	A migratory species that is resident to Australia. Found in terrestrial and coastal wetlands; favouring deep freshwater swamps, lakes and reservoirs; shallow coastal lagoons and salt marshes.	Low
Hieraaetus morphnoides	Little Eagle	-	V	Most abundant in lightly timbered areas with open areas nearby. Often recorded foraging in grasslands, crops, treeless dune fields, and recently logged areas. May nest in farmland, woodland and forest in tall trees (Marchant and Higgins 1993).	Moderate
Hirundapus caudacutus	White-throated Needletail	M	-	An aerial species found in feeding concentrations over cities, hilltops and timbered ranges (Pizzey and Knight 1997).	Moderate

Latin name	Common name	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
Lathamus discolor	Swift Parrot	E	E	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, 1981). The Swift Parrot is dependent on flowering resources across a wide range of habitats in its wintering grounds in NSW (Shields, 1992). This species is migratory, breeding in Tasmania and also nomadic, moving about in response to changing food availability (Pizzey, 1997).	Moderate
Melanodryas cucullata cucullata	Hooded Robin		V	Prefers lightly wooded country, usually open Eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Requires structurally diverse habitats featuring mature Eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses.	High
Melithreptus gularis gularis	Black-chinned Honeyeater	-	V	Occupies mostly upper levels of drier open forests or woodlands dominated by box and ironbark Eucalypts, especially Mugga Ironbark (*Eucalyptus sideroxylon*), White Box (*E. albens*), Inland Grey Box (*E. microcarpa*), Yellow Box (*E. melliodora*) and Forest Red Gum (*E. tereticornis*).	Low
Merops ornatus	Rainbow Bee-eater	M	-	Usually occurs in open or lightly timbered areas, often near water (Higgins, 1999).	Moderate
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, 1997).	Moderate
Myiagra cyanoleuca	Satin Flycatcher	M	-	Migratory species that occurs in coastal forests, woodlands and scrubs during migration. Breeds in heavily vegetated gullies (Pizzey, 1997).	Moderate
Neophema pulchella	Turquoise Parrot	-	V	Occurs in open woodlands and Eucalypt forests with a ground cover of grasses and under storey of low shrubs (Morris, 1980). Generally found in the foothills of the Great Divide, including steep rocky ridges and gullies (Higgins, 1999). Nest in hollow-bearing trees, either dead or alive; also in hollows in tree stumps. Prefer to breed in open grassy forests and woodlands, and gullies that are moist (Higgins, 1999).	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, 1997).	High
Ninox strenua	Powerful Owl	-	V	Occupies wet and dry Eucalypt forests and rainforests. Can occupy both un-logged and lightly logged forests as well as undisturbed forests where it usually roosts on the limbs of dense trees in gully areas. It is most commonly recorded within Red Turpentine in tall open forests and Black She-oak within open forests. Large mature trees with hollows at least 0.5 m deep are required for nesting. 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, 1997). Nest trees for this species are usually emergent with a diameter at breast height of at least 100 cm (Gibbons, 1997).	High
Petroica multicolor	Scarlet Robin	-	V	The Scarlet Robin's range includes all state capitals. Occurs in forests, woodlands; and heavier vegetation when breeding. During autumn and winter occurs in more open and cleared areas. It has dispersive or locally migratory seasonal movements. Is conspicuous in open and suburban habitats (Morcombe 2003).	Moderate

Latin name	Common name	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
Petroica phoenicea	Flame Robin	-	V	Flame Robins are found in a broad coastal band from southern Queensland to just west of the South Australian border (Australian Museum 2009). The species is also found in Tasmania. The preferred habitat in summer includes Eucalyptus forests and woodland, whilst in winter prefers open woodlands and farmlands. It is considered migratory. The Flame Robin breeds from about August to January (Morcombe 2003).	Moderate
Pezoporus wallicus wallicus	Eastern Ground Parrot	-	V	The Ground Parrot occurs in high rainfall coastal and near coastal low heathlands and sedgelands, generally below one metre in height and very dense. The coastal and subcoastal heathland and sedgeland habitats of the Ground Parrot are particularly fire-prone.	Moderate
Pyrrholaemus saggitatus	Speckled Warbler	-	V	The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some Eucalypt regrowth and an open canopy.	Moderate
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, 1997).	Low
Rostratula australis	Australian Painted Snipe	V,M	E	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, 1993).	Low
Xanthomyza phrygia	Regent Honeyeater	E	E	A semi-nomadic species occurring in temperate Eucalypt woodlands and open forests. Most records are from box-ironbark Eucalypt forest associations and wet lowland coastal forests (Pizzey, 1997).	Low
Stagonopleura guttata	Diamond Firetail	-	V	Feeds exclusively on the ground, on ripe and partly-ripe grass and herb seeds and green leaves, and on insects (especially in the breeding season). Found in grassy Eucalypt woodlands, including Box-Gum Woodlands and Snow Gum Eucalyptus pauciflora Woodlands. Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities.	Low
Stictonetta naevosa	Freckled Duck	-	V	The freckled duck breeds in permanent fresh swamps that are heavily vegetated. Found in fresh or salty permanent open lakes, especially during drought. Often seen in groups on fallen trees and sand spits (Simpson, 1996).	Low
Mammals					
Cercartetus nanus	Eastern Pygmy-possum	-	V	Inhabits rainforest through to sclerophyll forest and tree heath. Banksias and myrtaceous shrubs and trees are a favoured food source. Will often nest in tree hollows, but can also construct its own nest. Because of its small size it is able to utilise a range of hollow sizes including very small hollows (Gibbons, 1997). Individuals will use a number of different hollows and an individual has been recorded using up to 9 nest sites within a 0.5ha area over a 5 month period (Ward, 1990).	Moderate
Dasyurus maculatus maculatus	Spotted-tailed Quoll (southeastern mainland)	E	V	Uses a range of habitats including sclerophyll forests and woodlands, coastal heathlands and rainforests (Dickman, 1992). Habitat requirements include suitable den sites, including hollow logs, rock crevices and caves, an abundance of food and an area of intact vegetation in which to forage (Edgar, 1995).	Moderate-High

Latin name	Common name	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
Falsistrellus tasmaniensis	Eastern False Pipistrelle	-	V	Inhabit sclerophyll forests, preferring wet habitats where trees are more than 20 m high (Churchill, 1998). Two observations have been made of roosts in stem holes of living Eucalypts (Phillips, 1995). There is debate about whether or not this species moves to lower altitudes during winter, or whether they remain sedentary but enter torpor (Menkhorst, 1995). This species also appears to be highly mobile and records showing movements of up to 12 km between roosting and foraging sites (Menkhorst, 1995).	Moderate
Petrogale penicillata	Brush-tailed Rock-wallaby	V	E	Found in rocky areas in a wide variety of habitats including rainforest gullies, wet and dry sclerophyll forest, open woodland and rocky outcrops in semi-arid country. Commonly sites have a northerly aspect with numerous ledges, caves and crevices.	Low
Mormopterus norfolkensis	Eastern Freetail Bat	-	V	Most records are from dry Eucalypt forests and woodlands to the east of the Great Dividing Range. Appears to roost in trees, but little is known of this species' habits (Allison, 1995 Churchill, 1998).	Moderate
Phascolarctos cinereus	Koala	-	V	Inhabits Eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall.	Known
Potorous tridactylus	Long-nosed Potoroo	V	V	Inhabits coastal heath and wet and dry sclerophyll forests. Generally found in areas with rainfall greater than 760 mm. Requires relatively thick ground cover where the soil is light and sandy.	Low
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, melaleuca swamps and banksia woodlands. Bats commute daily to foraging areas, usually within 15 km of the day roost although some individuals may travel up to 70 km (Augee, 1999).	Known
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Located in a variety of drier habitats, including the dry sclerophyll forests and woodlands to the east and west of the Great Dividing Range (Hoye, 1995). Can also be found on the edges of rainforests and in wet sclerophyll forests (Churchill, 1998). This species roosts in caves and mines in groups of between 3 and 37 individuals (Churchill, 1998).	Moderate
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	-	V	Broad range of habitats including rainforest, wet and dry sclerophyll forest, paperbark forest and open grasslands. Roost in caves and man made habitats and under road culverts.	High
Myotis macropus (adversus)	Large-footed Myotis	-	V	Occurs in most habitat types as long as they are near permanent water bodies, including streams, lakes and reservoirs. Commonly roost in caves, but can also roost in tree hollows, under bridges and in mines (Churchill, 1998).	Moderate
Petaurus australis	Yellow-bellied Glider	-	V	Occur in tall mature Eucalypt forest generally in areas with high rainfall and nutrient rich soils. Forest type preferences vary with latitude and elevation; mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south. Found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria.	Moderate

Latin name	Common name	EPBC Act	TSC Act	Habitat*	Likelihood of occurrence
Petaurus norfolcensis	Squirrel Glider	-	V	Generally occurs in dry sclerophyll forests and woodlands but is absent from dense coastal ranges in the southern part of its range. Requires abundant hollow bearing trees and a mix of Eucalypts, banksias and acacias. There is only limited information available on den tree use by Squirrel gliders, but it has been observed using both living and dead trees as well as hollow stumps (Gibbons, 1997). Within a suitable vegetation community at least one species should flower heavily in winter and one species of Eucalypt should be smooth barked (Menkhorst, 1988). Endangered population in the Wagga Wagga LGA.	Moderate
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	-	V	The Yellow-bellied Sheathtail-bat is a wide-ranging species found across northern and eastern Australia. Roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. When foraging for insects, flies high and fast over the forest canopy, but lower in more open country. Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory. Breeding has been recorded from December to mid-March, when a single young is born. Seasonal movements are unknown; there is speculation about a migration to southern Australia in late summer and autumn.	Moderate
Scoteanax rueppellii	Greater Broad-nosed Bat	-	V	Prefer moist gullies in mature coastal forests and rainforests, between the Great Dividing Range and the coast. They are only found at low altitudes below 500 m (Churchill, 1998). In dense environments they utilise natural and human-made opening in the forest for flight paths. Creeks and small rivers are favoured foraging habitat. This species roosts in hollow tree trunks and branches (Churchill, 1998).	Moderate
Pseudomys novaehollandiae	New Holland Mouse	V	-	Coastal heath and dry sclerophyll forest and woodland.	Moderate
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, 1998).	Moderate
Varanus rosenbergi	Rosenberg's Goanna	-	V	This species is a Hawkesbury/Narrabeen sandstone outcrop specialist. Occurs in coastal heaths, humid woodlands and both wet and dry sclerophyll forests.	Moderate
Invertebrates					
Meridolum corneovirens	Cumberland Plain Land Snail	-	E	Lives in a very small area on the Cumberland Plain west of Sydney, from Richmond and Windsor south to Picton and from Liverpool west to the Hawkesbury and Nepean Rivers at the base of the Blue Mountains. Primarily inhabits Cumberland Plain Woodland. This community is a grassy, open woodland with occasional dense patches of shrubs. Lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish.	Low

*Unless otherwise stated, descriptions have been taken from DEC (2005) threatened species profiles.

Appendix 2: Flora recorded within the Study Area

Table 8. Flora species recorded in Study Area

Family	Botanical	Common name	Weed species*
Acanthaceae	*Brunoniella australis*	Blue Trumpet	
Adiantaceae	*Cheilanthes sieberi*	Rock Fern	
Anthericaceae	*Thysanotus tuberosus*	Common Fringe-lily	
Apiaceae	*Actinotus helianthi*	Flannel Flower	
Apiaceae	*Actinotus minor*	Lesser Flannel Flower	
Apiaceae	*Centella asiatica*	Indian Pennywort	
Apiaceae	*Platysace linearifolia*		
Apiaceae	*Xanthosia pilosa*	Woolly Xanthosia	
Apiaceae	*Xanthosia tridentata*	Rock Xanthosia	
Apocynaceae	*Marsdenia suaveolens*	Scented Marsdenia	
Araliaceae	*Astrotricha longifolia*		
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	*
Asteraceae	*Senecio madagascariensis*	Fireweed	*
Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane	*
Asteraceae	*Ozothamnus diosmifolius*	White Dogwood	
Asteraceae	*Hypochaeris radicata*	Catsear	*
Blechnaceae	*Blechnum cartilagineum*	Gristle Fern	
Campanulaceae	*Wahlenbergia gracilis*	Sprawling Bluebell	
Campanulaceae	*Wahlenbergia stricta*	Tall Bluebell	
Caryophyllaceae	*Stellaria media*	Common Chickweed	
Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak	
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	
Convolvulaceae	*Dichondra repens*	Kidney Weed	
Cunoniaceae	*Callicoma serratifolia*	Black Wattle	
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge	
Cyperaceae	*Caustis flexuosa*	Curly Wig	
Cyperaceae	*Schoenus melanostachys*		
Dennstaedtiaceae	*Pteridium esculentum*	Bracken	
Dilleniaceae	*Hibbertia riparia*		
Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower	
Elaeocarpaceae	*Elaeocarpus reticulatus*	Blueberry Ash	
Ericaceae	*Monotoca scoparia*		
Ericaceae	*Epacris pulchella*	Wallum Heath	
Ericaceae	*Woollsia pungens*		
Ericaceae	*Leucopogon lanceolatus*		
Ericaceae	*Lissanthe strigosa*	Peach Heath	
Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine	
Fabaceae (Faboideae)	*Pultenaea flexilis*		
Fabaceae (Faboideae)	*Mirbelia rubiifolia*	Heathy Mirbelia	
Fabaceae (Faboideae)	*Indigofera australis*	Australian Indigo	
Fabaceae (Faboideae)	*Hovea linearis*		
Fabaceae (Faboideae)	*Gompholobium minus*	Dwarf Wedge Pea	
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine	
Fabaceae (Faboideae)	*Dillwynia floribunda*		
Fabaceae (Faboideae)	*Bossiaea obcordata*	Spiny Bossiaea	
Fabaceae (Faboideae)	*Gompholobium grandiflorum*	Large Wedge Pea	
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle	
Fabaceae (Mimosoideae)	*Acacia linifolia*	White Wattle	

Family	Botanical	Common name	Weed species*
Fabaceae (Mimosoideae)	*Acacia longifolia*		
Fabaceae (Mimosoideae)	*Acacia suaveolens*	Sweet Wattle	
Fabaceae (Mimosoideae)	*Acacia ulicifolia*	Prickly Moses	
Gleicheniaceae	*Gleichenia dicarpa*	Pouched Coral Fern	
Goodeniaceae	*Goodenia bellidifolia*		
Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia	
Goodeniaceae	*Dampiera purpurea*		
Haloragaceae	*Gonocarpus teucrioides*	Germander Raspwort	
Haloragaceae	*Gonocarpus tetragynus*	Poverty Raspwort	
Iridaceae	*Patersonia glabrata*	Leafy Purple-flag	
Iridaceae	*Patersonia sericea*	Silky Purple-Flag	
Juncaceae	*Juncus continuus*		
Lauraceae	*Cassytha glabella*		
Lindsaeaceae	*Lindsaea linearis*	Screw Fern	
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	
Lomandraceae	*Lomandra fluviatilis*		
Lomandraceae	*Lomandra filiformis subsp. filiformis*		
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	*
Myrtaceae	*Melaleuca thymifolia*	Thyme Honey-myrtle	
Myrtaceae	*Angophora floribunda*	Rough-barked Apple	
Myrtaceae	*Baeckea linifolia*	Weeping Baeckea	
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark	
Myrtaceae	*Eucalyptus eugenioides*	Thin-leaved Stringybark	
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark	
Myrtaceae	*Eucalyptus globoidea*	White Stringybark	
Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint	
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum	
Myrtaceae	*Leptospermum polyanthum*		
Myrtaceae	*Kunzea ambigua*	Tick Bush	
Myrtaceae	*Corymbia gummifera*	Red Bloodwood	
Myrtaceae	*Leptospermum trinervium*	Slender Tea-tree	
Myrtaceae	*Leptospermum continentale*	Prickly Teatree	
Myrtaceae	*Eucalyptus racemosa*	Narrow-leaved Scribbly Gum	
Oleaceae	*Notelaea longifolia*	Large Mock-olive	
Osmundaceae	*Todea barbara*	King Fern	
Oxalidaceae	*Oxalis perennans*		
Phormiaceae	*Dianella caerulea var. producta*		
Phormiaceae	*Dianella caerulea var. caerulea*		
Phyllanthaceae	*Phyllanthus hirtellus*	Thyme Spurge	
Pittosporaceae	*Pittosporum undulatum*	Sweet Pittosporum	
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	
Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry	
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	
Poaceae	*Eragrostis curvula*	African Lovegrass	*
Poaceae	*Themeda australis*	Kangaroo Grass	
Poaceae	*Digitaria ciliaris*	Summer Grass	
Poaceae	*Eragrostis brownii*	Brown's Lovegrass	
Poaceae	*Austrodanthonia tenuior*	A Wallaby Grass	
Poaceae	*Austrodanthonia racemosa*	Wallaby Grass	
Poaceae	*Setaria gracilis*		*
Poaceae	*Poa sieberiana*	Snowgrass	
Poaceae	*Pennisetum clandestinum*	Kikuyu Grass	

Family	Botanical	Common name	Weed species*
Poaceae	*Paspalum dilatatum*	Paspalum	*
Poaceae	*Cynodon dactylon*	Common Couch	
Poaceae	*Microlaena stipoides*	Weeping Grass	
Poaceae	*Entolasia stricta*	Wiry Panic	
Poaceae	*Ehrharta erecta*	Panic Veldtgrass	
Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass	
Poaceae	*Dichelachne micrantha*	Shorthair Plumegrass	
Poaceae	*Chloris gayana*	Rhodes Grass	*
Poaceae	*Aristida vagans*	Threeawn Speargrass	
Poaceae	*Aristida ramosa*	Purple Wiregrass	
Poaceae	*Anisopogon avenaceus*	Oat Speargrass	
Poaceae	*Oplismenus aemulus*		
Proteaceae	*Lambertia formosa*	Mountain Devil	
Proteaceae	*Persoonia pinifolia*	Pine-leaved Geebung	
Proteaceae	*Grevillea parviflora subsp. parviflora*	Small-flower Grevillea	
Proteaceae	*Banksia ericifolia*	Heath-leaved Banksia	
Proteaceae	*Banksia serrata*	Old-man Banksia	
Proteaceae	*Banksia spinulosa*	Hairpin Banksia	
Proteaceae	*Grevillea sericea*	Pink Spider Flower	
Proteaceae	*Grevillea sphacelata*	Grey Spider Flower	
Proteaceae	*Hakea dactyloides*	Finger Hakea	
Proteaceae	*Hakea sericea*	Needlebush	
Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung	
Proteaceae	*Persoonia levis*	Broad-leaved Geebung	
Rhamnaceae	*Pomaderris intermedia*		
Rhamnaceae	*Pomaderris discolor*		
Rubiaceae	*Pomax umbellata*	Pomax	
Rubiaceae	*Opercularia diphylla*	Stinkweed	
Rubiaceae	*Opercularia hispida*	Hairy Stinkweed	
Rutaceae	*Correa reflexa*	Native Fuschia	
Rutaceae	*Eriostemon australasius*		
Rutaceae	*Nematolepis squamea subsp. squamea*	Satinwood	
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush	
Selaginellaceae	*Selaginella uliginosa*	Swamp Selaginella	
Solanaceae	*Solanum nigrum*	Black-berry Nightshade	*
Solanaceae	*Solanum prinophyllum*	Forest Nightshade	
Sterculiaceae	*Lasiopetalum ferrugineum*		
Thymelaeaceae	*Pimelea linifolia*	Slender Rice Flower	
Verbenaceae	*Verbena bonariensis*	Purpletop	*
Xanthorrhoeaceae	*Xanthorrhoea minor subsp. minor*		

Appendix 3. Fauna recorded during field survey

Type	Family	Common name	Scientific name	Observed (O) /Heard (H)	Biosphere (2009) site no.
Amphibians	Hylidae	Peron's Tree Frog	*Litoria peronii*	H	T9
Amphibians	Hylidae	Bleating Tree Frog	*Litoria dentata*	-	10, 20
Amphibians	Hylidae	Eastern Dwarf Tree Frog	*Litoria fallax*	-	T9, T20
Amphibians	Hylidae	Lesueurs Frog	*Litoria lesueuri*	-	20
Amphibians	Hylidae	Litoria peronii	*Litoria peronii*	-	T9
Amphibians	Hylidae	Verreaux's Tree Frog	*Litoria verreauxii*	-	T9
Amphibians	Myobatrachidae	Common Eastern Toadlet	*Crinia signifera*	H	-
Amphibians	Myobatrachidae	Brown-striped Frog	*Limnodynastes peronii*	-	T9
Amphibians	Myobatrachidae	Spotted Grass Frog	*Limnodynastes Tasmaniensis*	-	T9
Birds	Acanthizidae	White-browed Scrub wren	*Sericornis frontalis*	O	-
Birds	Alcedinidae	Laughing Kookaburra	*Dacelo novaeguineae*	O	8, 20, T10
Birds	Alcedinidae	Azure Kingfisher	*Alcedo azurea*	O	T20
Birds	Anatidae	Australian Wood Duck	*Chenonetta jubata*	-	T20
Birds	Anatidae	Grey Teal	*Anas gracilis*	-	T20
Birds	Artamidae	Australian Magpie	*Gymnorhina tibicen*	O	8, 10, T10
Birds	Artamidae	Pied Currawong	*Strepera graculina*	O	-
Birds	Artamidae	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	-	20
Birds	Corvidae	Australian Raven	*Corvus coronoides*	O	10
Birds	Cuculidae	Fan-tailed Cuckoo	*Cuculus flabelliformis*	-	8
Birds	Dicruridae	Willie Wagtail	*Rhipidura leucophrys*	O	8, T20
Birds	Dicruridae	New Zealand Fantail	*Rhipidura fuliginosa*	-	T20
Birds	Dicruridae	Magpie-lark	*Grallina cyanoleuca*	-	10
Birds	Eupetidae	Eastern Whipbird	*Psophodes olivaceus*	O	20, T20
Birds	Hirundinidae	Welcome Swallow	*Hirundo neoxena*	-	T9

Type	Family	Common name	Scientific name	Observed (O) /Heard (H)	Biosphere (2009) site no.
Birds	Maluridae	Splendid Fairy-wren	*Malurus splendens*	O	-
Birds	Meliphagidae	Little Wattlebird	*Anthochaera chrysoptera*	-	8, 20, T20
Birds	Meliphagidae	New Holland Honeyeater	*Anthochaera carunculata*	-	8, T20
Birds	Meliphagidae	Eastern Spinebill	*Acanthorhynchus Tenuirostris*	-	10, 20
Birds	Meliphagidae	Yellow-faced Honeyeater	*Lichenostomus chrysops*	O	T20
Birds	Meliphagidae	Lewin's Honeyeater	*Meliphaga lewinii*	O	-
Birds	Meliphagidae	Bell Miner	*Manorina melanophrys*	O	-
Birds	Meliphagidae	Noisy Miner	*Manorina melanocephala*	O	T10
Birds	Meliphagidae	New Holland Honeyeater	*Phylidonyris Novaehollandiae*	O	-
Birds	Pachycephalidae	Golden Whistler	*Pachycephala pectoralis*	-	T20
Birds	Pachycephalidae	Little Shrike-thrush	*Colluricincla megarhyncha*	-	T20
Birds	Paradalotidae	Spotted Pardalote	*Pardalotus punctatus*	O	-
Birds	Passeridae	Eurasian Tree Sparrow	*Passer montanus*	-	20
Birds	Petroicidae	Eastern Yellow Robin	*Eopsaltria australis*	O	20
Birds	Podargidae	Tawny Frogmouth	*Podargus strigoides*	-	T10
Birds	Psittacidae	Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*	O	8
Birds	Psittacidae	Galah	*Eolophus roseicapilla*	O	-
Birds	Psittacidae	Glossy Black Cockatoo	*Calyptorhynchus lathami*	O	-
Birds	Psittacidae	Little Corella	*Cacatua sanguinea*	-	T20
Birds	Psittacidae	Sulphur-crested Cockatoo	*Cacatua galerita*	O	T20
Birds	Psittacidae	Rainbow Lorikeet	*Trichyglossus haematodus*	O	10
Birds	Psittacidae	Crimson Rosella	*Platycercus elegans*	O	-
Birds	Psittacidae	Eastern Rosella	*Platycercus eximius*	O	-

Type	Family	Common name	Scientific name	Observed (O) /Heard (H)	Biosphere (2009) site no.
Birds	Psittacidae	Australian King-Parrot	*Alisterus scapularis*	O	-
Birds	Psittacidae	Common Koel	*Eudynamys scolopacea*	O	-
Birds	Sylviidae	Clamorous Reed-Warbler	*Acrocephalus stentoreus*	-	T20
Mammals	Canidae	Domestic Dog*	*Canis lupus familiaris*	O	-
Mammals	Canidae	Red Fox*	*Vulpes vulpes*	O	-
Mammals	Dasyuridae	Spotted-tailed Quoll	*Dasyurus maculatus*	-	Outside Study Area. Dead specimen on road.
Mammals	Dasyuridae	Brown Antechinus	*Antechinus stuartii*	-	10, 20
Mammals	Felidae	Cat	*Felis catus*	O	-
Mammals	Leporidae	Rabbit*	*Oryctolagus cuniculus*	O	-
Mammals	Macropodidae	Eastern Grey Kangaroo	*Macropus giganteus*	O	-
Mammals	Macropodidae	Swamp Wallaby	*Wallabia bicolor*	-	20
Mammals	Muridae	House Mouse	*Mus musculus*	-	10
Mammals	Muridae	Eastern Bush Rat	*Rattus fuscipes*	-	10
Mammals	Ornithorhynchidae	Platypus	*Ornithorhyncus anatinus*	-	20
Mammals	Phascolarctidae	Koala	*Phascolarctos cinereus*	-	20, T9, T20
Mammals	Phalangeridae	Common Brushtail Possum	*Trichosurus vulpecula*	-	20
Mammals	Pteropodidae	Grey-headed Flying-fox	*Pteropus poliocephalus*	-	20
Mammals	Tachyglossiade	Short-beaked Echidna	*Tachyglossus aculeatus*	-	10, 20
Mammals	Vombatidae	Wombat	*Vombatus ursinus*	O	-
Mammals	Vespertilionidae	Little Forest Bat	*Vespedelus vulturnus*	-	8, 10
Reptiles	Agamidae	Water Dragon	*Physignathus lesueurii*	O	-
Reptiles	Gekkonidae	Broad-tailed Gecko	*Phyllurus platurus*	O	-
Reptiles	Gekkonidae	Lesueur's Velvet	*Oedura lesueurii*	-	20

Type	Family	Common name	Scientific name	Observed (O) /Heard (H)	Biosphere (2009) site no.
		Gecko			
Reptiles	Scincidae	Copper-tailed Skink	*Ctenotus taeniolatus*	O	-
Reptiles	Scincidae	Red-throated Skink	*Acritoscincus platynota*	-	10
Reptiles	Scincidae	Dark-flecked Garden Sunskink	*Lampropholis delicata*	-	8, 10, 20
Reptiles	Agamidae	Jacky Lizard	*Amphibolurus muricatus*	-	10

Appendix 4. Seven Part Tests

Seven Part Tests were carried out for the following species:

Flora

- *Epacris purpurascens* var. *purpurascens;*
- *Grevillea parviflora* subsp. *parviflora;*
- *Leucopogon exolasius;*
- *Melaleuca deanei;*
- *Pomaderris brunnea;* and
- *Pultenaea aristata.*

Fauna

- Amphibians: Green and Golden Bell Frog, Littlejohn's Tree Frog, Giant Burrowing Frog and Red-crowned Toadlet.
- Mammals: Spotted-tailed Quoll (southeastern mainland), Eastern False Pipistrelle, Eastern Freetail Bat, Large-eared Pied Bat, Eastern Bent-wing Bat, Large-footed Myotis, Yellow-bellied Sheathtail-bat and Greater Broad-nosed Bat.
- Reptiles: Broad-headed Snake and Rosenberg's Goanna.

Threatened flora

Epacris purpurascens* var. *purpurascens	
Seven Part Test	**Address of criteria**
Background	*Epacris purpurascens* var. *purpurascens* is listed as Vulnerable on Schedule 2 of the TSC Act. The species was not recorded in the Study Area but has been previously recorded within the locality, approximately six kilometres to the south of the Study Area.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	*Epacris purpurascens* var. *purpurascens* produces a capsule and is dispersed as a seed. Pollination is most likely by bees or other small inspects. The species is killed by fire and re-establishes from soil-stored seed. Impacts associated with the proposal that may impact upon potential habitat for *Epacris purpurascens* var. *purpurascens* include: • Gas emission causing death or loss of the species; and • Potential localised changes to riparian vegetation as a result of stream flow. No individuals of *Epacris purpurascens* var. *purpurascens* were recorded in the Study Area during the current survey, and previous surveys. The proposal will not alter the existing fire regime of the Study Area. The proposal is also unlikely to impact on known pollination and dispersal mechanisms of the species. Furthermore, previous observations at Dendrobium Mine and Southern Coalfield support the low potential for subsidence related impacts on riparian vegetation, and therefore potential habitat for *Epacris purpurascens* var. *purpurascens*. It is unlikely that the proposal will have a significant impact on the lifecycle of *Epacris purpurascens* var. *purpurascens* such that a viable local population of the species is placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A

Epacris purpurascens* var. *purpurascens	
Seven Part Test	**Address of criteria**
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** *Epacris purpurascens* var. *purpurascens* was not recorded in the Study Area but it has been previously recorded within the locality, approximately six kilometres to the south of the Study Area. Potential habitat for the species is predicted to occur within Hinterland Sandstone Gully Forest and Sydney Hinterland Transition Forest and equates to approximately 296.53 hectares within the Study Area and 8,704.51 hectares within the locality. Creek line habitats may be potentially impacted by subsidence. However, significant impacts to riparian vegetation are unlikely given minor and isolated impacts to flow and pooling is predicted. **Fragmentation** Given the extensive habitat and low potential for impacts, fragmentation of potential habitat is unlikely to occur as a result of the Proposal. No isolation of populations is likely. **Importance of habitat affected** Given no individuals of *Epacris purpurascens* var. *purpurascens* have been recorded in the Study Area, the large extent of potential habitat within the locality which would not be subject to potential mine subsidence impacts, it is unlikely that the proposed works will have an adverse effect on the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for *Epacris purpurascens* var. *purpurascens.*
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	No recovery plan exists for *Epacris purpurascens* var. *purpurascens*.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards *Epacris purpurascens* var. *purpurascens* is the Study Area. *Epacris purpurascens* var. *purpurascens* has been listed as a species 'known to occur in areas affected by subsidence.' in the 'Alteration of habitat following subsidence due to Longwall mining' KTP determination.
Conclusion: The proposed action is unlikely to have a significant impact on *Epacris purpurascens* var. *purpurascens.*	

Grevillea parviflora* subsp. *parviflora	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	*Grevillea parviflora* subsp. *parviflora* is listed as Vulnerable on the TSC Act and Vulnerable on the EPBC Act. The species grows in heathy associations or shrubby woodland, in sandy or light clay soils usually over shale substrates. A large population consisting of hundreds to thousands of individuals was recorded to the east and south of the Study Area during the current survey.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The following is known about the breeding cycle of *Grevillea parviflora* subsp. *parviflora*: • Biology and ecology of the species is poorly known, though it is believed that the species lives between 25–60 years (D. Keith pers.comm. cited in Benson and McDougall 2000). • Flowering occurs in April, May and between July and December. The flowers are insect pollinated. One to two seeds are released at maturity (Benson & McDougall 2000) but have limited seed dispersal, probably of less than 2 metres (DSEWPaC 2013) • Plants are capable of suckering or regenerating from a rootstock (NSW DECC 2005p). Sucker stems usually occur in patches close to the parent plant (DSEWPaC 2013). • After fire or other disturbance, regeneration can occur from both the rhizomes and seed in the soil seedbank. However, after fire, adult plants are killed and seedling recruitment is uncommon (Benson & McDougall 2000). • Little is known about the production and viability of seed, seed predation or germination rates and requirements. Much of the current knowledge of *Grevillea parviflora* subsp. *parviflora* is based on general observations (DSEWPaC 2013). The project is unlikely to result in any impact which will cause the lifecycle of the species to be impacted. *Grevillea parviflora* subsp. *parviflora* was recorded in the Study Area during the current survey, and previous surveys. The proposal will not alter the existing fire regime of the Study Area. The proposal is also unlikely to impact on known pollination and dispersal mechanisms of the species. *Grevillea parviflora* subsp. parviflora does not occur within the riparian zones or along the ridgetops which will be exposed to subsidence. It is therefore unlikely that a significant impact toward a viable population is likely.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A

Grevillea parviflora* subsp. *parviflora	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habtiat** A population of *Grevillea parviflora* subsp. *parviflora* was recorded in the Study Area and to the immediate south of the Study Area. It has been previously recorded throughout the locality. Potential habitat for the species is predicted to occur within Shale Sandstone Transition Forest and Sydney Hinterland Transition Forest. Potential habitat equates to approximately 343.82 hectares occurring within the Study Area, and approximately 5630.71 hectares within the locality. The species does not occur within riparian areas or along ridgetops where subsidence may occur. **Fragmentation** Fragmentation of potential habitat is unlikely to occur as a result of the proposal. No isolations of populations are likely. **Importance of habitat affected** Habitat will not be impacted and therefore the proposal will not impact the long-term survival of the species and population within the locality.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for *Grevillea parviflora* subsp. *parviflora.*
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	No recovery plan exists for *Grevillea parviflora* subsp. *parviflora*.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards *Grevillea parviflora subsp. parviflora* is the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on *Grevillea parviflora* subsp. *parviflora.*	

Leucopogon exolasius	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	*Leucopogon exolasius* is listed as Vulnerable on the TSC Act and EPBC Act. *Leucopogon exolasius* was not recorded in the Study Area during the current survey or previous surveys. The species has been previously recorded in the locality, with the nearest record approximately 2 kilometres to the east of the Study Area. Potential habitat for the species within the Study Area includes: Hinterland Sandstone Gully Forest.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	*Leucopogon exolasius* is shrub to 1 m in height, which flowers from August to October. The fruit of *Leucopogon exolasius* is likely to be dispersed by bird species. Pollination is most likely from bees or other small insects. The species is also likely to require fire for germination. Impacts associated with the Proposal that may impact upon potential habitat for Leucopogon exolasius included: • Gas emission causing death or loss of the species; and • Potential localised changes to riparian vegetation as a result of stream flow. It is unlikely that potential impacts from the proposal would have an adverse impact on a viable population, given impacts are likely to be minor and localised (MSEC 2012). The potential impacts associated with the proposal are also unlikely to impact on known pollination and dispersal mechanisms of the species. Furthermore, previous observations at Dendrobium Mine and Southern Coalfield support the low potential for subsidence related impacts on potential habitat for *Leucopogon exolasius*. Based on the reasons above, it is considered unlikely that the proposal will have a significant impact on the lifecycle of *Leucopogon exolasius* such that a viable local population of the species is placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A

Leucopogon exolasius	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habtiat** *Leucopogon exolasius* was not recorded in the Study Area. It has not been recorded in Study Area during previous studies. Potential habitat in the Study Area for the species is within Hinterland Sandstone Gully Forest. Potential habitat for *Leucopogon exolasius* equates to approximately 31 hectares occurring within the Study Area, and over 5600 hectares within the locality. Hydrological changes may cause localised vegetation changes within riparian areas, however this is unlikely to occur. **Fragmentation** Given the extensive habitat and low potential for impacts, fragmentation of potential habitat is unlikely to occur as a result of the Proposal. No isolations of populations are likely. **Importance of habitat affected** Given no individuals of *Leucopogon exolasius* have been recorded in the Study Area, the large extent of potential habitat within the locality which would not be subject to potential mine subsidence impacts, it is unlikely that the proposed works will have an adverse effect on the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for *Leucopogon exolasius.*
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	No recovery plan exists for Epacris *Leucopogon exolasius*.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards *Epacris purpurascens var. purpurascens* is the Study Area. *Leucopogon exolasius* has been listed as a species 'known to occur in areas affected by subsidence.' in the 'Alteration of habitat following subsidence due to Longwall mining' KTP determination.
Conclusion: The proposed action is unlikely to have a significant impact on *Leucopogon exolasius.*	

Melaleuca deanei	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	*Melaleuca deanei* is listed as Vulnerable on the TSC Act and EPBC Act. *Melaleuca deanei* was not recorded in the Study Area during the current survey or previous surveys. The species has been previously recorded in the locality, with the nearest record approximately 2 kilometres to the north-east of the Study Area. Potential habitat for the species within the Study Area includes: Hinterland Sandstone Gully Forest.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	*Melaleuca deanei* grows in heath on sandstone. Flowers appear in summer but seed production appears to be small and consequently the species exhibits a limited capacity to regenerate. Impacts associated with the Proposal that may impact upon potential habitat for *Melaleuca deanei* included: • Gas emission causing death or loss of the species; and • Potential localised changes to riparian vegetation as a result of stream flow. It is unlikely that potential impacts from the proposal would have an adverse impact on a viable population, given impacts are likely to be minor and localised (MSEC 2012). The potential impacts associated with the proposal are also unlikely to impact on known pollination and dispersal mechanisms of the species. Furthermore, previous observations at Dendrobium Mine and Southern Coalfield support the low potential for subsidence related impacts on potential habitat for *Melaleuca deanei*. Based on the reasons above, it is considered unlikely that the proposal will have a significant impact on the lifecycle of *Melaleuca deanei* such that a viable local population of the species is placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A

Melaleuca deanei	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** *Melaleuca deanei* was not recorded in the Study Area. It has not been recorded in Study Area during previous studies. Potential habitat in the Study Area for the species is within Hinterland Sandstone Gully Forest. Potential habitat for *Melaleuca deanei* equates to approximately 31 hectares occurring within the Study Area, and over 5600 hectares within the locality. Hydrological changes may cause localised vegetation changes within riparian areas, however this is unlikely to occur. **Fragmentation** Given the extensive habitat and low potential for impacts, fragmentation of potential habitat is unlikely to occur as a result of the Proposal. No isolations of populations are likely. **Importance of habitat affected** Given no individuals of *Melaleuca deanei* have been recorded in the Study Area, the large extent of potential habitat within the locality which would not be subject to potential mine subsidence impacts, it is unlikely that the proposed works will have an adverse effect on the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for *Melaleuca deanei*.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	A recovery plan exists for *Melaleuca deanei*. Given the proposal is unlikely to result in any significant impact to the species or potential habitat, the proposal is therefore consistent with the plan.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards *Melaleuca deanei* is the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on *Melaleuca deanei*.	

Pomaderris brunnea	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	*Pomaderris brunnea* is listed as Vulnerable on the TSC Act and EPBC Act. *Pomaderris brunnea* was not recorded in the Study Area during the current survey or previous surveys. The species has been previously recorded in the locality, with the nearest record approximately 5 kilometres to the south-west of the Study Area. Potential habitat for the species within the Study Area includes: Hinterland Sandstone Gully Forest.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The following is known about the life cycle of *Pomaderris brunnea*: • The species is expected to live for 10-20 years, while the minimum time to produce seed is estimated to be 4-6 years • Brown Pomaderris grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines. • Flowers appear in September and October. • The species is expected to live for 10 - 20 years, while the minimum time to produce seed is estimated to be 4 - 6 years. It is unlikely that potential impacts from the proposal would have an adverse impact on a viable population, given impacts are likely to be minor and localised (MSEC 2012). The potential impacts associated with the proposal are also unlikely to impact on known pollination and dispersal mechanisms of the species. Furthermore, previous observations at Dendrobium Mine and Southern Coalfield support the low potential for subsidence related impacts on potential habitat for *Pomaderris brunnea*. Based on the reasons above, it is considered unlikely that the proposal will have a significant impact on the lifecycle of *Pomaderris brunnea* such that a viable local population of the species is placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A

Pomaderris brunnea	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** *Pomaderris brunnea* was not recorded in the Study Area. It has not been recorded in Study Area during previous studies. Potential habitat in the Study Area for the species is within Hinterland Sandstone Gully Forest. Potential habitat for *Pomaderris brunnea* equates to approximately 31 hectares occurring within the Study Area, and over 5600 hectares within the locality. Hydrological changes may cause localised vegetation changes within riparian areas, however this is unlikely to occur. **Fragmentation** Given the extensive habitat and low potential for impacts, fragmentation of potential habitat is unlikely to occur as a result of the Proposal. No isolations of populations are likely. **Importance of habitat affected** Given no individuals of *Pomaderris brunnea* have been recorded in the Study Area, the large extent of potential habitat within the locality which would not be subject to potential mine subsidence impacts, it is unlikely that the proposed works will have an adverse effect on the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for *Pomaderris brunnea.*
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	A recovery plan exists for *Pomaderris brunnea*. Given the proposal is unlikely to result in any significant impact to the species or potential habitat, the proposal is therefore consistent with the plan.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards *Pomaderris brunnea* is the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on *Pomaderris brunnea.*	

Pultenaea aristata	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	*Pultenaea aristata* is listed as Vulnerable on the TSC Act and EPBC Act. *Pultenaea aristata* was not recorded in the Study Area during the current survey or previous surveys. The species has been previously recorded in the locality, with the nearest record approximately 7 kilometres to the east of the Study Area. Potential habitat for the species within the Study Area includes: Hinterland Sandstone Gully Forest.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The following is known about the life cycle of *Pultenaea aristata*: • Pultenaea aristata is endemic to the Woronora Plateau in NSW, between Helensburgh and Mount Keira; • Grows in low nutrient sandstone soils in both moist and dry areas; • The species is often associated with the Upland Swamp vegetation complex; • Flowers appear in yellow to light orange terminal heads between September and October; • Pollinators not known. It is unlikely that potential impacts from the proposal would have an adverse impact on a viable population, given impacts are likely to be minor and localised (MSEC 2012). The potential impacts associated with the proposal are also unlikely to impact on known pollination and dispersal mechanisms of the species. Furthermore, previous observations at Dendrobium Mine and Southern Coalfield support the low potential for subsidence related impacts on potential habitat for *Pultenaea aristata*. Based on the reasons above, it is considered unlikely that the proposal will have a significant impact on the lifecycle *Pultenaea aristata* such that a viable local population of the species is placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local	N/A

Pultenaea aristata	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
occurrence is likely to be placed at risk of extinction	
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** *Pultenaea aristata* was not recorded in the Study Area. It has not been recorded in Study Area during previous studies. Potential habitat in the Study Area for the species is within Hinterland Sandstone Gully Forest. Potential habitat for *Pultenaea aristata* equates to approximately 31 hectares occurring within the Study Area, and over 5600 hectares within the locality. Hydrological changes may cause localised vegetation changes within riparian areas, however this is unlikely to occur. **Fragmentation** Given the extensive habitat and low potential for impacts, fragmentation of potential habitat is unlikely to occur as a result of the Proposal. No isolations of populations are likely. **Extent of habitat affected** Given no individuals of *Pultenaea aristata* have been recorded in the Study Area, the large extent of potential habitat within the locality which would not be subject to potential mine subsidence impacts, it is unlikely that the proposed works will have an adverse effect on the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for *Pultenaea aristata.*
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	A recovery plan exists for *Pultenaea aristata*. Given the proposal is unlikely to result in any significant impact to the species or potential habitat, the proposal is therefore consistent with the plan.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards *Pultenaea aristata* is the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on *Pultenaea aristata.*	

Fauna

Giant Burrowing Frog, Green and Golden Bell Frog, and Littlejohn's Tree Frog	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	Littlejohn's Tree Frog is listed as Vulnerable on the TSC Act and EPBC Act. Littlejohn's Tree Frog has a distribution that includes the plateaus and eastern slopes of the Great Dividing Range from Watagan State Forest (90 km north of Sydney) south to Buchan in Victoria. The majority of records are from within the Sydney Basin Bioregion with only scattered records south to the Victorian border and this species has not been recorded in southern NSW within the last decade. Records are isolated and tend to be at high altitude. The Giant Burrowing Frog is listed as Vulnerable on the TSC Act and EPBC Act. The Giant Burrowing Frog is distributed in south eastern NSW and Victoria, and appears to exist as two distinct populations: a northern population largely confined to the sandstone geology of the Sydney Basin and extending as far south as Ulladulla, and a southern population occurring from north of Narooma through to Walhalla, Victoria. Found in heath, woodland and open dry sclerophyll forest on a variety of soil types except those that are clay based. The Green and Golden Bell Frog is listed as Vulnerable on the TSC Act and EPBC Act. The Green and Golden Bell has been found in a wide range of water bodies in NSW except fast flowing streams. It inhabits many disturbed sites, including abandoned mines and quarries (Pyke et al. 2002). Giant Burrowing Frog, Green and Golden Bell Frog, and Littlejohn's Tree Frog were not recorded in the Study Area during the current survey or previous surveys. All three species have potential habitat along the Georges River and its tributaries. Mallaty Creek and Woodhouse Creek within the Study Area provide very little potential habitat due to the lack of deep pools, flowing water and aquatic habitat features. All three species have been previously recorded within the locality within Dharawal Conservation Area and Heathcote National Park.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The following is known about the breeding cycle of the Giant Burrowing Frog: • Breeding habitat of this species is generally soaks or pools within first or second order streams. The species are also commonly recorded from 'hanging swamp' seepage lines and where small pools form from the collected water. • Individuals spend 95% of their time outside of breeding sites, when breeding, they move into the breeding site either immediately before or following heavy rain and occupy these sites for up to 10 days. Individuals do not generally attempt to breed every year. • Breeding occurs mainly in autumn and Males show strong territoriality at breeding sites. Egg masses are foamy with an average of approximately 500-800 eggs and are laid in burrows or under vegetation in small pools. After rains, tadpoles are washed into larger pools where they complete their development in ponds or ponded areas of the creekline. Tadpole development ranges from around 12 weeks duration to up to 12 months with late developing tadpoles overwintering and completing development when warmer temperatures return. (DEC 2005) The following is known about the breeding cycle of the Green and Golden Bell Frog:

Giant Burrowing Frog, Green and Golden Bell Frog, and Littlejohn's Tree Frog	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
	• In NSW, the Green and Golden Bell Frog has been found in a wide range of water bodies except fast flowing streams (Pyke & White 1996). • Inhabits marshes, dams and stream-sides, particularly those containing bullrushes (Typha spp.) or spikerushes (Eleocharis spp.). • Optimum habitat includes water-bodies that are unshaded, free of predatory fish such as Plague Minnow (Gambusia holbrooki), have a grassy area nearby and diurnal sheltering sites available. • Some sites, particularly in the Greater Sydney region occur in highly disturbed areas. • The species is active by day and usually breeds in summer when conditions are warm and wet. • Males call while floating in water and females produce a raft of eggs that initially float before settling to the bottom, often amongst vegetation. • Tadpoles feed on algae and other plant-matter; adults eat mainly insects, but also other frogs. • Preyed upon by various wading birds and snakes. The following is known about the breeding cycle of the Littlejohn's Tree Frog: • Breeding is triggered by heavy rain and can potentially occur all year, but is usually from late summer to early spring when conditions are favourable. • Males call from low vegetation close to slow flowing pools. • Eggs are laid in loose gelatinous masses attached to small submerged twigs. • Eggs and tadpoles are mostly found in still or slow flowing pools that receive extended exposure to sunlight, but will also use temporary isolated pools. It is unlikely that potential impacts from the proposal would have an adverse impact on a viable population, given impacts to watercourses are likely to be minor and localised (MSEC 2012). No prey species are likely to be impacted by the proposal. The potential impacts associated with the proposal are also unlikely to impact on known breeding pools of the species. Furthermore, none of the species have been previously recorded in the Study Area.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A

Giant Burrowing Frog, Green and Golden Bell Frog, and Littlejohn's Tree Frog	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** The Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog have potential habitat along the Georges River and Hinterland Sandstone Gully Forest in the Study Area. Approximately 31 hectares of Hinterland Sandstone Gully Forest has been mapped within the Study Area, and over 5600 hectares within the locality. The Giant Burrowing Frog and Littlejohn's Tree Frog requires creek with sandy banks, deep pools, or drainage lines with rocky outcrops. **Fragmentation** The subsidence predicted has the potential to alter a portion of these habitat features within the Study Area, however impacts are likely to be isolated and minor. **Importance of habitat affected** Whilst it is the possible that subsidence could dry or increase flow to a breeding pool which may impact upon tadpoles of the species, the likelihood of this occurring is low. Furthermore, none of the species have been recorded in the Study Area and the extent of habitat of habitat is extensive.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for the Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	No recovery plan exists for the Giant Burrowing Frog and Littlejohn's Tree Frog. A draft management plan is available for the Green and Golden Bell Frog. Given the proposal is unlikely to result in any significant impact to the species or potential habitat, the proposal is therefore consistent with the plan.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog in the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree	

Red-crowned Toadlet	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	The Red-crowned Toadlet is listed as Vulnerable on Schedule 2 of the TSC Act. The Red-crowned Toadlet occurs on wetter ridge tops and upper slopes of sandstone formations on which the predominant vegetation is dry open forests and heaths. This species typically breeds within small ephemeral creeks that feed into larger semi-perennial streams. These creeks are characterised after rain by a series of shallow pools lined with dense grasses, ferns and low shrubs. Potential habitat for this species occurs in the Study Area on ridges, in creeks and ephemeral drainage lines within woodland habitat. The species was not recorded during the current survey or previous surveys. The species has been previously recorded in the locality, approximately 4 kilometres to the east of the Study Area.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The following is known about the lifecycle of the Red-crowned Toadlet (DEC 2005s): ❒ Inhabits periodically wet drainage lines below sandstone ridges that often have shale lenses or cappings; ❒ Shelters under rocks and amongst masses of dense vegetation or thick piles of leaf litter; ❒ Breeding congregations occur in dense vegetation and debris beside ephemeral creeks and gutters; ❒ Eggs are laid in moist leaf litter, from where they are washed by heavy rain; a large proportion of the development of the tadpoles takes place in the egg; and, ❒ Disperses outside the breeding period, when they are found under rocks and logs on sandstone ridges and forage amongst leaf-litter. The Red-crowned Toadlet was not recorded within the Study Area during the current survey and previous surveys. Potential breeding and foraging habitat for this species occurs on ridges, in creeks and ephemeral drainage lines within woodland habitats. The area of habitat that may be potentially impacted by subsidence, include Georges River and its tributaries and rock outcrops. MSEC (2012) predict the changes in water level resulting from the extraction of the proposed longwalls are not expected to result in any measurable impact and it is unlikely that there would be any significant increases in the levels of ponding, flooding, or scouring of the river banks resulting from the extraction of the proposed longwalls. It is possible, that there could be some very localised small increased levels of ponding or flooding where the predicted maximum tilts coincide with existing pools, steps or cascades along the river, however, any changes are not expected to result in a significant impact. Any draining of a breeding pool containing eggs, tadpoles or metemorphs of the frog may result in the loss of Red-crowned Toadlets within that pool. However, given the species was not recorded and no known populations occur within the Study Area, and predicted impacts are likely to be minor and isolated, it is unlikely that a viable local population be placed at risk of extinction..
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A
a) In the case of an endangered ecological community or critically	N/A

Red-crowned Toadlet	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	
b) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** The Red-crowned Toadlet has not been recorded within the Study Area. Potential habitat for this species occurs in creeks and ephemeral drainage lines within woodland habitat. Vegetation communities include: Hinterland Sandstone Gully Forest, Sydney Hinterland Transition Forest and Shale Sandstone Transition Forest. Approximately 374.12 hectares of similar vegetation communities are located within the Study Area. Over 6,000 ha of potential habitat is widely distributed within the locality. However, it should be noted that ephemeral drainage lines are infrequent within these vegetation communities. The subsidence predicted has the potential to alter a minor portion of these habitat features within the Study Area. It is highly unlikely that all potential habitats would be impacted by subsidence. **Fragmentation** Minor alteration of surface flow in creeks and drainage lines, is unlikely to reduce the number of breeding sites for the species. Fragmentation is unlikely as significant impacts to pools is unlikely. **Importance of habitat affected** Given the species has not been previously recorded in the Study Area, and the variety of potential habitat which will not be impacted by the proposal, the Study Area is not of high importance to the long-term survival of the species in the locality.
c) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for the Red-crowned Toadlet.
d) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	No recovery plan exists for the Red-crowned Toadlet.
e) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards Red-crowned Toadlet in the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on the Red-crowned Toadlet	

Spotted-tailed Quoll	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	The Spotted-tailed Quoll is listed as Endangered on Schedule 2 of the TSC Act. This species was not recorded during the current survey, however a dead specimen was recorded along a road within Appin Area 5 during previous surveys (Biosphere Environmental 2009). Potential habitat for this species in the Study Area is within woodland, riparian vegetation and caves.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The following is known about the lifecycle of the Spotted-tailed Quoll: • Mostly nocturnal, although will hunt during the day; spends most of the time on the ground, although also an excellent climber and may raid possum and glider dens and prey on roosting birds. • Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. • Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites. • Use 'latrine sites', often on flat rocks among boulder fields and rocky cliff-faces; these may be visited by a number of individuals; latrine sites can be recognised by the accumulation of the sometimes characteristic 'twisty-shaped' faeces deposited by animals. • Consumes a variety of prey, including gliders, possums, small wallabies, rats, birds, bandicoots, rabbits and insects; also eats carrion and takes domestic fowl. • Females occupy home ranges up to about 750 hectares and males up to 3500 hectares; usually traverse their ranges along densely vegetated creeklines. • Average litter size is five; both sexes mature at about one year of age. Subsidence may impact on foraging and breeding habitats through fracturing of creek bedrock, and diversion of surface water flow. However, based on the previous experience at the Dendrobium Mine, the incidence of this occurring has been considered low (MSEC 2012). Furthermore potential habitat is extensive in the Study Area. Subsidence may impact on foraging and breeding habitats through the collapsing of caves and overhangs. No large-scale rock falls or cracking is predicted (MSEC 2012). It should be noted that rock falls may also create new habitat for the species. Mortality or injury as a result of rock falls may occur, although this is unlikely. Given subsidence may create new habitat within the Study Area for the species, it is unlikely that the proposal would place a viable population of the Spotted-tailed Quoll at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A

Spotted-tailed Quoll	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** Potential habitat for the species in the Study Area includes woodland and forest vegetation communities within close proximity to rocky areas including: Hinterland Sandstone Gully Forest, Shale Sandstone Transition Forest and Sydney Hinterland Transition Forest. Potential habitat within the Study Area is less than 300 hectares. Only a small portion of potential habitat along creeklines and ridgetops may be impacted by the proposal. Approximately 7,000 hectares of potential habitat is included in the locality, however it should be noted that only where suitable breeding, foraging and sheltering resource occur within these communities is where the species is likely to occur. Subsidence has potential to impact a portion of these habitat features such as caves, and vegetation changes along riparian zones. Potential impacts are not predicted to cause large scale rock collapses. Rock collapses may create new habitat for the species. **Fragmentation** Fragmentation of habitat is unlikely as not all habitat features are likely to be affected by subsidence. **Importance of habitat affected** The Study Area has not been considered of importance to the long-term survival of a local population or populations of the Spotted-tailed Quoll in the locality. Habitat to the north, south and east of the study area is extensive.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for the Spotted-tailed Quoll.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	A national recovery plan exists for the Spotted-tailed Quoll. Given impacts associated with the proposal are likely to be negligible, the proposal is not inconsistent with the objectives of the plan.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards Spotted-tailed Quoll in the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on the Spotted-tailed Quoll	

Broad-headed Snake	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	The Broad-headed Snake is listed as Endangered on the TSC Act and Vulnerable on the EPBC Act. The Broad-headed Snake has a preferred habitat centred on the communities occurring on the Triassic sandstone of the Sydney Basin. The sites where they occur are typified by exposed sandstone outcrops and benching and in these locations the vegetation is mainly woodland, open woodland and/or heath. The Broad-headed Snake seasonally occupies distinctive microhabitats within these broader habitat types. They utilise rock crevices and exfoliating sheets of weathered sandstone during the cooler months and tree hollows during summer (Webb & Shine 1998b). Some of the canopy tree species found to regularly co-occur at known sites include: *Corymbia eximia, C. gummifera, Eucalyptus sieberi, E. punctata* and *E. piperita* (NPWS unpublished). The species was not recorded during the current survey or during previous surveys.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The Broad-headed Snake is nocturnal to crepuscular (active at dusk) and is an 'ambush predator', preying predominantly on lizards, particularly Lesueurs Velvet Geckos (Wells 1981; Webb & Shine 1994), at least during the cooler months. During this time the species can be found frequenting exposed sandstone ridgetops where it refuges under exfoliating sheets of sandstone resting on naked rock or within crevices. These refuges often have a predominantly west to north westerly aspect. During the warmer months of the year they become arboreal frequenting tree hollows and undergo a presumed dietary shift to small mammals although crepuscular arboreal skinks (*Eulamprus tenuis*) have also been reported in the diet of summer captured individuals. The snake has low rates of growth, slow maturation and a breeding cycle that is less frequent than every year. These factors in concert may predispose the species to become threatened. The Broad-headed Snake was not recorded during the surveys however, potential breeding and foraging habitat for this species occurs on ridge lines – particularly around sandstone outcrops. Vegetation communities include: Sydney Hinterland Transition Woodland and Hinterland Sandstone Gully Forest. The Broad-headed Snake may be potentially impacted by subsidence. Impacts include cracking and collapsing of rocky outcrops, overhangs and cliffs, of which the species resides. The potential for these to occur is minor (MSEC 2012). Based on the experience of mining at Dendrobium, Appin and Tower Collieries, there have been no large scale cliff instabilities observed outside the extents of longwall mining. There have been, however, small and isolated rockfalls observed outside the extents of mining, but these represent a very small proportion of the total length of cliffline. Given rock falls are likely to be minor and isolated, habitat features and food source and unlikely to be greatly impacted by subsidence. Habitat available in the Study Area and within the locality which would not be impacted by the proposal is extensive. Furthermore, no records of the Broad-headed Snake have been made within the Study Area. Given the above reasons, it is unlikely that a viable population of Broad-headed Snake would be placed at a risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A

Broad-headed Snake	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** The Broad-headed Snake occurs within ridgetop habitat in the following vegetation communities within the Study Area: Sydney Hinterland Transition Woodland and Hinterland Sandstone Gully Forest. The Study Area contains over 100 hectares of ridgetop habitat with over 4000 hectares located within the locality. Specifically, the species requires exposed sandstone outcrops within woodland and open forest. The potential habitat is widely distributed within the locality particularly to the east. A large portion of potential habitat in the locality is protected within Sydney Metropolitan Catchment Lands, Heathcote National Park and Dharawal Conservation Area. Subsidence has the potential to cause cracking and collapsing of rocky outcrops, overhangs and cliffs, of which the species resides. Based on previous studies in Southern Coalfield, large scale rock collapses are unlikely. **Fragementation** Fragmentation or isolation of Broad-headed Snake habitat within the Study Area is unlikely to occur, given the extent of habitat and minimal potential impacts. **Importance of habitat affected** The Study Area has not been considered of importance to the long-term survival of a local population or populations of the Broad-headed Snake in the locality. Habitat to the north, south and east of the study area is extensive and will not be impacted by the proposal.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for the Broad-headed Snake.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	To date, no recovery plan exists for the Broad-headed Snake.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards Broad-headed Snake in the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on the Broad-headed Snake.	

Rosenberg's Goanna	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	The Rosenberg's Goanna is listed as Vulnerable on the TSC Act. Rosenberg's Goanna occurs on the Sydney Sandstone in Wollemi National Park to the north-west of Sydney, in the Goulburn and ACT regions and near Cooma in the south. There are records from the South West Slopes near Khancoban and Tooma River. Also occurs in South Australia and Western Australia. The Rosenberg's Goanna was not recorded during the current survey or previous surveys. Potential habitat for the species in the Study Area includes vegetation to the east of longwall 37 and east of the Georges River within woodland and forest vegetation communities including: Shale Sandstone Transition Forest, Hinterland Sandstone Gully Forest and Sydney Hinterland Transition Forest. However it should be noted that only where suitable breeding, foraging and sheltering resource occur within these communities is where the species is likely to occur.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	Habitat requirements and the ecology for this species is described as: • Found in heath, open forest and woodland; • Associated with termites, the mounds of which this species nests in; termite mounds are a critical habitat component; • Individuals require large areas of habitat; • Feeds on carrion, birds, eggs, reptiles and small mammals; • Shelters in hollow logs, rock crevices and in burrows, which they may dig for themselves, or they may use other species' burrows, such as rabbit warrens; Runs along the ground when pursued (as opposed to the Lace Monitor, which climbs trees); • Lays up to 14 eggs in a termite mound; the hatchlings dig themselves out of the mounds; • Generally slow moving; on the tablelands likely only to be seen on the hottest days. Potential foraging habitat for this species occurs in forests and woodlands where there are termite mounds, rock outcrops, crevices and hollow logs. The Rosenberg's Goanna may be potentially impacted by subsidence. Impacts include cracking and collapsing of rocky outcrops, overhangs and cliffs, of which the species resides. The potential for these to occur is minor. Based on the experience of mining at Dendrobium, Appin and Tower Collieries, there have been no large scale cliff instabilities observed outside the extents of longwall mining. There have been, however, small and isolated rockfalls observed outside the extents of mining, but these represent a very small proportion of the total length of cliffline. Given rock falls are likely to be minor and isolated, habitat features and food source and unlikely to be greatly impacted by subsidence. Habitat available in the Study Area and within the locality which would not be impacted by the proposal is extensive. Given the above reasons, it is unlikely that a viable population of Rosenberg's Goanna would be placed at a risk of extinction.

Rosenberg's Goanna	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** Potential habitat for the species in the Study Area includes woodland and forest vegetation communities including: Shale Sandstone Transition Forest, Sydney Hinterland Transition Forest, and Hinterland Sandstone Gully Forest. However it should be noted that only where suitable breeding, foraging and sheltering resource occur within these communities is where the species is likely to occur. Potential habitat within the Study Area is approximately 374.12 hectares. Only a small portion of potential habitat may be impacted by the proposal. Over 6000 hectares of potential habitat is included in the locality. **Fragmentation** Woodland and forest habitat are unlikely to be impacted by subsidence. Fragmentation of habitat is therefore unlikely. **Importance of habitat affected** Given rock falls are likely to be minor and isolated, habitat features and food source and unlikely to be greatly impacted by subsidence. Habitat available in the Study Area and within the locality which would not be impacted by the proposal is extensive.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for the Rosenberg's Goanna.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	To date, no recovery plan exists for the Rosenberg's Goanna.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards Rosenberg's Goanna in the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on the Rosenberg's Goanna.	

Microchiropteran Bats – Cave roosting species	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	Potential habitat for five cave-roosting bat species within the Study Area includes: Eastern Bentwing-bat, Large-eared Pied Bat, Eastern Free-tail Bat, Eastern False Pipistrelle, and Yellow-bellied Sheathtail-bat. All of these species have been grouped together for this assessment due to similarity in breed and roosting habitat. All species are listed as Vulnerable on the TSC Act. None of the species were recorded during the current survey or previous surveys.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The following is known about the species: • The Eastern Bentwing-bat, and Large-eared Pied Bat can be considered cave-dependant as they utilise caves almost exclusively for roosting requirements. • Yellow-bellied Sheathtail-bat, Eastern False use caves, rocky overhangs, and crevices for roosting some of the time but may use other similar structures such as tree hollows. • The Large-eared Pied Bat, Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat occur over a variety of habitats. • Large-eared Pied Bat is generally found in timbered area. • The Eastern False Pipistrelle inhibits sclerophyll forests. • Foraging behaviours and flight capability varies between species. • Large-eared Pied Bat has a relatively slow flight and forages within the canopy. • Yellow-bellied Sheathtail-bat and Eastern Bentwing-bat are fast high fliers foraging above the canopy. • The Eastern False Pipistrelle is fast and manoeuvrable foraging within the canopy. Impacts associated with subsidence may involve the fracturing of bedrock resulting in the collapse of rocky overhangs, rocky crevices and small caves. This may result in the loss or modification of potential foraging, roosting and breeding habitat for the bat species. Large scale cliff instabilities and collapsing of rock overhangs not predicted to occur. As such, the loss of potential foraging, roosting and breeding habitat for the bat species is likely to be minimal. It is unlikely that potential foraging resources within the Study Area would be significantly impacted, as woodland and forest areas are unlikely to be impacted by subsidence. Furthermore, habitat features in the Study Area and locality which would not be impacted by subsidence is extensive. Roosting and breeding habitat features are widely distributed throughout the locality and Study Area. Given the species is highly mobile, the proposal is unlikely to impact on potential habitat. The proposal is not likely to impact the lifecycle of the species to the extent that a local population of the species may be placed at risk of extinction.

Microchiropteran Bats – Cave roosting species	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: iii. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or iv. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A
d) In relation to the habitat of a threatened species, population or ecological community: iv. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and v. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and vi. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** Potential habitat for these species is widely distributed within woodland and forest habitats the Study Area. The Study Area contains over 300 hectares of roosting, breeding and foraging resources, which represent a small portion compared to over 7,000 ha of potential habit in the locality. Subsidence has potential to impact a portion of these habitat features such as rock outcrops and overhangs. Based on the experience of mining at Dendrobium, Appin and Tower Collieries, there have been no large scale cliff instabilities observed outside the extents of longwall mining. There have been, however, small and isolated rockfalls observed outside the extents of mining, but these represent a very small proportion of the total length of cliff line. **Fragmentation** Fragmentation is unlikely due to the high mobility of the species, and the extensive habitat available in the Study Area and locality. **Importance of habitat affected** Given the extent of potential habitat in the Study Area and locality and the high mobility of the species, the Study Area is of moderate importance to the long-term survival of the Eastern Bentwing-bat, Large-eared Pied Bat, Eastern Free-tail Bat, Eastern False Pipistrelle, and Yellow-bellied Sheathtail-bat.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for the Eastern Bentwing-bat, Large-eared Pied Bat, Eastern Free-tail Bat, Eastern False Pipistrelle, and Yellow-bellied Sheathtail-bat..
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	To date, no recovery plan exists for the Eastern Bentwing-bat, Large-eared Pied Bat, Eastern Free-tail Bat, Eastern False Pipistrelle, and Yellow-bellied Sheathtail-bat.

Microchiropteran Bats – Cave roosting species	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards Eastern Bentwing-bat, Large-eared Pied Bat, Eastern Free-tail Bat, Eastern False Pipistrelle, and Yellow-bellied Sheathtail-bat. In the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on the Eastern Bentwing-bat, Large-eared Pied Bat, Eastern Free-tail Bat, Eastern False Pipistrelle, and Yellow-bellied Sheathtail-bat..	

Southern Myotis (Myotis macropus)	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	The Southern Myotis is listed as Vulnerable on Schedule 2 of the TSC Act. The Large-footed Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. It is rarely found more than 100 km inland, except along major rivers. The species generally roosts in groups of 10 to15 close to water in caves, mine shafts, hollow-bearing trees, stormwater channels, buildings, under bridges and in dense foliage. They forage over streams and pools catching insects and small fish by raking their feet across the water surface. The species was not recorded during the current or previous surveys in the Study Area. Potential habitat for the species in the Study Area includes woodland and forest vegetation communities including: Hinterland Sandstone Gully Forest and Sydney Hinterland Transition Forest.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The following is known about the Southern Myotis: • Generally roost in groups of 10 to 15 close to water in caves, mine shafts, hollow-bearing trees, stormwater channels, buildings, under bridges and in dense foliage. • Forage over streams and pools catching insects and small fish by raking their feet across the water surface. • They will choose a cave that overhangs pools even when the caves are rather open (Churchill, 1998). • Females have one young each year. • They form small breeding groups with a single male and several females (Churchill, 1998). Subsidence may impact on foraging and breeding habitats through fracturing of creek bedrock, and diversion of surface water flow. Changes may result in the impact to prey species such as fish and water-reliant insects. However, this is unlikely to occur as impacts to creeks likely to be insignificant (MSEC 2012). The potential collapse of rock over hangs and caves due to subsidence impact may cause a loss of roosting and breeding habitat. Rock falls are predicted to be minor within the Study Area. Based on the experience of mining at Dendrobium, Appin and Tower Collieries, there have been no large scale cliff instabilities observed outside the extents of longwall mining. There have been, however, small and isolated rock falls observed outside the extents of mining, but these represent a very small proportion of the total length of cliff line. As such, the loss of potential foraging, roosting and breeding habitat for the bat species is likely to be minimal. Given the mobility of the species, the large habitat features present in the Study Area and locality, and foraging and roosting resources are less likely to be impacted by subsidence. It is unlikely that the proposal would place a viable population of the Southern Myotis at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A

Southern Myotis (Myotis macropus)	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** Potential habitat for the species within woodland and forest habitats within the Study Area is approximately 370 hectares, which represent a small portion compared to over 7000 hectares of potential habitat in the Locality. Habitats within close proximity to water courses for foraging, roosting and breeding are important for the species. Subsidence has potential to impact a portion of these habitat features such as rock outcrops and overhangs, and diversion of surface water which may impact upon prey species. Potential impacts are not predicted to cause large scale rock collapses. Rock collapses may create new habitat for the species. **Fragmentation** Fragmentation is unlikely due to the high mobility of the species, and the extensive habitat available in the Study Area and locality. **Importance of habitat affected** Given the extent of potential habitat in the Study Area and locality, and the high mobility of the species, the Study Area is of moderate importance to the long-term survival of the Southern Myotis.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for Southern Myotis.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	To date, there is no recovery plan or threat abatement plan for the Southern Myotis.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards the Southern Myotis in the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on the Southern Myotis	

Greater Broad-nosed Bat (*Scoteanax rueppellii*)	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	The Greater Broad-nosed Bat is listed as Vulnerable on Schedule 2 of the TSC Act. The Greater Broad-nosed Bat is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In NSW it is widespread on the New England Tablelands, however does not occur at altitudes above 500 m. The species was not recorded during the current or previous surveys in the Study Area. Potential habitat for the species in the Study Area includes woodland and forest vegetation communities including: Hinterland Sandstone Gully Forest and Sydney Hinterland Transition Forest.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The following is known about the Greater Broad-nosed Bat: • Utilises a variety of habitats from woodland through to moist and dry Eucalypt forest and rainforest, though it is most commonly found in tall wet forest. • Although this species usually roosts in tree hollows, it has also been found in buildings. • Forages after sunset, flying slowly and directly along creek and river corridors at an altitude of 3 to 6 m. • Open woodland habitat and dry open forest suits the direct flight of this species as it searches for beetles and other large, slow-flying insects; this species has been known to eat other bat species. • Little is known of its reproductive cycle, however a single young is born in January; prior to birth, females congregate at maternity sites located in suitable trees, where they appear to exclude males during the birth and raising of the single young. The Greater Broad-nosed Bat was not recorded within the Study Area. Potential for the species occurs within forest and woodland in the Study Area, where there are trees with hollows and decorticating bark suitable for roosting and foraging. Subsidence may impact on foraging and breeding habitats through fracturing of creek bedrock may cause localised vegetation changes. However, based on previous experience, this any impact is likely to be minor. Subsidence is unlikely to impact on hollow bearing trees or decorticating bark in the Study Area. The species is mobile and likely to utilise habitat features throughout the Study Area and locality. Given the mobility of the species, the large habitat features present in the Study Area and locality, and minor impacts to foraging and roosting resources, it is unlikely that the proposal would place a viable population of the Greater Broad-nosed Bat at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A

Greater Broad-nosed Bat (*Scoteanax rueppellii*)	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A
d) In relation to the habitat of a threatened species, population or ecological community: i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** Potential habitat for the species within woodland and forest habitats within the Study Area is approximately 370 hectares, which represent a small portion compared to over approximately 7000hectares of potential habitat in the locality. Hollow bearing trees and trees with exfoliating bark are important habitat features for the species. Minor possible surface water flow diversions could occur in some locations along the Georges River, however these are likely to be minor and isolated. Localised vegetation changes in riparian areas may occur. However, given the low occurrence likelihood and the extent of potential habitat in the Study Area and Locality it is unlikely that this would significantly impact the species. Trees hollows and trees with exfoliating bark are unlikely to be impact by subsidence. **Fragmentation** Fragmentation is unlikely due to the high mobility of the species, and the extensive habitat available in the Study Area and locality. **Importance of habitat affected** Given the species has not been recorded in the Study Area, the extent of potential habitat in the Study Area and locality, and the high mobility of the species, the Study Area is of moderate importance to the long-term survival of the Greater broad-nosed bat.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for Greater broad-nosed bat.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	To date, there is no recovery plan or threat abatement plan for the Greater broad-nosed bat.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards the Greater broad-nosed bat in the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on the Greater broad-nosed bat	

Greater Broad-nosed Bat (*Scoteanax rueppellii*)	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
Background	The Greater Broad-nosed Bat is listed as Vulnerable on Schedule 2 of the TSC Act. The Greater Broad-nosed Bat is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In NSW it is widespread on the New England Tablelands, however does not occur at altitudes above 500 m. The species was not recorded during the current or previous surveys in the Study Area. Potential habitat for the species in the Study Area includes woodland and forest vegetation communities including: Hinterland Sandstone Gully Forest and Sydney Hinterland Transition Forest.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The following is known about the Greater Broad-nosed Bat: • Utilises a variety of habitats from woodland through to moist and dry Eucalypt forest and rainforest, though it is most commonly found in tall wet forest. • Although this species usually roosts in tree hollows, it has also been found in buildings. • Forages after sunset, flying slowly and directly along creek and river corridors at an altitude of 3 to 6 m. • Open woodland habitat and dry open forest suits the direct flight of this species as it searches for beetles and other large, slow-flying insects; this species has been known to eat other bat species. • Little is known of its reproductive cycle, however a single young is born in January; prior to birth, females congregate at maternity sites located in suitable trees, where they appear to exclude males during the birth and raising of the single young. The Greater Broad-nosed Bat was not recorded within the Study Area. Potential for the species occurs within forest and woodland in the Study Area, where there are trees with hollows and decorticating bark suitable for roosting and foraging. Subsidence may impact on foraging and breeding habitats through fracturing of creek bedrock may cause localised vegetation changes. However, based on previous experience, this any impact is likely to be minor. Subsidence is unlikely to impact on hollow bearing trees or decorticating bark in the Study Area. The species is mobile and likely to utilise habitat features throughout the Study Area and locality. Given the mobility of the species, the large habitat features present in the Study Area and locality, and minor impacts to foraging and roosting resources, it is unlikely that the proposal would place a viable population of the Greater Broad-nosed Bat at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	N/A

Greater Broad-nosed Bat (*Scoteanax rueppellii*)	
Assessment of Significance criteria (Seven Part Test)	**Address of criteria**
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: iii. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or iv. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	N/A
d) In relation to the habitat of a threatened species, population or ecological community: iv. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and v. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and vi. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	**Extent of habitat** Potential habitat for the species within woodland and forest habitats within the Study Area is approximately 370 hectares, which represent a small portion compared to over approximately 7000 hectares of potential habitat in the locality. Hollow bearing trees and trees with exfoliating bark are important habitat features for the species. Minor possible surface water flow diversions could occur in some locations along the Georges River, however these are likely to be minor and isolated. Localised vegetation changes in riparian areas may occur. However, given the low occurrence likelihood and the extent of potential habitat in the Study Area and Locality it is unlikely that this would significantly impact the species. Trees hollows and trees with exfoliating bark are unlikely to be impact by subsidence. **Fragmentation** Fragmentation is unlikely due to the high mobility of the species, and the extensive habitat available in the Study Area and locality. **Importance of habitat affected** Given the species has not been recorded in the Study Area, the extent of potential habitat in the Study Area and locality, and the high mobility of the species, the Study Area is of moderate importance to the long-term survival of the Greater broad-nosed bat.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	Under the TSC Act, the Director-General maintains a Register of critical habitat. To date, no critical habitat has been declared for Greater broad-nosed bat.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or TAP	To date, there is no recovery plan or threat abatement plan for the Greater broad-nosed bat.
g) Whether the action proposed constitutes or is part of a KTP or is likely to result in the operation of, or increase the impact of, a KTP	Key Threatening Processes listed on the TSC Act relevant to the proposal include: • Alteration of habitat following subsidence due to longwall mining; • Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands. The proposal has the potential to increase the above KTPs towards the Greater broad-nosed bat in the Study Area.
Conclusion: The proposed action is unlikely to have a significant impact on the Greater broad-nosed bat	

Appendix 5. EPBC Act Assessments

Assessments of Significance were carried out for the following species:

Flora

- *Grevillea parviflora* subsp. *parviflora;*
- *Leucopogon exolasius;*
- *Melaleuca deanei;*
- *Pomaderris brunnea;* and
- *Pultenaea aristata.*

Fauna

- Amphibians: Green and Golden Bell Frog, Littlejohn's Tree Frog and Giant Burrowing Frog.
- Mammals: Spotted-tailed Quoll (southeastern mainland), and Large-eared Pied Bat.
- Reptiles: Broad-headed Snake.

Definitions

'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:

- for activities such as foraging, breeding, roosting, or dispersal
- for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators) to maintain genetic diversity and long term evolutionary development, or
- for the reintroduction of populations or recovery of the species or ecological community.

Such habitat may be, but is not limited to: habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act.

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- key source populations either for breeding or dispersal
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range.

Flora species

Grevillea parviflora* subsp. *parviflora	
Vulnerable Species	**Significant Assessment Criteria**
Background	*Grevillea parviflora* subsp. *parviflora* was recorded during the current survey above longwall 38. A large population of the species was recorded to the south of the Study Area, toward the tail end of longwall 38 within the Dharawal Conservation Area. Hundreds to thousands of individuals were recorded in this area. Potential habitat for the species includes the following vegetation communities within the Study Area: Sydney Hinterland Transition Woodland and SSTF.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	A large population of *Grevillea parviflora* subsp. *parviflora* occurs toward the tail end of longwall 38 within the Dharawal Conservation Area. Hundreds to thousands of individuals were recorded in this area. A population count has not been conducted, and as such, this assessment has used a precautionary approach to assume that the population is an 'important population' based on the following: • population may be a key source populations either for breeding or dispersal in the Study Area and locality; and • the populations may be necessary for maintaining genetic diversity in the Study Area. The population of *Grevillea parviflora* subsp. *parviflora* is unlikely to be impacted by subsidence, as the species does not occur within vegetation which is dependent on surface flows or water table levels. The woodland and forest environments that it occurs in are not surface or groundwater dependent, and therefore subsidence is unlikely to impact the species.
Reduce the area of occupancy of an important population	The project is unlikely to reduce the area of occupancy of an important population as habitat is not likely to be impacted by subsidence.
Fragment an existing important population into two or more populations	Fragmentation is unlikely as subsidence will not impact the potential habitat *Grevillea parviflora subsp. parviflora* occurs in.
Adversely affect habitat critical to the survival of a species	The project is unlikely to adversely affect habitat critical to the survival of the species as subsidence is unlikely to impact potential habitat of the threatened population.
Disrupt the breeding cycle of an important population	The following is known about the breeding cycle of *Grevillea parviflora* subsp. *parviflora*: • Biology and ecology of the species is poorly known, though it is believed that the species lives between 25–60 years (D. Keith pers.comm. cited in Benson and McDougall 2000). • Flowering occurs in April, May and between July and December. The flowers are insect pollinated. One to two seeds are released at maturity (Benson & McDougall 2000) but have limited seed dispersal, probably of less than 2 m (DSEWPaC 2013) • Plants are capable of suckering or regenerating from a rootstock (NSW DECC 2005p). Sucker stems usually occur in patches close to the parent plant (DSEWPaC 2013). • After fire or other disturbance, regeneration can occur from both the rhizomes and seed in the soil seedbank. However, after fire, adult plants are killed and seedling recruitment is uncommon (Benson & McDougall 2000). • Little is known about the production and viability of seed, seed predation or germination rates and requirements. Much of the current knowledge of *Grevillea parviflora* subsp. *parviflora* is based on general observations (DSEWPaC 2013).

Grevillea parviflora* subsp. *parviflora	
	The project is unlikely to result in any impact which will cause the lifecycle of the species to be impacted.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Based on the subsidence predictions (MSEC 2012), the proposal will not result in any impact to potential habitat for *Grevillea parviflora subsp. parviflora.*
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Subsidence will not result in the establishment of invasive species within potential habitat for *Grevillea parviflora subsp. parviflora.*
Introduce disease that may cause the species to decline, or	Subsidence is unlikely to result in the introduction of disease, including the spread of *Phytophthora cinnamomi*, which may result in species decline.
Interfere substantially with the recovery of the species.	The project will not result in the loss of an individual, habitat or impact to an important population. The proposal will not interfere substantially with the recovery of the species.
Conclusion	**The proposal is unlikely to result in a significant impact on *Grevillea parviflora* subsp. *parviflora***

Leucopogon exolasius	
Vulnerable Species	**Significant Assessment Criteria**
Background	*Leucopogon exolasius* was not recorded during the current survey or during FloraSearch (2009) in the Study Area. Potential habitat for the species includes Hinterland Sandstone Gully Forest in the Study Area. The species has been previously recorded to the east of the study within Sydney Catchment Special Areas. The species has not been recorded previously in the Study Area.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	An important population of *Leucopogon exolasius* was not recorded during the current survey or previous surveys in the Study Area. The species is relatively inconspicuous and is unlikely to remain undetected during the field survey. It is therefore unlikely that an important population exists in the Study Area.
Reduce the area of occupancy of an important population	The project is unlikely to reduce the area of occupancy of an important population as: • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal.
Fragment an existing important population into two or more populations	The proposal is unlikely to result in impacts to potential habitat for *Leucopogon exolasius,* which would cause large scale fragmentation. Furthermore, no population of *Leucopogon exolasius* was recorded in the Study Area.
Adversely affect habitat critical to the survival of a species	The project is unlikely to adversely affect habitat critical to the survival of the species as: • The species was not recorded in the Study Area; • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal.
Disrupt the breeding cycle of an important population	Leucopogon exolasius is shrub to 1 m in height, which flowers from August to October. The fruit of Leucopogon exolasius is likely to be dispersed by bird species. Pollination is most likely from bees or other small insects. The species is also likely to require fire for germination. The project is unlikely to result in any impact which will cause the lifecycle of the species to be impacted.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Based on the subsidence predictions (MSEC 2012), the proposal will not result in any significant impact to potential habitat for *Leucopogon exolasius.* Whilst it is possible that subsidence may cause some minor changes in hydrological flows and cracking, it is unlikely that the impacts would be on a scale that potential habitat would be impacted.
Result in invasive species that are harmful to a vulnerable species becoming	Subsidence will not result in the establishment of invasive species within potential habitat for *Leucopogon exolasius.*

Leucopogon exolasius	
established in the vulnerable species' habitat	
Introduce disease that may cause the species to decline, or	Subsidence is unlikely to result in the introduction of disease, including the spread of *Phytophthora cinnamomi*, which may result in species decline.
Interfere substantially with the recovery of the species.	The project is unlikely to interfere substantially with the recovery of the species as: • The species was not recorded in the Study Area; • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal. • No recovery has been made for the species.
Conclusion	**The proposal is unlikely to result in a significant impact on *Leucopogon exolasius***

Melaleuca deanei	
Vulnerable Species	**Significant Assessment Criteria**
Background	*Melaleuca deanei* was not recorded during the current survey or during FloraSearch (2009) in the Study Area. Potential habitat for the species includes Hinterland Sandstone Gully Forest in the Study Area. The species has been previously recorded in the locality along the Georges River and creeklines with the Sydney Catchment Authority Special Areas.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	An important population of *Melaleuca deanei* was not recorded during the current survey or previous surveys in the Study Area. The species is relatively inconspicuous and is unlikely to remain undetected during the field survey. It is therefore unlikely that an important population exists in the Study Area.
Reduce the area of occupancy of an important population	The project is unlikely to reduce the area of occupancy of an important population as: • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal.
Fragment an existing important population into two or more populations	The proposal is unlikely to result in impacts to potential habitat for *Melaleuca deanei* which would cause large scale fragmentation. Furthermore, no population of *Melaleuca deanei was* recorded in the Study Area.
Adversely affect habitat critical to the survival of a species	The project is unlikely to adversely affect habitat critical to the survival of the species as: • The species was not recorded in the Study Area; • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal.
Disrupt the breeding cycle of an important population	*Melaleuca deanei* species grows in heath on sandstone. Flowers appear in summer but seed production appears to be small and consequently the species exhibits a limited capacity to regenerate. The project is unlikely to result in any impact which will cause the lifecycle of the species to be impacted. Only potential habitat along creeklines may be impacted by subsidence. Woodland environments away from the watercourses are unlikely to be impacted.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Based on the subsidence predictions (MSEC 2012), the proposal will not result in any significant impact to potential habitat for *Melaleuca deanei.* Whilst it is possible that subsidence may cause some minor changes in hydrological flows and cracking, it is unlikely that the impacts would be on a scale that potential habitat would be impacted.
Result in invasive species that are	Subsidence will not result in the establishment of invasive species within potential habitat for *Melaleuca deanei.*

Melaleuca deanei	
harmful to a vulnerable species becoming established in the vulnerable species' habitat	
Introduce disease that may cause the species to decline, or	Subsidence is unlikely to result in the introduction of disease, including the spread of *Phytophthora cinnamomi*, which may result in species decline.
Interfere substantially with the recovery of the species.	The project is unlikely to interfere substantially with the recovery of the species as: • The species was not recorded in the Study Area; • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal. • A recovery plan has been made for the species. The proposal is unlikely to interfere with the plan.
Conclusion	**The proposal is unlikely to result in a significant impact on *Melaleuca deanei***

Pomaderris brunnea	
Vulnerable Species	**Significant Assessment Criteria**
Background	*Pomaderris brunnea* was not recorded during the current survey or during FloraSearch (2009) in the Study Area. Potential habitat for the species includes Hinterland Sandstone Gully Forest in the Study Area. The species has been previously recorded in the locality to the east of the Study Area. Most of the records are near Douglas Park and Menangle Park.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	An important population of *Pomaderris brunnea* was not recorded during the current survey or previous surveys in the Study Area. The species is relatively inconspicuous and is unlikely to remain undetected during the field survey. It is therefore unlikely that an important population exists in the Study Area.
Reduce the area of occupancy of an important population	The project is unlikely to reduce the area of occupancy of an important population as: • An important population was not recorded in the Study Area; • The species has not been previously recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal.
Fragment an existing important population into two or more populations	The proposal is unlikely to impact potential habitat for *Pomaderris brunnea.* Fragmentation is not predicted. Furthermore, no population of *Pomaderris brunnea was* recorded in the Study Area.
Adversely affect habitat critical to the survival of a species	The project is unlikely to adversely affect habitat critical to the survival of the species as: • The species was not recorded in the Study Area; • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal.
Disrupt the breeding cycle of an important population	The following is known about the breeding cycle of *Pomaderris brunnea*: • The species is expected to live for 10-20 years, while the minimum time to produce seed is estimated to be 4-6 years • Brown Pomaderris grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines. • Flowers appear in September and October. • The species is expected to live for 10 - 20 years, while the minimum time to produce seed is estimated to be 4 - 6 years. The project will not remove individuals of this species and it is unlikely that significant impacts, if any, would occur to potential habitat as a result of subsidence. The project is unlikely to disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or	Based on the subsidence predictions (MSEC 2012), the proposal will not result in any significant impact to potential habitat for *Pomaderris brunnea.*

Pomaderris brunnea	
decrease the availability or quality of habitat to the extent that the species is likely to decline	Whilst it is possible that subsidence may cause some minor changes in hydrological flows and cracking, it is unlikely that the impacts would be on a scale that potential habitat would be impacted.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Subsidence will not result in the establishment of invasive species within potential habitat for *Pomaderris brunnea.*
Introduce disease that may cause the species to decline, or	Subsidence is unlikely to result in the introduction of disease, including the spread of *Phytophthora cinnamomi*, which may result in species decline.
Interfere substantially with the recovery of the species.	The project is unlikely to interfere substantially with the recovery of the species as: • The species was not recorded in the Study Area; • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal. • A recovery plan exists for the species. The proposal is unlikely to interfere with the plan.
Conclusion	**The proposal is unlikely to result in a significant impact on *Pomaderris brunnea***

Pultenaea aristata	
Vulnerable Species	**Significant Assessment Criteria**
Background	*Pultenaea aristata* was not recorded during the current survey or during FloraSearch (2009) in the Study Area. Potential habitat for the species includes Hinterland Sandstone Gully Forest in the Study Area. The species has been previously recorded in the locality to the east of the Study Area with Sydney Catchment Authority Special Areas.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	An important population of *Pultenaea aristata* was not recorded during the current survey or previous surveys in the Study Area. The species is relatively inconspicuous and is unlikely to remain undetected during the field survey. It is therefore unlikely that an important population exists in the Study Area.
Reduce the area of occupancy of an important population	The project is unlikely to reduce the area of occupancy of an important population as: • An important population was not recorded in the Study Area; • The species has not been previously recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal.
Fragment an existing important population into two or more populations	The proposal is unlikely to impact potential habitat for *Pultenaea aristata.* Fragmentation is not predicted. Furthermore, no population of *Pultenaea aristida* was recorded in the Study Area.
Adversely affect habitat critical to the survival of a species	The project is unlikely to adversely affect habitat critical to the survival of the species as: • The species was not recorded in the Study Area; • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal.
Disrupt the breeding cycle of an important population	The following is known about the breeding cycle of *Pultenaea aristata*: • Pultenaea aristata is endemic to the Woronora Plateau in NSW, between Helensburgh and Mount Keira; • Grows in low nutrient sandstone soils in both moist and dry areas; • The species is often associated with the Upland Swamp vegetation complex; • Flowers appear in yellow to light orange terminal heads between September and October; • Pollinators not known. The project will not remove individuals of this species and it is unlikely that significant impacts, if any, would occur to potential habitat as a result of subsidence. The project is unlikely to disrupt the breeding cycle of an important population.

Pultenaea aristata	
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Based on the subsidence predictions (MSEC 2012), the proposal will not result in any significant impact to potential habitat for *Pultenaea aristata.* Whilst it is possible that subsidence may cause some minor changes in hydrological flows and cracking, it is unlikely that the impacts would be on a scale that potential habitat would be impacted.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Subsidence will not result in the establishment of invasive species within potential habitat for *Pultenaea aristata.*
Introduce disease that may cause the species to decline, or	Subsidence is unlikely to result in the introduction of disease, including the spread of *Phytophthora cinnamomi*, which may result in species decline.
Interfere substantially with the recovery of the species.	The project is unlikely to interfere substantially with the recovery of the species as: • The species was not recorded in the Study Area; • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Dieback of potential habitat as a result of subsidence gas emissions is not predicted. • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal. • A recovery plan exists for the species. The proposal is unlikely to interfere with the plan.
Conclusion	**The proposal is unlikely to result in a significant impact on *Pultenaea aristata***

Fauna species

Amphibians: Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog	
Vulnerable Species	**Significant Assessment Criteria**
Background	The Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog were not recorded during the current survey or during previous surveys in the Study Area. All three species have potential habitat along the Georges River and its tributaries. Mallaty Creek and Woodhouse Creek within the Study Area provide very little potential habitat due to the lack of deep pools, flowing water and aquatic habitat features. All three species have been previously recorded within the locality within Dharawal Conservation Area and Heathcote National Park.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	No important populations of the Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog are known to occur within the Study Area. The current survey, and targeted surveys conducted by Biosphere Environmental (2009) did not records any of the species. MSEC (2012) states it is unlikely that there would be any significant increases in the levels of ponding, flooding, or scouring of watercourses in the Study Area resulting from the extraction of the proposed longwalls. It is noted it is possible, that there could be some very localised small increased levels of ponding or flooding where the predicted maximum tilts coincide with existing pools, steps or cascades along the river, however, any changes are not expected to result in a significant impact .such as possible localised loss of pools. Based on these predictions, it is unlikely that potential habitat would greatly, or if at all, impacted by the proposal. Given the extensive habitat along the Georges River and its tributaries, potential localised impacts to ponding are unlikely to result in a decrease of habitat or resources. It is therefore likely the proposal would not lead to a long-term decrease in the size of an important population of Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog should they occur in the Study Area.
Reduce the area of occupancy of an important population	Subsidence impacts associated with the project may cause some localised ponding, flooding and surface water flows. However, given the extensive potential habitat within the Study Area for Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog, it is unlikely the potential habitat would be limited to an extent that it would greatly reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	Fragmentation of an existing important population into two or more population of Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog is unlikely to occur due to the following: • No known populations of the frog species occur within the Study Area. • Potential habitat for each for each frog species is extensive along the Georges River and its tributaries. • Impacts to potential habitat area as a result of subsidence are likely to be minor and isolated. • Whilst there is potential for subsidence to impact a pool containing tadpoles of the frog species, it is highly unlikely to occur given the MSEC predictions. • Not all potential habitats are likely to be impacted by the proposal.
Adversely affect habitat critical to the survival of a species	The project is unlikely to adversely affect habitat critical to the survival of the Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog as: • No known populations of the frog species occur within the Study Area. • No critical habitat occurs in the Study Area.

Amphibians: Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog	
	• Potential habitat for each for each frog species is extensive along the Georges River and its tributaries. • Impacts to potential habitat area as a result of subsidence are likely to be minor and isolated.
Disrupt the breeding cycle of an important population	The following is known about the breeding cycle of the Giant Burrowing Frog: • Breeding habitat of this species is generally soaks or pools within first or second order streams. The species are also commonly recorded from 'hanging swamp' seepage lines and where small pools form from the collected water. • Individuals spend 95% of their time outside of breeding sites, when breeding, they move into the breeding site either immediately before or following heavy rain and occupy these sites for up to 10 days. Individuals do not generally attempt to breed every year. • Breeding occurs mainly in autumn and Males show strong territoriality at breeding sites. Egg masses are foamy with an average of approximately 500-800 eggs and are laid in burrows or under vegetation in small pools. After rains, tadpoles are washed into larger pools where they complete their development in ponds or ponded areas of the creekline. Tadpole development ranges from around 12 weeks duration to up to 12 months with late developing tadpoles overwintering and completing development when warmer temperatures return. (DEC 2005) The following is known about the breeding cycle of the Green and Golden Bell Frog: • In NSW, the Green and Golden Bell Frog has been found in a wide range of water bodies except fast flowing streams (Pyke & White 1996). • Inhabits marshes, dams and stream-sides, particularly those containing bullrushes (Typha spp.) or spikerushes (Eleocharis spp.). • Optimum habitat includes water-bodies that are unshaded, free of predatory fish such as Plague Minnow (Gambusia holbrooki), have a grassy area nearby and diurnal sheltering sites available. • Some sites, particularly in the Greater Sydney region occur in highly disturbed areas. • The species is active by day and usually breeds in summer when conditions are warm and wet. • Males call while floating in water and females produce a raft of eggs that initially float before settling to the bottom, often amongst vegetation. • Tadpoles feed on algae and other plant-matter; adults eat mainly insects, but also other frogs. • Preyed upon by various wading birds and snakes. The following is known about the breeding cycle of the Littlejohn's Tree Frog: • Breeding is triggered by heavy rain and can potentially occur all year, but is usually from late summer to early spring when conditions are favourable. • Males call from low vegetation close to slow flowing pools. • Eggs are laid in loose gelatinous masses attached to small submerged twigs. • Eggs and tadpoles are mostly found in still or slow flowing pools that receive extended exposure to sunlight, but will also use temporary isolated pools. The project is unlikely to cause the lifecycle of the species to be impacted as: • Potential habitat in the Study Area is extensive; • Only minor and localised impacts to Georges River are predicted; • The proposal is unlikely to increase prey species which may impact the species lifecyle; • The proposal is unlikely to reduce the amount of prey such as insects, frogs and plant matter; • The proposal is unlikely to significantly reduce the amount of breeding pools in the Study Area.

Amphibians: Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog	
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely that the project will result in the loss of habitat to the extent that the Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog is likely to decline. Potential habitat across the Study Area is extensive. Furthermore, the species has not been recorded in the Study Area. Based on MSEC (2012), localised and isolated impacts to pools may occur, however, given the extent and quality of potential habitat in the Study Area and locality, it is unlikely the proposal will be such that a decline in the species is likely.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	It is unlikely that the project will increase Gambusia holbrooki becoming established in Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog habitat.
Introduce disease that may cause the species to decline, or	Subsidence is unlikely to result in the introduction of disease, including the spread of *amphibian chytrid fungus*, which may result in species decline.
Interfere substantially with the recovery of the species.	The project is unlikely to interfere substantially with the recovery of the Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog as: • The species were not recorded in the Study Area; • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor changes in hydrology. Such changes are unlikely to result in any significant loss of potential habitat for the species; • Habitat is extensive in the Study Area. It is highly unlikely all potential habitats would be impacted by the proposal.
Conclusion	**The proposal is unlikely to result in a significant impact on Giant Burrowing Frog, Green and Golden Bell Frog and Littlejohn's Tree Frog**

Spotted-tailed Quoll (southeastern mainland)	
Endangered species	**Significant Assessment Criteria**
Background	The Spotted-tailed Quoll was not recorded during the current survey. The species was recorded during the Biosphere (2009) survey to the south of the Study Area. The specimen was observed dead along a roadside approximately 1.5 kilometres to the south of the Study Area. The Spotted-tailed Quoll has potential habitat along the Georges River vegetation corridor in the Study Area. This area provides an abundance of habitat features such as hollow logs, hollow-bearing trees, rock crevices and dense vegetation.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	No important populations of the Spotted-tailed Quoll are known to occur within the Study Area. Targeted trapping surveys by Biosphere (2009) did not record any individuals of the Spotted-tailed Quoll. However, given the species was recorded approximately 1.5 kilometres to the south of the Study Area, it is likely the species may utilise the Study Area. MSEC (2012) states the proposal is not expected to result in any large cliff instabilities, and impacts to rock outcrops are likely to be small. Such habitat features are extensive along the Georges River and within the Study Area. The proposal will not result in impacts to other habitat features such as hollow-bearing logs and dense vegetation. Given the predicted impacts are likely to be minor, and not all potential habitat will be impacted by subsidence, it is unlikely the proposal would lead to a long-term decrease in the size of an important population of the Spotted-tailed Quoll should it occurs in the Study Area.
Reduce the area of occupancy of an important population	Subsidence impacts associated with the project may cause some isolated minor cliff falls and rock outcrop collapse. However, given the extensive potential habitat within the Study Area for Spotted-tailed Quoll, it is unlikely the potential habitat would be limited to an extent that it would greatly reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	Fragmentation of an existing important population into two or more population of Spotted-tailed Quoll is unlikely to occur due to the following: • No known populations of the species occur within the Study Area. • Potential habitat for each for the species is extensive along the Georges River and within the Crown land and Dharawal Conservation area to the east. . • Impacts to potential habitat area as a result of subsidence are likely to be minor and isolated. • Whilst there is potential for a rock fall to cause death or injury to the species, this is highly unlikely to occur. • Not all potential habitats are likely to be impacted by the proposal.
Adversely affect habitat critical to the survival of a species	The project is unlikely to adversely affect habitat critical to the survival of the Spotted-tailed Quoll as: • No Critical Habitat for the species occurs within the Study Area. • No known populations of the species occur within the Study Area. • Potential habitat for each for the species is extensive along the Georges River and within the Crown land and Dharawal Conservation area to the east. . • Impacts to potential habitat area as a result of subsidence are likely to be minor and isolated. • Whilst there is potential for a rock fall to cause death or injury to the species, this is highly unlikely to occur. • Not all potential habitats are likely to be impacted by the proposal.

Spotted-tailed Quoll (southeastern mainland)	
Disrupt the breeding cycle of an important population	The following is known about the breeding cycle of the Spotted-tailed Quoll: • Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. • Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites. • Mostly nocturnal, although will hunt during the day; spends most of the time on the ground, although also an excellent climber and may raid possum and glider dens and prey on roosting birds. • Use 'latrine sites', often on flat rocks among boulder fields and rocky cliff-faces; these may be visited by a number of individuals; latrine sites can be recognised by the accumulation of the sometimes characteristic 'twisty-shaped' faeces deposited by animals. • Consumes a variety of prey, including gliders, possums, small wallabies, rats, birds, bandicoots, rabbits and insects; also eats carrion and takes domestic fowl. • Females occupy home ranges up to about 750 hectares and males up to 3500 hectares; usually traverse their ranges along densely vegetated creeklines. • Average litter size is five; both sexes mature at about one year of age. The project is unlikely to cause the lifecycle of the species to be impacted as: • Potential habitat in the Study Area is extensive; • Only minor and localised impacts to Georges River are predicted; • The proposal is unlikely to increase prey species which may impact the species lifecyle; • The proposal is unlikely to reduce the amount of prey such as rats, wallabies, birds etc. • The proposal will not impact upon hollow bearing trees, logs, woodland and dense vegetation.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely that the project will result in the loss of habitat to the extent that the Spotted-tailed Quoll is likely to decline. Potential habitat across the Study Area is extensive. Approximately 377.91 hectares of potential habitat occurs within the Study Area. Most of the potential habitat occurs along the Georges River gorge and will not be impacted by the proposal. Furthermore, an important population of the species has not been recorded in the Study Area. Based on MSEC (2012), minor, localised and isolated impacts to rock outcrops and cliffs may occur, however, given the extent and quality of potential habitat in the Study Area and locality, it is unlikely the proposal will be such that a decline in the species is likely.
Result in invasive species that are harmful to a vulnerable species becoming established in the endangered species' habitat	It is unlikely that the project will increase any invasive species becoming established in Spotted-tailed Quoll habitat.
Introduce disease that may cause the species to decline, or	Subsidence is unlikely to result in the introduction of disease which may result in species decline.

Spotted-tailed Quoll (southeastern mainland)	
Interfere substantially with the recovery of the species.	The project is unlikely to interfere substantially with the recovery of the Spotted-tailed Quoll as: • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor impacts to potential habitat; • Not all potential habitat such as woodland, logs, hollow-bearing trees and dense vegetation will be impacted by the proposal; • Habitat is extensive in the Study Area. It is highly unlikely all potential habitat would be impacted by the proposal.
Conclusion	**The proposal is unlikely to result in a significant impact on the Spotted-tail Quoll**

Broad-headed Snake	
Vulnerable species	**Significant Assessment Criteria**
Background	The Broad-headed Snake was not recorded during the current survey. The Broad-headed Snake was not recorded during previous surveys by Biosphere Environment (2009). There are numerous records for the species within the Locality. Most of the records occur within Heathcote National Park and Dharawal Conservation Area. The species has potential habitat along the ridgelines of the Georges River in the Study Area. The species utilises exposed sandstone outcrops, rock crevices and exfoliating sheets of weathered sandstone and tree hollows.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	No important populations of the Broad-headed Snake are known to occur within the Study Area. The species was not recorded during the current survey, and during previous surveys in the Study Area. MSEC (2012) states the proposal is not expected to result in any large cliff instabilities, and impacts to rock outcrops are likely to be small. Such habitat features are extensive along the Georges River and within the Study Area. The proposal will not result in impacts the broad-headed snake may utilise such as such as hollow-bearing trees. Given the predicted impacts are likely to be minor, and not all potential habitat will be impacted by subsidence, it is unlikely the proposal would lead to a long-term decrease in the size of an important population of the Broad-headed should it occurs in the Study Area.
Reduce the area of occupancy of an important population	Subsidence impacts associated with the project may cause some isolated minor cliff falls and rock outcrop collapse. However, given the extensive potential habitat within the Study Area for Broad-headed Snake, it is unlikely the potential habitat would be limited to an extent that it would greatly reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	Fragmentation of an existing important population into two or more population of Broad-headed Snake is unlikely to occur due to the following: • No known populations of the species occur within the Study Area. • Potential habitat for each for the species is extensive along the Georges River and within the Crown land and Dharawal Conservation area to the east. . • Impacts to potential habitat area as a result of subsidence are likely to be minor and isolated. • Not all potential habitat is likely to be impacted by the proposal.
Adversely affect habitat critical to the survival of a species	The project is unlikely to adversely affect habitat critical to the survival of the Broad-headed Snake as: • No Critical Habitat for the species occurs within the Study Area. • No known populations of the species occur within the Study Area. • Potential habitat for each for the species is extensive along the Georges River and within the Crown land and Dharawal Conservation area to the east. . • Impacts to potential habitat area as a result of subsidence are likely to be minor and isolated. • Not all potential habitat is likely to be impacted by the proposal.

Broad-headed Snake	
Disrupt the breeding cycle of an important population	The following is known about the breeding cycle of the Broad-headed Snake (DEC 2005) (SEWPaC 2013): • The Broad-headed Snake has a preferred habitat centred on the communities occurring on the Triassic sandstone of the Sydney Basin. • The sites where they occur are typified by exposed sandstone outcrops and benching and in these locations the vegetation is mainly woodland, open woodland and/or heath. • The Broad-headed Snake seasonally occupies distinctive microhabitats within these broader habitat types. They utilise rock crevices and exfoliating sheets of weathered sandstone during the cooler months and tree hollows during summer. • The Broad-headed Snake is nocturnal to crepuscular (active at dusk) and is an 'ambush predator', preying predominantly on lizards, particularly Lesueurs Velvet Geckos, at least during the cooler months. • During this time the species can be found frequenting exposed sandstone ridgetops where it refuges under exfoliating sheets of sandstone resting on naked rock or within crevices. These refuges often have a predominantly west to north westerly aspect. This aspect effect is thought to provide thermoregulatory advantage and maximises temperature levels for the peak feeding periods of early evening. • During the warmer months of the year they become arboreal frequenting tree hollows and undergo a presumed dietary shift to small mammals, although crepuscular arboreal skinks (Eulamprus tenuis) have also been reported in the diet of summer captured individuals (G. Turner 1998 unpublished). • They give birth to live young (ovoviviparous) The project is unlikely to disrupt the breeding cycle of an important population due to the following: • Subsidence impacts to rock outcrops are likely to be minimal and isolated (MSEC 2012). Only small scale impacts to surface rock and potential habitat are predicted. • The species has not been previously recorded in the Study Area. • The species was not recorded during current surveys. • No important population has been recorded in the Study Area. • Not all potential habitat is likely to be impacted by the project. • Hollow bearing trees will not be impacted by subsidence. • Food source is unlikely to be impacted by the project.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely that the project will result in the loss of habitat to the extent that the Broad-headed Snake is likely to decline. Most of the potential habitat occurs along the Georges River gorge. Based on MSEC (2012), minor, localised and isolated impacts to rock outcrops and cliffs may occur, however, given the extent and quality of potential habitat in the Study Area and locality, it is unlikely the proposal will be such that a decline in the species is likely. Hollow-bearing trees and logs will not be impacted by the proposal. Furthermore, an important population of the species has not been recorded in the Study Area.
Result in invasive species that are harmful to a vulnerable species becoming established in the endangered species' habitat	It is unlikely that the project will increase any invasive species becoming established in Broad-headed Snake habitat.

Broad-headed Snake	
Introduce disease that may cause the species to decline, or	Subsidence is unlikely to result in the introduction of disease which may result in species decline.
Interfere substantially with the recovery of the species.	The project is unlikely to interfere substantially with the recovery of the Broad-headed Snake as: • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor impacts to potential habitat; • Not all potential habitat such as logs, hollow-bearing trees will be impacted by the proposal; • Prey species will not be impacted by the proposal; • Habitat is extensive in the Study Area. It is highly unlikely all potential habitat would be impacted by the proposal.
Conclusion	**The proposal is unlikely to result in a significant impact on the Broad-headed Snake**

Large-eared Pied Bat	
Vulnerable species	**Significant Assessment Criteria**
Background	The Large-eared Pied Bat was not recorded during the current survey and previous surveys in the Study Area. The species has been recorded in the locality. The species has potential breeding habitat along the Georges River and foraging habitat throughout the Study Area.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	No important populations of the Large-eared Pied Bat are known to occur within the Study Area. The species was not recorded during the current or previous survey however has potential habitat in the Study Area. . The species is unlikely to be impacted by the proposal as: • No important population occurs within the Study Area; • Impacts to riparian vegetation as a result of the proposal are unlikely, and if do occur, would be minor and insignificant. • Subsidence impacts to rock outcrops are likely to be minimal and isolated (MSEC 2012). Only small scale impacts to surface rock and potential habitat are predicted. • Potential habitat in the Study Area is extensive and not all are susceptible to subsidence.
Reduce the area of occupancy of an important population	Subsidence impacts associated with the project are unlikely to result in a reduction of area of occupancy as: • No important population occurs within the Study Area; • Subsidence impacts to rock outcrops are likely to be minimal and isolated (MSEC 2012). Only small scale impacts to surface rock and potential habitat are predicted. • Habitat is extensive within the Study Area. Not all habitat will be impacted by subsidence.
Fragment an existing important population into two or more populations	Fragmentation of an existing important population into two or more population of Large-eared Pied Bat is unlikely to occur due to the following: • No known populations of the species occur within the Study Area. • Potential habitat for each for the species is extensive along the Georges River and within the Crown land and Dharawal Conservation area to the east. . • Impacts to potential habitat area as a result of subsidence are likely to be minor and isolated. • Not all potential habitat is likely to be impacted by the proposal.
Adversely affect habitat critical to the survival of a species	The project is unlikely to adversely affect habitat critical to the survival of the Grey-headed Flying-fox as: • No Critical Habitat for the species occurs within the Study Area. • No known populations of the species occur within the Study Area. • Potential habitat for each for the species is extensive along the Georges River and within the Crown land and Dharawal Conservation area to the east. . • Impacts to potential habitat area as a result of subsidence are likely to be minor and isolated. • Not all potential habitat is likely to be impacted by the proposal.

Large-eared Pied Bat	
Disrupt the breeding cycle of an important population	The following is known about the breeding cycle of the Large-eared Pied Bat: • Roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (Petrochelidon ariel), frequenting low to mid-elevation dry open forest and woodland close to these features. Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves and overhangs. They remain loyal to the same cave over many years. • Found in well-timbered areas containing gullies. • The relatively short, broad wing combined with the low weight per unit area of wing indicates manoeuvrable flight. This species probably forages for small, flying insects below the forest canopy. • Likely to hibernate through the coolest months. • It is uncertain whether mating occurs early in winter or in spring The project is unlikely to disrupt the breeding cycle of an important population due to the following: • The species has not been previously recorded in the Study Area. • The species was not recorded during current surveys. • No important population has been recorded in the Study Area. • Not all potential habitat is likely to be impacted by the project. • Hollow bearing trees will not be impacted by subsidence. • Food source is unlikely to be impacted by the project.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely that the project will result in the loss of habitat to the extent that the Large-eared Pied Bat is likely to decline. Most of the breeding potential habitat occurs along the Georges River gorge. Foraging habitat is extensive throughout the Study Area. Based on MSEC (2012), minor, localised and isolated impacts to rock outcrops and cliffs may occur, however, given the extent and quality of potential habitat in the Study Area and locality, it is unlikely the proposal will be such that a decline in the species is likely. Hollow-bearing trees and logs will not be impacted by the proposal. Impacts to riparian vegetation are unlikely, and if were to occur, would be minor and isolated. Furthermore, an important population of the species has not been recorded in the Study Area.
Result in invasive species that are harmful to a vulnerable species becoming established in the endangered species' habitat	It is unlikely that the project will increase any invasive species becoming established in Large-eared Pied Bat habitat.
Introduce disease that may cause the species to decline, or	Subsidence is unlikely to result in the introduction of disease which may result in species decline.

Large-eared Pied Bat	
Interfere substantially with the recovery of the species.	The project is unlikely to interfere substantially with the recovery of the Large-eared Pied Bat as: • An important population was not recorded in the Study Area; • Subsidence associated with the proposal may cause only minor impacts to potential habitat; • Not all potential habitat such as logs, hollow-bearing trees will be impacted by the proposal; • Prey species will not be impacted by the proposal; • Habitat is extensive in the Study Area. It is highly unlikely all potential habitat would be impacted by the proposal.
Conclusion	**The proposal is unlikely to result in a significant impact on the Large-eared Pied Bat**

Attachment B – West Cliff Longwalls 37 and 38 Aquatic Ecology Impact Assessment (Cardno Ecology Lab, 2013)

Cardno Ecology Lab

Shaping the Future

Marine and Freshwater Studies

West Cliff Longwalls 37- 38

Aquatic Flora and Fauna Assessment

Job Number: EL1112050

Prepared for BHP Billiton – Illawarra Coal

January 2013

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Cover Image: The upper Georges River May 2012. Photographer Dan Pygas , Cardno Ecology Lab

Document Control

Report Number	Status	Date	Author		Reviewer	
EL1112050 A	Final	23 January 2012	Dan Pygas Dr Theresa Dye	DP TD	Dr Arthur Dye	TD

Summary

BHP Billiton Illawarra Coal is seeking approval to extract Longwalls 37 and 38, located to the north and east respectively of their current longwall mining operations in West Cliff Area 5. This Aquatic Flora and Fauna Assessment (AFFA) has been prepared to support the Biodiversity Management Plan (BMP) component of the West Cliff Area 5 Longwalls 37 and 38, Extraction Plan. The AFFA focuses on the aquatic habitats, flora and fauna that occur in the watercourses that flow through the area and could potentially be affected by the mining of Longwalls 37 and 38. The most significant watercourse is the approximately 3.8 km upper reach of the perennial Georges River which is situated to the east of Longwalls 29-37 and west of Longwall 38. The Study Area is also traversed by three ephemeral creeks (Mallaty, Nepean and Woodhouse) and 15 minor tributaries of the Georges River.

The AFFA includes:

- A synthesis 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 mitigation and monitoring of potential impacts on aquatic ecology and contingent measures.

The upstream section of the river is characterised by long shallow pools connected by sections of shallow flow over bedrock. Further downstream, the river consists of deeper pools with connecting flow through boulder fields. The substratum consists of large areas of sandstone bedrock, accumulations of sand and silt within pools, as well as sections of boulder and cobble and some riffle sections. There are also several dense beds of aquatic macrophytes and accumulations of woody debris within the river. The flow is derived from catchment areas and the licenced discharges from Appin and West Cliff Collieries. The quality of the water depends on the relative contribution of rainfall inputs from the catchment, rural and urban runoff and licenced discharges.

The river provides permanent habitat for aquatic macrophytes, aquatic macroinvertebrates and fish. At least 20 species of aquatic macrophytes have been recorded in the upper Georges River, with Cumbungi (*Typha* sp.) Spike Rush (*Juncus* sp.) and Clubrush (*Isolepsis* sp.) being the most common in the Study Area. Over 100 aquatic macroinvertebrate taxa have been recorded since 2002. Four native (Long-finned eel, Cox's Gudgeon, Fire-tailed Gudgeon and Lake's Carp gudgeon), and one introduced species of fish (Eastern Gambusia) have been caught in the section of the river that flows through West Cliff Area 5. A platypus was recently observed in the river within the West Cliff Area 5 Study Area (just downstream of aquatic ecology monitoring Site 8 and adjacent to proposed Longwall 38) during the terrestrial fauna assessment for the Bulli Seam Operations Environmental Assessment.

Geographic distribution records indicate two threatened invertebrates, Adams Emerald Dragonfly (*Archaeophya adamsi)* and Sydney Hawk Dragonfly (*Austrocordulia leonardi*) and one threatened fish species, Macquarie Perch (*Macquaria australasica*), could potentially occur in the Study Area. The presence of numerous barriers to fish passage in the upper Georges River, however, suggests that Macquarie Perch are unlikely to be able to access potential habitat within the Study Area. The aquatic habitat within the Study Area is not suitable for Adams Emerald Dragonfly, so it is unlikely to be present. There are a few deep pools within the Study Area that could potentially be used by Sydney Hawk Dragonfly, but these are not shady or likely to contain the cool water that this species prefers.

The assessment of aquatic ecology consequences of the predicted subsidence during extraction of Longwalls 37 and 38 based on the Extraction Plan layout is similar to or less than that expected on the basis of the Part 3A Application layout. Any changes in ponding and flooding and stream alignment would have negligible effects on aquatic habitats or biota

in the Georges River. The effects on aquatic ecology of fracturing of the river bed and induction or enhancement of ferruginous springs would be localised, minor in extent and transient in nature and therefore likely negligible in a local and/or regional context. In the ephemeral creeks, the diversion of water into sub-surface layers during low flow periods is unlikely to have detectable effects on the availability of aquatic habitats or aquatic biota, because of the large variability in natural flows and infilling of fractures with alluvial deposits over time. The changes in ponding and flooding that may occur would have negligible impact on the availability and quality of aquatic habitats and associated biota.

Four approaches would be used to manage potential impacts on aquatic ecology within the 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; and
- Contingent measures should impacts exceed predictions.

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1 Introduction

1.1 Project Background

The West Cliff Colliery, situated east southeast of the town of Appin in the Wollondilly and Campbelltown Local Government Areas, is part of BHP Billiton – Illawarra Coal (BHPBIC) Bulli Seam operations in the Southern Coalfield of NSW. BHPBIC is currently extracting coal from the West Cliff Area 5 domain, which comprises Longwalls 29–38. Government approval for the mining of Longwalls 29-30 and parts of 31-33 was granted in December 2003. Approval for mining of the remainder of Longwalls 31-33 and Longwalls 34-36 was granted in September 2006 and December 2009, respectively.

On 22 December 2011, the Planning and Assessment Commission (PAC), under delegation of the NSW Minister of Planning, approved the continuation of the BSO Project under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act). One of the conditions of the Project Approval is that an approved Extraction Plan, indicating how potential subsidence effects, impacts and environmental consequences associated with the extraction of coal will be managed, is in place prior to the commencement of mining. BHPBIC is currently preparing an Extraction Plan for Longwalls 37 and 38 and has commissioned various specialist consultants to undertake supporting assessments. Cardno Ecology Lab (formerly The Ecology Lab Pty Ltd) was commissioned by BHPBIC to prepare the Aquatic Flora and Fauna Assessment (AFFA) for this plan.

The Study Area for the AFFA is defined as the surface area that is likely to be affected by the proposed mining of West Cliff Longwalls 37 and 38. The Study Area encompasses the area bounded by the following limits:

- A 35 degree angle of draw line from the proposed extents of Longwalls 37 and 38; and
- The predicted limit of vertical subsidence, taken as the predicted 20 mm subsidence contour resulting from the extraction of the proposed Longwalls 37 and 38; and
- Watercourses (including the Georges River), outside these areas, but within the predicted limits of 20 mm total upsidence and 20 mm total closure that are expected to experience either far-field movements or valley related movements.

The major watercourse of relevance to the proposed longwalls is the reach of the Georges River, a perennial river system, situated to the east of proposed Longwall 37 and west of Longwall 38. The watercourses that traverse Longwalls 37 (i.e. headwaters of Mallaty and Nepean Creeks and an unnamed tributary of the Georges River) and 38 (i.e. four unnamed tributaries of the Georges River) are ephemeral systems that contain minimal or no aquatic habitat. The proposed longwalls will not undermine the Georges River.

1.2 Scope of Works

The scope of works for the AFFA includes:

- Reporting on the results of surveys of aquatic flora and fauna undertaken in the Study Area utilising recognised survey techniques, in accordance with the requirements of the EP&A Act and relevant guidelines;
- Assessment of the diversity and relative abundance of native and introduced aquatic flora and fauna;
- Identification and description of the range of habitats utilised by aquatic flora and fauna;

- Conducting targeted surveys for threatened species of aquatic flora and fauna, listed in the Schedules of the NSW Threatened Species Conservation Act, 1995 (*TSC Act)*, Fisheries Management Act 1994 (*FM Act*) and Commonwealth Environment Protection and Biodiversity Conservation Act, 1999 (*EPBC Act)*, that occur or could potentially occur within the study area or surrounds;
- Preparation of maps showing the location of any threatened species identified;
- Assessment of the potential impacts of the proposed mining on aquatic habitats and biota, including threatened species; and
- Addressing other aquatic flora and fauna issues required to gain Extraction Plan Approval and the relevant requirements of the BSO Project Approval.

1.3 Statutory Requirements

The statutory obligations with regards to West Cliff Area 5 include:

- The relevant conditions of Project Approval for the BSO Project; and
- Legislation containing 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 (Table 1);
- 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 workings on aquatic flora and fauna, with a specific focus on threatened species, populations and their habitats, endangered ecological communities and water dependent ecosystems.

Note that 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 West Cliff Area 5 Study Area.

Natural Feature	Performance Measure
Georges River	Negligible environmental consequences over at least 80% of the stream length subject to vertical subsidence >20 mm (that is negligible diversion of flows, change in the natural drainage behaviour of pools, gas releases, iron staining, and increases in water cloudiness). No subsidence impact or environmental consequence greater than minor.
Other watercourses	No greater subsidence impact or environmental consequences than predicted in the *Bulli Seam Operations Environmental Assessment, Volumes 1-5* (EA) and Preferred Project Report titled *Bulli Seam Operations Project (MP 08_0150)* (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:

- The Georges River Pre-Mining Ecology Study (MPR 1999);
- Effects of Mine Subsidence on Aquatic Habitats in Upper Georges River (The Ecology Lab 2002a);
- Remediation of Georges River at Marhnyes Hole - Aquatic Ecology (The Ecology Lab 2002b);
- West Cliff Workings - Effects of Mine Subsidence on Aquatic Habitat and Biota in Waterways near Appin (The Ecology Lab (2003);
- Ecological effects of mine water discharge from West Cliff Colliery into Brennans Creek. Interim Report: Module 2 AUSRIVAS Analysis (The Ecology Lab (2004a);
- Effects of Remediation of Georges River at Marhnyes Hole on Aquatic Ecology (The Ecology Lab (2004b);
- West Cliff Area 5 Effects of Mine Subsidence on Aquatic Habitat and Biota (The Ecology Lab 2005);
- Ecological Effects of Mine Water Discharge from West Cliff Colliery into Brennans Creek (The Ecology Lab 2006c);
- West Cliff Colliery Longwall 31a End of Panel Report Aquatic Habitat and Biota (The Ecology Lab (2007);
- West Cliff Colliery Area 5 Longwalls 34-36 Assessment of Mine Subsidence Impacts on Aquatic Habitat and Biota (The Ecology Lab (2008a);
- West Cliff Colliery Longwall 32 End of Panel Report Aquatic Habitat and Biota (The Ecology Lab (2008b);
- Aquatic Ecology Assessment undertaken at location GR1 situated immediately upstream of the Appin East pit top discharge point into the Georges River and GR2 situated adjacent to the eastern end of proposed Longwall 37, for the BSO EA (Bioanalysis 2009);
- West Cliff Colliery Longwall 33 End of Panel Report. Aquatic Habitat and Biota (Cardno Ecology Lab 2010);
- West Cliff Longwalls 31-36, Aquatic Ecology Monitoring Autumn 2010 (Cardno Ecology Lab 2010);
- Review of Aquatic Fauna and Flora for West Cliff Longwall 34 (Cardno Ecology Lab 2011);
- West Cliff Longwalls 31-36 Aquatic Ecology Monitoring Spring 2011 (Cardno Ecology Lab (2012).

Additional information on the aquatic habitats, flora and fauna at sites in the Georges River adjacent to the Study Area were collected in May 2012. The methods utilised in these field-based investigations are provided in **Appendix 1** and the GPS coordinates of the sampling sites are presented in **Appendix 2**.

Information from studies undertaken in other parts of the upper Georges River is presented, where appropriate.

2.1 Physical Setting

The Georges River is a perennial watercourse that originates over 8 km to the south of the Study Area and flows past Sydney's south western suburbs and into Botany Bay (MSEC 2012). The section of the Georges River skirting around the eastern end of Longwall 37 and the western margin of Longwall 38 within the Study Area is moderately incised with Hawkesbury Sandstone outcropping to the east and Wianamatta Shale to the west (Ecoengineers 2012). The bedrock of the river is Hawkesbury Sandstone. The total length of the stretch of the Georges River within the Study Area extending to the predicted limits of 20 mm total upsidence and 20 mm total closure is approximately 3.8 km (MSEC 2012). The land surrounding this reach is largely undisturbed native bushland with some rural areas.

The land to the east of Longwall 37 generally drains into the Georges River while that in the centre and west ultimately drains into the Nepean River via Nepean, Mallaty and Woodhouse Creeks (Ecoengineers 2012). Nepean Creek is located to the west of Longwall 37, Woodhouse Creek to the north, and Mallaty Creek directly above Longwall 37. The land associated with Longwall 38 drains west to the Georges River via several minor tributaries.

Mallaty Creek is a relatively small (approximately 2 km long), ephemeral, 3rd order watercourse that flows through pasture, chicken farms and some semi-urban development to the west of Appin Road with a narrow riparian strip. It flows into Ousedale Creek and ultimately the Nepean River between Douglas Park and Menangle weirs. Mallaty Creek is located directly above Longwalls 34 to 37.

2.2 Aquatic Habitat

2.2.1 The Georges River

The section of the Georges River within the Study Area comprises a series of pools and rock bars. Upstream sections are characterised by long shallow pools connected by sections of shallow flow over bedrock. Further downstream, the river consists of deeper pools with connecting flow through boulder fields. The pools vary in length from 5 m to 337 m (MSEC 2012) and are generally connected, but can become disconnected during extended dry weather with some drying up completely or partially (MSEC 2012). The rock bars along this section of the river vary in length from 5 m to 80 m and are generally low with many being exposed during moderate flows. Licensed discharges from Appin and West Cliff Collieries are the main source of flow in this section of river, with recent flows averaging 0.3 ML/day and 4 ML/day respectively (MSEC 2012). The river also receives occasional inflows from Brennans Creek Dam when this overtops during large rainfall events.

The substratum comprises large areas of sandstone bedrock, accumulations of sand and silt within pools, as well as sections of boulder and cobble and some riffle sections. There are also several dense beds of aquatic macrophytes and accumulations of woody debris within the river (Cardno Ecology Lab 2012). The aquatic habitat occurring at sites GR1 and GR2, upstream of the Study Area is comparable to that within the Study Area (Bioanalysis 2009).

2.2.2 Other Watercourses

The other watercourses are ephemeral and provide only limited aquatic habitat. The upper reaches of Mallaty Creek are subject to modified flow due to farm dams and mine-subsidence impacts (Bioanalysis 2009). In May 2010, following an extended dry period, no water was observed at the aquatic ecology monitoring site (Site 12) on this creek (Cardno Ecology Lab 2010). In November 2011, the aquatic habitat at this site consisted of two small pools with no observable flow, despite recent rainfall (Cardno Ecology Lab 2012). These observations reflect the ephemeral nature of this watercourse (Cardno Ecology Lab 2012).

The catchments of Woodhouse Creek and Nepean Creek have been developed as cattle pasture, so most of the native vegetation has been cleared and only thin bands of riparian vegetation remain.

2.3 Water Quality

The flows within the river are derived from catchment areas and licensed discharges of mine water from Appin and West Cliff Collieries. The quality of the water in the reach of the upper Georges River adjacent to the Study Area therefore depends on the relative contributions from rainfall, rural and urban runoff and licensed discharges, in addition to any potential effects associated with mine-induced subsidence. During dry periods, the controlled discharge from Brennans Creek Dam is the major source of flow in the river.

The average baseline water quality data for sites on the Georges River upstream, downstream and within the Study Area collected between August 2004 and February 2010 is presented in Ecoengineers (2012). The mean electrical conductivity (EC) and pH levels for each site were above the ANZECC/ARMCANZ (2000) upper default trigger value (DTV) for upland rivers in south-eastern Australia, and mean dissolved oxygen (DO) levels were slightly below the lower DTV at the majority of sites. Ecoengineers (2012) noted that there was very little difference in the baseline water quality data immediately upstream, adjacent to, and downstream of the Study Area. The elevated EC and pH levels are due to the discharge of mine-water and other anthropogenic effects (The Ecology Lab 2008c).

The *in situ* water quality has also been measured during the aquatic ecology monitoring undertaken in relation to mining of West Cliff Area 5 (The Ecology Lab 2003; 2005; 2008a; 2008c; Cardno Ecology Lab 2010; 2012). These data indicate that EC and pH in the Georges River often exceed the upper DTV and that DO and turbidity levels did so on occasion. In May 2012, the EC and pH levels were found to be above the upper DTV at all the sites sampled, but DO and turbidity levels were only outside the guidelines at two of the six sites sampled (**Appendix 3**).

The quality of water at GR1 and GR2 was measured in autumn 2008 and spring 2008, respectively (Bioanalysis 2009). At GR1, EC and pH were within the guidelines at both sites, however, DO and turbidity levels were below the lower DTV and above the upper DTV respectively at one site. At GR2, the pH and turbidity measurements at both sites were within the guidelines, but the EC and DO levels were above the upper DTV and below the lower DTV, respectively.

In Mallaty Creek, EC levels in excess of the upper DTV and DO levels below the lower DTV have been recorded (Cardno Ecology Lab 2012). In May 2012, turbidity was also well above the upper DTV, reflecting the poor quality of the surrounding riparian vegetation. No water was observed in this creek in May 2010 (Cardno Ecology Lab 2010b).

2.4 Riparian Vegetation

Relatively undisturbed riparian strips help to stabilise river banks, which in turn helps to prevent significant erosion and sediment mobilisation. Riparian vegetation is also a source of instream woody debris, which provides important habitat for many species of aquatic fauna, including fish.

Bioanalysis (2009) noted that the banks at GR1 were generally well vegetated by trees, including *Eucalypt* spp. and *Acacia* spp. and that emergent macrophytes such as Tall spikerush (*Eleocharis sphacelata*) and *Typha orientalis* were also present in autumn 2008. In spring 2008, *Fimbristylis* sp., perennial grass *Lepidosperma filiforme*, Black Bog Rush (*Schoenus melanostachys*), Water Gum (*Tristaniopsis laurina*) and *Isolepis inundata* were observed at GR2.

In November 2011, the riparian vegetation on each bank of the Georges River was found to be in good condition, with gaps occurring mostly at road crossings (Cardno Ecology Lab 2012). Mature trees were common and native plants such as Mat Rush (*Lomandra* sp.) and Sawgrass (*Gahnia* sp.) plus a few introduced taxa were also present.

2.5 Aquatic Macrophytes

Aquatic macrophytes fulfil many important ecological roles, including the provision of refuge and nursery habitat for aquatic fauna, serve as a source of food and are important in nutrient cycling. At least 20 species have been recorded in the reach of the Georges River within and upstream of the Study Area (See **Appendix 4** for details) (The Ecology Lab 2003, 2005, 2008a and c; Cardno Ecology Lab 2010 and 2012; Bioanalysis 2009). It should be noted that only instream aquatic macrophytes were recorded by The Ecology Lab and Cardno Ecology Lab, but Bioanalysis (2009) listed species observed instream and within the riparian zone.

The Ecology Lab (2002a; 2005d; 2008d) noted that Cumbungi (*Typha* spp.) was the dominant instream macrophyte in the reach of the Georges River between its confluence with Brennans Creek and Marhynes Hole, but *Potamogeton tricarinatus* (synonym *sulcatus*), *Juncus usitatus*, *Isolepis prolifera* and various emergent grasses were also present. Cardno Ecology Lab (2012) found that Cumbungi (*Typha* sp.) spike rush (*Juncus* sp.) and clubrush (I*solepsis* sp.) were relatively abundant in the section of the Georges River within and adjacent to the Study Area.

Bioanalysis (2009) found that the emergent macrophytes, Tall Spikerush (*Eleocharis sphacelata*) and Cumbungi (*Typha orientalis*), and submerged macrophyte *Potamogeton sulcatus*, were relatively abundant at GR1 in spring 2008 and that a large stand of *Typha domingensis* was present at GR2 in autumn 2008.

2.6 Aquatic Macroinvertebrates

Several different sampling methods have been used, including the two-minute kick technique used to sample aquatic macroinvertebrates associated with edge and riffle habitats in the upper Georges River (Jarvis 1997); dip net sweeps of riffle and pool edges (MPR 1999), the AUSRIVAS dip-netting protocol (The Ecology Lab 2008 a and c; Bioanalysis 2009; Cardno Ecology Lab 2010 and 2012); quantitative sampling of submerged rocks (The Ecology Lab 2004b) and quantitative timed sweeps of a dip net across all available habitats (Bioanalysis 2009; Cardno Ecology Lab, this study). The results obtained using the different sampling methods are outlined below.

2.6.1 Timed Kick Technique

This technique was used to sample the aquatic macroinvertebrates associated with edge and riffle habitats at nine sites in the upper river on five occasions between 1995 and 1996 (Jarvis 1997). A total of 122 taxa from 79 macroinvertebrate families were identified, with the majority being insects. Dytiscid beetles, a pollution tolerant taxon, dominated the fauna at six of the study sites and accounted for 40% of the animals sampled. Jarvis (1997) found that macroinvertebrate diversity and abundance increased downstream to Marhynes Hole but decreased below this location. The structure of assemblages at upstream sites differed from that found downstream, but it was not clear whether this was due to a change in altitude or water quality.

2.6.2 Random Dip Net Sweeping

MPR (1999) used random dip net sweeps of riffle and pool edges to sample the aquatic macroinvertebrates occurring at 10 sites up and downstream of Marhnyes Hole in the

Georges River. Sampling was done on a single occasion. Coleopteran beetles were the most common taxa recorded.

2.6.3 AUSRIVAS Sampling

The macroinvertebrate taxa that have been recorded in the AUSRIVAS sampling undertaken in the Georges River adjacent to and upstream of The Study Area are listed in **Appendix 5**. A total of 117 taxa have been recorded since 2002.

Considerably fewer taxa have been recorded per site with between nine and 30 taxa being recorded per site near Marhnyes Hole (upstream of the Study Area) between October 2002 and May 2004 (The Ecology Lab 2002b; 2004a) and between nine and 31 taxa being sampled at the West Cliff Area 5 aquatic ecology monitoring sites between May 2002 and November 2011 (The Ecology Lab 2004b; 2005; 2008a; 2008c; Cardno Ecology Lab 2010; 2012) (**Appendix 6**). In May 2008, the samples collected at sites GR1-1 and GR1-2 (upstream of the Study Area) yielded five and nine taxa, respectively whereas those collected at sites GR2-1 and GR2-2 (within the Study Area) in December 2008 contained 12 and 21 taxa, respectively (Bioanalysis 2009).

Differences in the overall health of the macroinvertebrate fauna (as indicated by AUSRIVAS bands) at the sites along the Georges River have also been noted (**Appendix 6**). **I**n May 2007, the fauna at most sites was significantly impaired relative to AUSRIVAS reference conditions (B and B), but that at two sites was equivalent to reference condition (Band A) (The Ecology Lab 2008a). The OE50 taxa scores for this survey indicate between 0 and 33% of the expected families with a 50% probability of occurrence were absent. In September 2008, the fauna at eight study sites was significantly impaired, but that at the other four sites was equivalent to reference condition (The Ecology Lab 2008c). The OE50 taxa scores for this survey indicate between 7 and 37% of the expected families with a 50% probability of occurrence were absent. In May 2010, the fauna at eight study sites was significantly impaired, that at two sites was equivalent to reference condition, but that at the remaining sites was severely impaired (Band C) (Cardno Ecology Lab 2010). During this survey, between 22% and 65% of the expected taxa were missing. In November 2011, the fauna at two sites was severely impaired (lacking over 56% of the expected taxa) and significantly impaired at the remaining five sites (lacking between 11% and 47% of the expected taxa) sampled (Cardno Ecology Lab 2012). The fauna at GR1-1 and GR1-2, was found to be severely impaired in autumn 2008, as was that at GR2-1 in spring 2008 (Bioanalysis 2009). The fauna at GR2-2, however, was significantly impaired.

Appendix 6 also shows the condition of the fauna at some sites was consistent over time (e.g. Sites 1-4), but that at other sites declined over time (e.g. Sites 6, 7 and 8). The SIGNAL2 scores suggest that the state of the assemblages at all sites has varied over time, with each being subject to either severe (scores < 4) or moderate pollution (scores > 4).

2.6.3.1 Mallaty Creek

Site 12 on Mallaty Creek, one of the West Cliff Area 5 aquatic ecology monitoring sites, has been surveyed on four occasions, but on one of these (May 2010) no water was found (The Ecology Lab 2008a and c; Cardno Ecology Lab 2010 and 2012) (**Appendix 6**). The samples collected during the other three surveys contained between 17 and 25 taxa and were rated as equivalent to the AUSRIVAS reference condition in May 2007 and September 2008, but as significantly impaired in November 2011. The SIGNAL2 Scores, however, were indicative of severe pollution in May 2007 and November 2011 but moderate pollution in September 2008.

2.6.4 Quantitative Sampling

The Ecology Lab (2004b) collected replicate quantitative samples of macroinvertebrates from approximately equally sized submerged rocks at six sites in the Georges River near

Marhnyes Hole between October 2002 and May 2004 (**Appendix 7**). A total of 52 taxa were collected, with Chironomidae, followed by Caenidae and Hydrophilidae being the most abundant.

Bioanalysis (2009) collected replicate macroinvertebrate samples over a set time period from a variety of habitats utilised by macroinvertebrates, including pool edge, macrophytes, riffles, pools and beneath rocks (See **Appendix 1** for further details of the sampling method). A total of 19 taxa were recorded from GR1 in May 2008, and 23 from GR2 in December 2008 (**Appendix 8**). Leptoceridae and Leptophlebiidae were the most abundant taxa found at GR1, while Caenidae and Chironomidae were most abundant at GR2.

In May 2012, the same methodology was used by Cardno Ecology Lab to collect quantitative macroinvertebrate data from six sites within/adjacent to the Study Area. Between 28 and 33 taxa were sampled from each site, with a total of 59 taxa sampled across all the sites (**Appendix 9**). Caenidae, Baetidae and Chironomidae were the most abundant taxa. Both the abundance and diversity of the samples collected from each site were much greater than that reported by Bioanalysis (2009).

2.7 Fish

The Australian Museum records indicate eight species of fish were found in the upper Georges River between 1899 and 1980 and that three of these (Golden Perch, Silver Perch and Trout Cod) were caught in the vicinity of Appin, but not in the Georges River or its tributaries.

In 2000, DPI Fisheries conducted a boat-based and backpack-based electrofishing survey at four locations on the Georges River (downstream of Liverpool Weir, Cambridge Avenue, Simmo's Beach and Freres Crossing), that are upstream of tidal influences, but downstream of West Cliff Area 5. A total of 13 species were caught, but numbers per site varied from three to eight, with the urban site downstream of Liverpool Weir and non-urban site at Simmo's Beach yielding the smallest and largest number of species, respectively (Williams *et al.* 2004). Two introduced species, Eastern Gambusia (*Gambusia holbrooki*) and Goldfish (*Carassius auratus*) were caught.

It is important to note that the construction of Liverpool Weir in 1836 created a significant barrier to upstream migration and is likely to have resulted in species that migrate between freshwater and the sea to breed becoming locally extinct upstream (Gehrke *et al*. 2002). In 1997, a vertical-slot fishway was installed at the weir to assist fish in their movement past the barrier. Despite this, several species that migrate between freshwater and the sea to complete their life cycle were not recorded, suggesting that rebuilding of upstream populations was limited. The presence of a further 77 barriers to fish passage on the Georges River upstream of Liverpool, including road culverts, weirs, piped sections and levees (Nichols and McGirr 2005), suggests that the fish fauna in the Study Area will be much less diverse.

The fish populations occurring in the stretch of the river in the vicinity of Marhynes Hole, upstream of the Study Area, have been surveyed by MPR (2001) and The Ecology Lab (2002a and 2004a). MPR (2001) found Eastern Gambusia upstream and downstream of Marhynes Hole and two native species, Firetailed Gudgeon (*Hypseleotris galii*) and Dwarf Flathead Gudgeon (*Philypnodon* sp.) below Marhynes Hole. The Ecology Lab (2002a and 2004a) recorded Long-finned Eels (*Anguilla reinhardtii*), Short-finned Eels (*Anguilla australis*), Striped Gudgeon (*Gobiomorphus australis*), Midgley's carp Gudgeon and an unidentified gudgeon species in the vicinity of Marhynes Hole.

A number of backpack electrofishing surveys have been undertaken in the stretch of the river adjacent to West Cliff Area 5 between March 2002 and November 2011. Long-finned Eel, Eastern Gambusia and Fire-tailed Gudgeon, were recorded during the May 2002, March 2005 and September 2008 surveys (The Ecology Lab 2003, 2005 and 2008c), but only

Eastern Gambusia and Fire-tailed Gudgeon were caught in May 2010 (Cardno Ecology Lab 2010). During the November 2011 survey, Long-finned Eel, Eastern Gambusia and Fire-tailed Gudgeon were again found plus two additional species, Coxs's gudgeon (*Gobiomorphus coxii*) and Lake's carp gudgeon (*Hypseleotris* sp. 5) (Cardno Ecology Lab 2012). Freshwater crayfish (Family Parastacidae) and freshwater shrimp (Family Atyidae) were also observed in the Georges River (Cardno Ecology Lab 2012). Short-finned Eel, Eastern Gambusia and Fire-tailed Gudgeon were the only fish species caught during the backpack electrofishing and bait trap surveys conducted in spring and autumn 2008 as part of the Aquatic Ecology Assessment for the Bulli Seam Operations (Bioanalysis 2009).

Flathead gudgeon is the only species that has been recorded in Mallaty Creek (The Ecology Lab 2003).

2.8 Threatened Species

A search of relevant databases indicates that the following threatened aquatic species or their habitats could potentially occur in the Study Area:

- Adams Emerald Dragonfly (*Archaeophya adamsi*)
- Sydney Hawk Dragonfly (*Austrocordulia leonardi*)
- Macquarie Perch (*Macquaria australasica*).

All three species are listed as Endangered under the *Fisheries Management Act 1994*. The Macquarie Perch is also listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999.*

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 DPI, 2007). The species is known from the Hawkesbury-Nepean, Georges River and Port Hacking drainages, but has not been recorded within the Study Area. The larvae have specific habitat requirements and have only been found under rocks in deep, shady river pools with cool water (NSW DPI, 2007). The upstream reach of the Georges River adjacent to the proposed longwalls is characterised by long shallow pools connected by sections of shallow flow over bedrock so does not contain suitable habitat for this species. Further downstream, there are deeper pools with connecting flow through boulder fields, but these are in wider sections of the river where there is more sunlight and either a bedrock or sandy/silty substratum. Given the above, it is possible but unlikely that there is a viable local population of Sydney Hawk Dragonfly within the Study Area.

Adam's Emerald Dragonfly is also extremely rare, having been collected in small numbers at only a few locations in the greater Sydney region: Somersby Falls and Floods Creek in Brisbane Waters National Park near Gosford; Berowra Creek near Berowra and Hornsby; Bedford Creek in the Lower Blue Mountains; and Hungry Way Creek in Wollemi National Park (Fisheries Scientific Committee 2008). There are no records of Adams Emerald Dragonfly from the southern Sydney region or other parts of the Hawkesbury-Nepean catchment, despite extensive surveys in the Georges and Nepean River catchments. The larvae of Adam's Emerald Dragonfly have been found in narrow, shaded riffle zones with moss and abundant riparian vegetation in small creeks with gravel or sandy bottoms (NSW DPI 2012). The section of the Georges River within the vicinity of West Cliff Area 5 does not contain appropriate riffle habitat for this species, so it too is unlikely to be present.

The records from the Australian Museum indicate a specimen of Macquarie Perch was caught in the Georges River catchment, near Campbelltown in 1894 (DPI, 2008). This species has recently been recorded by DPI-Fisheries in the Georges River, near its confluence with Punchbowl Creek, approximately 15 km downstream of the extent of longwall mining (Scott Carter, pers. comm.). There are, however, no records of this species occurring in the upper Georges River in the vicinity of West Cliff Area 5, despite the

extensive fish surveys undertaken by MPR (2001), The Ecology Lab (2003, 2005, 2008c) and Cardno Ecology Lab (2010 and 2012). Intensive sampling in two tributaries of the Georges River (O'Hares Creek and Stokes Creek) that contain the rocky pool habitat used by this species has also failed to detect any Macquarie Perch (Knight and Bruce, 2008). The presence of numerous barriers to fish passage in the upper Georges River suggests that Macquarie Perch are unlikely to be present in the reach of the Georges River adjacent to West Cliff Area 5.

2.9 Protected Species

There have been a few recent sightings and reports of platypuses (*Ornithorhynchus anatinus*) occurring in the upper Georges River and its tributary streams (Grant 2002; Grant *et al.* 2008). There is also a record of a platypus from the section of the Georges River that flows through the West Cliff Area 5 domain just downstream of aquatic ecology Site 8 and adjacent to proposed Longwall 38 (Biosphere Environmental Consultants 2009). A platypus was also observed at the Appin East pit top discharge point to Georges River by Illawarra Coal Holdings Pty Ltd (ICHPL) employees (Biosphere Environmental Consultants 2009).

2.10 Conclusion

Substantial information is available on aquatic habitats, water quality, aquatic macroinvertebrate and fish fauna in the upper reaches of the Georges River adjacent to West Cliff Area 5. Most of this information comes from studies undertaken after the commencement of mining upstream of the Study Area, hence there is the possibility that the baseline information available for comparison has been influenced by this previous mining.

3 Assessment of Potential Impacts

The extraction of coal from Longwalls 37 and 38 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 joints 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 37 and 38 is based on the maximum predicted subsidence parameters for the section of the Georges River and its various unnamed tributaries and three named creeks (Mallaty, Nepean and Woodhouse) that flow through the Study Area (MSEC 2012) and their predicted impacts on the physico-chemical characteristics of the waterways (MSEC 2012, Ecoengineers 2012). 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.

3.1 Maximum Predicted Ground Movements in Watercourses

Table 2 compares the maximum predicted ground movements in the Georges River and its various tributaries, Mallaty Creek, Nepean Creek and Woodhouse Creek based on the layout in the Extraction Plan (MSEC 2012) 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 smaller maximum predicted subsidence, greater maximum upsidence and no change in closure along the Georges River than the Part 3A Application Layout.

Table 2: The maximum predicted ground movements in the Georges River and its unnamed tributaries, Mallaty Creek, Nepean Creek and Woodhouse Creek based on the layout of longwalls presented in the Extraction Plan (MSEC 2012) 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
Georges River	Maximum subsidence of 90 mm and 100mm after extraction of Longwalls 37 and 38, respectively.	Maximum subsidence - 150 mm.
	Maximum upsidence of 180 mm and 190mm after extraction of Longwalls 37 and 38, respectively.	Maximum upsidence - 130 mm.
	Maximum total closure of 210 mm and 220 mm after extraction of Longwalls 37 and 38, respectively.	Maximum closure - 220 mm.
	Maximum conventional tilt along the alignment of the river of 0.6 mm/m and 0.9 mm/m after extraction of Longwalls 37 and 38, respectively.	
	Maximum conventional tilts across the alignment resulting from the extraction of the proposed longwalls is 1.4 mm/m.	
Georges River tributaries GR103-108, GR110 and GR114	Maximum subsidence after extraction of longwall 37 of < 20 mm for GR103, GR107, GR108, GR110, 50 mm for GR114, 790 mm for GR104 and 1120 mm for GR105. Maximum subsidence after extraction of longwall 38 of 90 mm for GR103, 550 mm for GR107, 640 mm for GR 108, 660 mm for GR110 and GR114, 820 mm for GR104 and 1120 mm for GR105.	
	Maximum upsidence after extraction of longwall 37 of 20 mm for GR108, 30 mm for GR110, 40 mm for GR103, 60 mm for GR107, 90 mm for GR114, 190 mm for GR104 and 240 mm for GR105. Maximum upsidence after extraction of longwall 38 of 70 mm for GR103, 100 mm for GR107, 110 mm for GR114, 140 mm for GR108 and GR110, 190 mm for GR104 and 240 mm for GR105. Maximum closure after extraction of longwall 37 of 40 mm for GR108, 50	

	mm for GR110, 60 mm for GR103, 70 mm for GR114, 90 mm for GR107, 200 mm for GR104 and 230 mm for GR105. Maximum conventional tilt along the alignment of the tributaries of 1.2 - 6.0 mm/m after extraction of Longwall 38, with the latter being equivalent to a change in grade of 1:170.	
Mallaty Creek	Maximum subsidence of 1125 mm after extraction of each longwall.	Maximum subsidence - 1200 mm
	Maximum upsidence of 675 mm after extraction of each longwall.	Maximum upsidence - 700 mm
	Maximum closure of 725 mm after extraction of each longwall.	Maximum closure - 650 mm
	Maximum conventional tilt along the alignment of the creek of 4.9 mm/m after extraction of Longwall 38 which is equivalent to a change in grade of 1:200.	
Nepean Creek	Maximum subsidence of 875 mm and 900 mm after extraction of Longwalls 37 and 38, respectively.	Not provided in MSEC (2009)
	Maximum upsidence of 150 mm after extraction of each longwall.	
	Maximum closure of 75 mm after extraction of each longwall.	
	Maximum conventional tilt along the alignment of the creek of 3.4 mm/m after extraction of Longwall 38 which is equivalent to a change in grade of 1:300.	

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

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

These predictions indicate there would be no significant impacts on the physico-chemical features of the Georges River. Increased levels of ponding and flooding and fracturing of the river bed may occur, but these impacts are expected to be short-lived, minor and localised in their extent. From these predictions it can be concluded that extraction of Longwalls 37 and 38 will result in negligible diversion of flows, negligible changes in the natural drainage behaviour of pools, negligible iron staining and negligible increase in water cloudiness in the Georges River and that impacts on the physico-chemical attributes of the drainage lines will be no greater than predicted in the Environmental Assessment and Preferred Project Report and not be significant. The predictions outlined in **Table 3** are thus consistent with the Subsidence Impact Performance Measures for the Georges River and other watercourses specified in the Project Approval for the Bulli Seam Operations Project.

3.3 Consequences for Aquatic Ecology

Table 4 compares the results of the original assessment of the consequences of the extraction of longwalls in West Cliff Area 5 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 (2012) in support of the Extraction Plan layout. The predicted changes in ponding and flooding and stream alignment would have negligible effects on aquatic habitats or biota in the Georges River. The effects on aquatic ecology of fracturing of the river bed plus any induction or enhancement of ferruginous springs would be localised, minor in extent and transient in nature and therefore negligible. In the drainage lines, the diversion of water into sub-surface layers during low flow periods is unlikely to have detectable effects on the availability of aquatic habitats or aquatic biota, because of the large variability in natural flows and infilling of fractures with alluvial deposits over time. The changes in ponding and flooding that may occur in these ephemeral watercourses would be minor and localised and would thus have a negligible 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 37 and 38 based on the Extraction Plan layout is thus similar to or less than that based on the Part 3A Application Layout.

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

Watercourse	Attribute	Predicted Impacts
Georges River	Surface water level	No measurable impacts related to net vertical movements are expected. Any vertical movements resulting from extraction of the longwalls would be small relative to the natural drop in water level along the river.
	Ponding, flooding and scouring of stream banks	Significant increases are unlikely, because the change in maximum predicted tilts along the river are small relative to the average natural gradient. Increased levels of ponding or flooding may occur in areas where the predicted maximum tilts coincide with existing pools, steps or cascades. These increases are expected to be small and localised and will therefore not have a significant impact. The impacts on scouring are expected to be minimal due to the sandstone river bed.
	Change in stream alignment	Unlikely to be any significant change, because of the very small size of the predicted changes in the cross-bed gradients relative to the natural gradients. Impacts on stream alignment would also be minor compared to changes in the river depth and width that occur during high flows.
	Bed rock and surface flows	There is unlikely to be significant rock fracturing and surface flow diversions, because the longwalls would be at least 50 m away from most rockbars and riffles and maximum closures of 200 mm are predicted. Minor, isolated fracturing of the river bed may occur within 400 metres of the proposed longwalls, but this would not cause significant diversion of surface flows. Natural flow diversions have been observed along sections of the Georges River which have not been affected by mining. It is therefore possible, however unlikely, that the extraction of the proposed longwalls could slightly increase the current rate of surface water flow diversions in the river (MSEC 2012).
	Ground water inflows	Induction of ferruginous springs is unlikely, but if it does occur it could lead to a reduction in dissolved oxygen levels at their emergence point if their flow rate exceeds 0.1 ML/day while at a time when flows in the river are <0.3 ML/day (i.e. <15% probability). The reduction in dissolved oxygen levels is unlikely to have a significant impact unless the flow rate of the springs exceeds 0.1 ML/day when flows in the river are less than 0.3 ML/day.

	Water quality	Effects on water quality would depend on the relative volume of sub surface flow diversions and surface flows. In general, sub-bed diversions would maintain and may slightly increase ecotoxic concentrations of Zinc. There will be no significant effect on the natural pH (between 8.0 and 9.5) of the Georges River due to the extraction of the proposed Longwalls. Emerging water is unlikely to exceed national guidelines for dissolved oxygen where less than one third of flow is diverted. Only where one third or more of the flow is diverted would dissolved oxygen exceed guidelines. If all flow was diverted the emerging water would have reduced levels of dissolved oxygen.
Drainage lines	Ponding, flooding and scouring of stream banks	Significant increases are unlikely, but there could be minor localised increases in ponding and flooding at some points along the drainage lines.
	Creek beds and bedrock	Fracturing, bulking and dilation may occur in the uppermost bedrock. This is unlikely to be seen in creeks with alluvial beds as the fractures will be infilled by deposits during flow events. In areas of the drainage lines with exposed bedrock, some surface water flows may be diverted into underlying strata and drainage of pools may occur during low flow periods. Water will re-emerge downstream, so net loss of water from the catchment is unlikely.
	Ground water inflows	Extraction of Longwall 37 could potentially lead to development of new ferruginous springs or enhancement of existing ones.
	Water quality	Significant impacts resulting from the formation of springs are unlikely.

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	Georges River – Isolated instances of fracturing of bed rock and iron staining, transient increases in water quality parameters, such as iron, transient gas emissions in some pools.	Impacts to aquatic habitat, if any, due to potential minor, isolated fracturing of the river bed or slight increases in the rate of natural surface water flow diversions are expected to be negligible Gas emissions could occur and if they do, they could result in a temporary and localised reduction in dissolved oxygen levels, such effects are expected to result in a negligible impact to aquatic habitat Minor localised iron staining is not expected to result in changes in water quality and should not therefore affect the quality of aquatic habitat. Small, localised increases in the level of ponding or flooding may lead to minor, small increases in the longitudinal connectivity of aquatic habitats.
	Drainage lines - reduced water levels in pools and persistence of inter-pool flow, isolated iron staining, increases in water quality parameters, such as iron, and transient emissions of gas	Minor, localised increases in the level of ponding or flooding may occur. These could result in minor, localised increases in the longitudinal connectivity of aquatic habitats. Fracturing in areas where bedrock is exposed may lead to diversion of surface flows and drainage of pools may occur during low flow periods. This would result in localised, temporary reductions in small areas of pool habitat. Owing to the ephemeral nature of these drainage lines, and the relatively poor quality of ephemeral habitat, such effects would be negligible in a local and regional context. Localised development or enhancement of iron staining is not expected to result in changes in water quality, so there should be no effects on the quality of aquatic habitat.

		Gas emissions could occur and if they do, there could be a reduction in dissolved oxygen levels and decline in the quality of aquatic habitat, when water is present in these streams. These effects are expected to be negligible.
Aquatic macrophytes	Georges River - As significant fracturing leading to localised surface flow loss is unlikely to occur, mining is unlikely to have a significant impact on the composition or distribution of macrophytes	As impacts on aquatic habitats would be negligible, the effects on composition and distribution of macrophytes would be negligible also
	Drainage lines – As significant fracturing and surface flow diversions are unlikely and aquatic macrophytes are not abundant in these ephemeral, degraded streams, mining would not have a significant impact on the composition or distribution of macrophytes	Impacts on the aquatic flora that may inhabit these ephemeral watercourses are unlikely to be detectable, because of the large variability in natural flows and low abundance of the plants.
Riparian vegetation	Unlikely that stream water level changes or strata gas emissions resulting from mine subsidence would have an adverse effect on the ecological role of riparian vegetation.	Localised, minor fracturing of bedrock could have a minor, localised impact on riparian vegetation. Gas emissions could occur, however no associated impacts to riparian vegetation are expected.
Aquatic macroinvertebrates	Georges River – Reduction in DO levels associated with gas emissions and iron staining that coincided with low flow conditions could have a measurable impact on macroinvertebrates. As impacts on water quality are expected to be minor, short-lived and localised, it is unlikely that there would be significant effects on macroinvertebrates.	As per the Part 3A layout. Minor changes in the distribution of 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 this reach of the river.
	Drainage Lines - 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 would perish as a result of desiccation and/or predation. Drainage of pools after river bed or rock bar fracturing may prevent downstream drift of	Impacts on the aquatic macroinvertebrates that may periodically inhabit these ephemeral watercourses resulting from diversion of flows are unlikely to be detectable, because of the large variability in natural flows and degraded nature of the streams.

	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 would be difficult to detect, because of the degraded nature of these streams.	
Fish	Georges River - As impacts on water quality are expected to be minor, temporary and localised and fish are highly mobile, it is unlikely that fish populations would be significantly adversely affected by the small areas of habitat potentially impacted by mining.	As per the Part 3A layout.
	Drainage lines – Potential habitat for fish and fish assemblages may be impacted if fracturing and loss of water occurs. Freshwater eels may be able to relocate to nearby pools, but most species would perish as a result of desiccation and/or predation. Drainage of pools may also result in a temporary barrier to fish passage. Despite the above, it is unlikely that localised loss of fish would have a significant impact on the size of fish populations.	As per the Part 3A layout
Threatened Species	Macquarie Perch have recently been recorded in the Georges River, approximately 15 km downstream of West Cliff Area 5. As loss of habitat due to fracturing of rock bars and drainage of pools is not expected to occur and changes in water quality are expected to be localised, transient and unlikely to have adverse effects, mining would not have a significant effect on Macquarie Perch populations	As per the Part 3A layout.

4 Management of Potential Impacts on Aquatic Ecology

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

- 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 37 and 38 on aquatic habitats and biota in the Georges River would be minimised by:

- Adopting a mine layout that does not involve undermining of the river and setting Longwalls 37 and 38 at least 20 m and 45 m back respectively from the centreline of the Georges 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; and
- Identifying physical and chemical impacts that occur during the extraction of Longwalls 37 and 38 and timely implementation of appropriate remediation works.

The proposed mine layout is unlikely to result in significant fracturing or surface flow diversions (MSEC 2012). Minor fracturing could occur in the bed of the Georges River as a result of the extraction of the proposed longwalls, however, any fracturing that does occur in the river bed is expected to be isolated and minor and would not result in more than minor water flow diversions. Thus, any impacts to aquatic ecology are expected to be negligible.

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 detect and document changes in the aquatic habitats and biota that may arise during or following the extraction of Longwalls 37 and 38 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 section of the Georges River that flows through the Study Area, a baseline 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

Monitoring would be undertaken at:

- Sites 9, 10 and 11 on the Georges River situated upstream, adjacent and downstream of the south-eastern end of Longwall 37, respectively; and
- Sites 6 and 8 on the Georges River situated upstream and adjacent to Longwall 38, respectively.

Monitoring has already been undertaken at the above sites, with Site 6 having been monitored on six occasions since May 2002, Sites 8 and 9 on four occasions since May 2007 and Sites 10 and 11 on two occasions, in May 2010 and November 2011 (Cardno Ecology Lab 2012). These sites were also visited in November 2012 (Cardno Ecology Lab in Preparation). Baseline data are consequently available for all the sites except Site 13. No further monitoring is recommended at Site 13. Site 13 is downstream of Site 11 which in turn is downstream of Longwalls 37 and 38. Any potential impacts would be expected to diminish moving downstream, and, as such, Site 11 would be expected to be at a greater risk of any impact compared with Site 13. There is however, a lack of consistency in the timing of the monitoring events, with some having been conducted in autumn and others in spring. This reduces the power of the analysis and interpretation of trends in aquatic macroinvertebrates. In view of this, it is recommend that future monitoring focus on the spring period and that another baseline survey is undertaken at the above sites in spring 2013. Further monitoring would be conducted once during the mining of each longwall and on two occasions after the completion of mining.

No monitoring is proposed for the drainage lines due to their ephemeral nature and limited value as aquatic habitat.

4.2.3 Indicators

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

- *In situ* water quality;
- Aquatic macroinvertebrates; and
- Fish.

The condition of the aquatic habitat at each site would also be assessed.

4.2.4 Monitoring Methodology

The methods outlined below would be used to monitor the above indicators. Note that the same methodology has been used to assess the effects of mining Longwalls 29-36 (The Ecology Lab 2008c; Cardno Ecology Lab 2010b and 2012).

4.2.4.1 Habitat Assessment

At each study site, a qualitative assessment of the condition of aquatic habitat would be undertaken, based on the following attributes:

- Instream features such as sequence of pools, runs and riffles (shallow areas with broken water);
- Stream substratum;
- Potential refuge areas during periods of low flow (e.g. large deep pools);
- Presence of fish habitat including snags, bank undercuts and aquatic plants; and
- Presence of any barriers to fish passage.

A photographic record of each site would be captured using a digital camera.

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- Presence of fish habitat including snags, bank undercuts and aquatic plants; and
- Presence of any barriers to fish passage.

A photographic record of each site would be captured using a digital camera.

4.2.4.2 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 calibrated multi-sensor probe. 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 at each site.

The EC, DO, pH and turbidity measures would be compared with the ANZECC (2000) default trigger values. Specific guidelines are not available for temperature and ORP measures.

4.2.4.3 Aquatic Macroinvertebrates

At each site, aquatic macroinvertebrates associated with the pool edge habitat would be sampled by using dip nets (250 µm mesh) to agitate and scoop up material from vegetated areas of the river bank. Riffle habitat would not be sampled because this habitat is not present throughout this stretch of the river. Samples would be collected over a period of 3-5 minutes from a 10 m length of habitat along the river, in accordance with the Australian Rivers Assessment (AUSRIVAS) methodology (Turak *et al.* 2004). If the required habitat was discontinuous, patches of habitats with a total length of 10 m would be sampled. Each AUSRIVAS 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.

Environmental variables, such as alkalinity, modal river width and depth, percentage boulder or cobble cover, latitude and longitude, which are required for running the AUSRIVAS predictive models for edge habitat, would be recorded in the field. Distance from source, altitude, and land-slope would be determined from appropriate topographic maps. Mean annual rainfall would be determined from the regional precipitation maps presented in the AUSRIVAS Sampling and Processing Manual (Turak *et al.* 2004).

In accordance with the AUSRIVAS protocol, the samples would be sorted under a binocular microscope (at 40 X magnification), macroinvertebrates would be identified to family level and up to ten animals of any one taxon counted (Turak *et al.* 2004). 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 either the spring or autumn AUSRIVAS predictive models for the edge habitat, depending on the timing of the survey (Ransom *et al.* 2003). 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

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 at each monitoring site. 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.

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 a negligible, minor or greater than minor 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

Should the impacts of the extraction of Longwalls 37 and 38 on aquatic habitats and biota in the Georges River be greater than predicted, the following contingent measures are recommended:

- Reviewing the mine layout and the appropriate offset distances from the Georges 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 Georges River.

If these management strategies prove ineffectual, appropriate offset and compensatory measures are recommended.

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

Monitoring		Management		
Sites (Fig 1)	**Parameters**	**Trigger (at impact sites only)**	**Action**	Responsibility
• Sites 9, 10 and 11 on the Georges River situated upstream, adjacent and downstream of the south-eastern end of Longwall 37 • Sites 3 and 8 on the Georges River situated upstream and adjacent to Longwall 38, respectively.	• Habitat Surveys • Photographic records • Macroinvertebrate Monitoring • Fish Sampling • *In Situ* Water Quality Measurements • Monitored in conjunction with: – Flow – River Morphology	***Normal*** • No sign or negligible reduction in aquatic habitat observed during BHPB IC Georges River monitoring. • These may be revised in consultation with key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Continue with monitoring program • Report in End of Panel Report • Capture photographic record, if visible. • Report annually with Annual Environmental Management Reporting (AEMR).	Manager Approvals (BHPB IC)
		Within Prediction • Minor reduction in aquatic habitat as compared to baseline assessment or control site • Threatened species detected in the area and mining impacts occur 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.	• Continue with monitoring program • Report in End of Panel Report • Capture photographic record, if visible. • Report annually with Annual Environmental Management Reporting (AEMR).	Manager Approvals (BHPB IC)

		Exceeding Prediction • Greater than minor reduction in aquatic habitat as compared to baseline assessment or control site or complete loss of habitat. • Identified mortality of threatened species in proximity to identified mining impact • Reduction in macroinvertebrate AUSRIVAS Band Score (>2 Band Score difference as compared with baseline assessment or control site) in the vicinity of an identified mining and water quality impact	• Capture photographic record. • Notify relevant stakeholders , including 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. • 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. • 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.	Manager Approvals (BHPB IC) Expert Aquatic Ecology Consultants

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6 Figures

Figure 1: Location of aquatic ecology sampling sites on Georges River and Mallaty Creek.

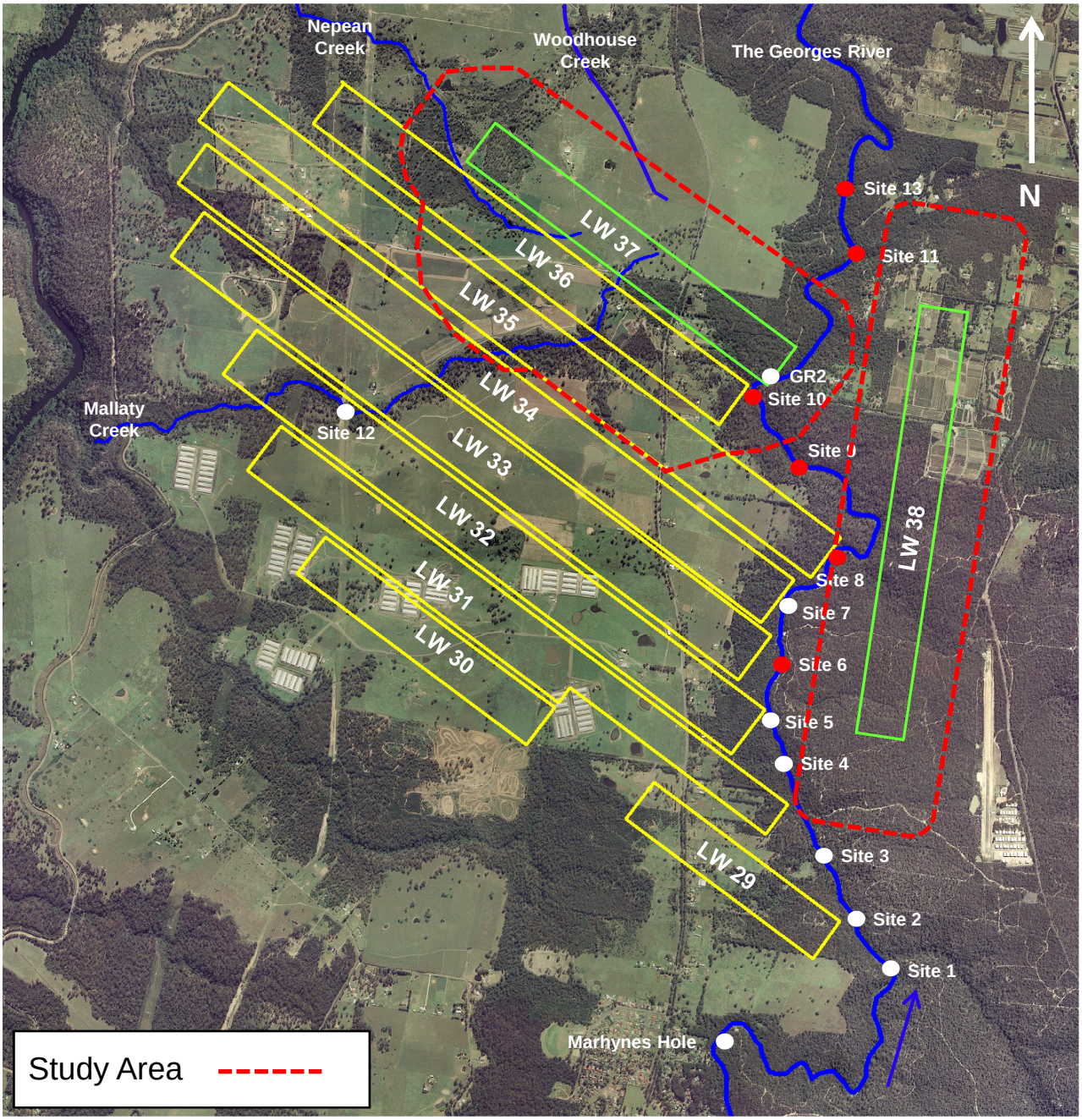

Figure 1. Location of aquatic ecology sampling sites on Georges River and Mallaty Creek. Red dots indicate sites visited in May 2012. GR1 is located upstream of Marhynes Hole.

7 Plate

Plate 1: a) Site 13 looking downstream and b) upstream May 2012. c) Long finned eel (*Anguiilla reinhardtii*) sampled in the Georges River May 2012. d) Fyke net deployed in the Georges River May 2012

(a)

(b)

(c)

(d)

Plate 1: a) Site 13 looking downstream and b) upstream May 2012. c) Long finned eel (*Anguiilla reinhardtii*) sampled in the Georges River May 2012. d) Fyke net deployed in the Georges River May 2012.

8 Appendices

Appendix 1: May 2012 Study Methods.
Appendix 2: GPS coordinates of aquatic ecology sampling sites on the Georges River visited in May 2012.
Appendix 3: Mean (±S.E.) water quality measurements recorded at aquatic ecology sampling sites on the Georges River visited in May 2012.
Appendix 4: Aquatic macrophyte taxa recorded in the Georges River.
Appendix 5: Aquatic macroinvertebrate taxa recorded in AUSRIVAS sampling in the Georges River.
Appendix 6: Total number of aquatic macroinvertebrates, OE50 taxa scores and AUSRIVAS bands for sites on the Georges River visited by Cardno Ecology Lab and Bioanalysis.
Appendix 7: Macroinvertebrates found on rocks collected from pools at six sites near Marhynes Hole in the Georges River in (a) October 2002, (b) January 2003; (c) January 2004 and (d) May 2004.
Appendix 8: Aquatic macroinvertebrate taxa and their relative abundance recorded in the Georges River by Bioanalysis (2009) using quantitative sampling methods.
Appendix 9: Macroinvertebrate taxa collected by Cardno Ecology Lab from sites on the Georges within, or adjacent to, the Study Area using quantitative sampling methods.
Appendix 10: Fish species recorded in the Georges River.
Appendix 11: Total number of fish caught in the Georges River using electrofishing, fyke netting and bait trapping techniques at sites adjacent to Longwalls 37 and 38 in May 2012.

8.1 Appendix 1 – May 2012 Study Methods

The autumn 2012 sampling included the collection of data on in-situ water quality, aquatic habitat, macroinvertebrates, fish and macrophytes. Details of the methods used to collect data on each of these key aquatic indicators are described in the sections below.

8.1.1 Sampling Sites

The autumn 2012 survey involved the collection of samples at sites 6, 8, 9, 10, 11 and 13 on the Georges River (**Figure 1**). These sites are located upstream (Sites 6, 8, 9 and 10) and downstream (Sites 11 and 13) of the proposed south eastern end of Longwall 37. The proposed Longwall 38 runs parallel to the Georges River on its eastern bank, and all sites sampled with the exception of Site 13 (which is northwest and downstream) are located directly to the west of this proposed longwall. GPS coordinates for each of the sites sampled in Autumn 2012 are presented in **Appendix 2**.

8.1.2 Sampling Techniques

8.1.2.1 *In-situ* water quality

At each site, two replicate measurements of water quality were collected using a fully calibrated Yeokal 611 multi-sensor water quality probe. Replicate measurements were taken in an attempt to capture potential variability in the physico-chemistry of the water within each site visited, i.e. in different habitats and depths. The following measurements were collected at each site:

- Electrical conductivity (µs/cm);
- Salinity (ppt);
- Temperature (°C);
- Turbidity (ntu);
- Dissolved oxygen (mg/L and % saturation);
- pH; and
- Oxidation reduction potential (mV).

Water quality measurements would be compared with the ANZECC/ARMCANZ (2000) default trigger values for slightly disturbed upland rivers of south eastern Australia, these being the most relevant to the study sites.

8.1.2.2 Aquatic Habitat

The position of each study site was recorded using a hand-held GPS unit and digital photographs showing upstream and downstream views of the site were taken. Standardised descriptions of adjacent land and condition of riverbanks, channel and bed were recorded using a modified version of the Riparian, Channel and Environmental Inventory (RCE) modified for Australian conditions by Chessman *et al.* (1997).

General observations of water and in-stream aquatic habitat characteristics, such as flow rates, clarity and odour, identity and condition of riparian vegetation, substratum characteristics and presence of impediments to fish passage was then described. Morphological features, such as the width-depth ratio, bank stability and composition, silt cover, gravel bars, pools, riffles, runs and snags were also noted. The potential for sites to provide fish habitat was then assessed according to criteria developed by NSW DPI (Fairfull and Witheridge 2003).

8.1.2.3 In-stream Aquatic Macrophyte Assessment

In-stream aquatic macrophytes (both submerged and emergent) were identified to species at each site. A visual estimation of the total cover of each-species was then made for the wetter area within the 100m reach of each site. Dominant vegetation species present in the

riparian zone were also described and an estimation of cover provided. The shading and general structure of the riparian vegetation was also recorded (trees/shrubs/grasses).

8.1.2.4 Aquatic Macroinvertebrate Sampling

A 250 µm mesh dip net was used to collect three replicate sweep samples of macroinvertebrates from a total length of 2 m at each study site, incorporating all habitats represented. The habitats sampled included vegetation along the pool edge, macrophyte zones, rocky run, pool, snag and rock. Each replicate sample was collected over a period of one minute of total dip net sampling effort. The animals collected in each sample were placed into pre-labelled plastic sample containers filled with 70% alcohol.

A 1/4 to 1/8 sub-sample of each sample determined by weight was sorted under a binocular microscope (at 40 X magnification), with all macroinvertebrates extracted, identified to family and counted level using standard taxonomic keys and references. After sorting and identification, all invertebrates collected and the remaining residue were stored in 70% alcohol in containers appropriate for long-term storage.

8.1.2.5 Fish and Mobile Invertebrates

A variety of sampling techniques were used to collect fish and mobile invertebrates (e.g. crayfish). At Sites 6, 10 and 13, two fyke nets were installed overnight, facing upstream and downstream. The fyke nets used had panels 8 m long on either side of a central funnel 3.5 m long, with 18-30 mm mesh. The cod end of each net was fitted with a polystyrene float and set out of the water, attached to overhanging vegetation, so that any platypus, water birds, water rats or frogs inadvertently caught would be able to breathe at the surface of the water.

At all sites eight baited traps were also deployed overnight amongst vegetation and near submerged logs or within dense vegetation. Each trap was baited with approximately 50 grams of sardines. The traps used had a 3 mm mesh throughout, were approximately 350 mm long, 200 mm wide and had an entrance that tapers in to 15 mm,

Backpack electrofishing was also conducted at each site along approximately 100m of the creek at each site. This was restricted to depths of less than 1m, which occurred through much of the sites sampled. The operator of the electrofisher stunned fish by discharging electric pulses into the water enabling them to be captured by an assistant equipped with a dip net.

All fish caught were placed into a large container containing creek water, identified, counted, checked for abnormalities and then released as quickly as practicably possible. The number of each species of fish captured using each method at each site was recorded on data sheets. Non-native species were humanely euthanized and buried, as per DPI NSW requirements. All fish captured, and their fate, will be reported to DPI NSW and the Director General's Ethics Committee as per the conditions of our permit to sample fish.

Appendix 2: GPS coordinates of aquatic ecology sampling sites visited on the Georges River in May 2012. Datum: WGS 84, Zone 56 H.

Sites	6	8	9	10	11	13
Easting	296877	297145	296970	296709	297204	297131
Northing	6216094	6216736	6217230	6217614	6218446	6218671

Appendix 3: Mean (±S.E.) water quality measurements recorded at aquatic ecology sampling sites visited on the Georges River in May 2012. Grey shading indicates measurement were outside ANZECC/ARMCANZ 2000 Default Trigger Values (DTVs) for slightly disturbed upland rivers in south-eastern Australia.

Variable	ANZECC/ARMCANZ (2000) DTVs	Site 6		Site 8		Site 9		Site 10		Site 11		Site 13	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Temperature (°C)		10.5	0.0	10.7	0.2	10.6	0.4	10.3	0.0	10.7	0.0	10.9	0.0
Conductivity (µS/cm)	30 - 350	1028	0	1007	1	1013	5	1033	3	1034	3	1031	2
pH	6.5 - 8.0	8.3	0.0	8.3	0.0	8.4	0.0	8.5	0.0	8.6	0.0	8.5	0.0
ORP (mV)		447	2	465	7	421	2	447	2	443	1	451	1
DO (%sat'n)	90 - 110	106.9	1.6	81.6	0.7	100.5	3.0	89.8	0.8	95.8	0.5	95.1	0.5
Turbidity (ntu)	2 - 25	5.8	0.9	1.1	0.2	7.2	0.2	0.7	0.1	5.9	0.3	5.8	0.2

Appendix 4: Aquatic macrophyte taxa recorded in the Georges River. Shading indicates sites within, or adjacent to, the Study Area for Longwalls 37-38. GR1 is upstream of the Study Area. Cardno Ecology Lab: *(The Ecology Lab 2003; 2005; 2008a; 2008c; Cardno Ecology Lab 2010; 2012).

Taxa	Bioanalysis (2009) GR1	Bioanalysis (2009) GR2	Cardno Ecology Lab*
Baumea articulata			x
Baumea juncea			x
Chorizandra cymbaria	x		
Eleocharis sphacelata	x		
Eleocharis sp.			x
Fimbristylis sp.		x	
Gahnia clarkei	x		
Hemarthria uncinata		x	
Isolepis prolifer			x
Isolepis inundata	x	x	
Isolepis sp.			x
Juncus fockei		x	
juncus usitatus			x
Juncus polyanthemus	x		
Lepidosperma filiforme	x	x	
Potamogeton sulcatus	x		
Potamogeton ticarinatus			x
Potamogeton sp.			x
Schoenus melanostachys		x	
Tristaniopsis laurina		x	
Typha orientalis	x		
Typha spp.			x
Vallisneria sp.			x

Appendix 5: Aquatic macroinvertebrate taxa recorded in AUSRIVAS sampling in the Georges River. Shading indicates sites within, or adjacent to, the Study Area for Longwalls 37-38. Sites at Marhynes Hole and GR1 are upstream of the Study Area.

Reference	TEL (2002a)	TEL (2002b)		TEL (2004b)			TEL (2006)		TEL (2005)	TEL (2007)	TEL (2008a)	Bioanalysis (2009)		TEL (2008c)	CEL (2010)	CEL (2012)
Location	Sites 1-6	Marhynes Hole		Marhynes Hole			Marhynes Hole		Sites 1-6	Sites 3 and 4	Sites 1-9, 12	GR1	GR2	Sites 1-12	Sites 1-11	Sites 5-12
Survey Date	May 02	Oct 02	Oct 02	Jan 03	Jan 04	May 04	June 04	Jun 05	Spr 05	Mar 05	Mar 07	Nov 08	May 08	Dec 08	Sep 08	May 10	Nov 11
Acarina unidentified		x	x	x	x	x				x						x	x
Aeshnidae	x	x	x	x	x	x	x	x	x	x	x	x			x		
Aphididae															x	x	
Araneae								x		x		x		x			
Atriplectididae	x						x			x						x	x
Atyidae	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Austrocorduliidae			x	x	x		x	x		x					x	x	x
Baetidae	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x
Caenidae	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x
Calamoceratidae	x	x	x	x	x	x	x	x		x		x		x	x		
Calanoida unidentified							x			x							
Ceinidae							x	x				x		x		x	x
Ceratopogonidae	x			x	x		x	x	x	x	x	x			x	x	x
Chironomidae/Chironominae	x		x	x	x	x	x	x	x	x	x	x		x	x		
Chironomidae/Diamesinae							x		x	x	x					x	x
Chironomidae/Orthocladiinae	x		x	x		x	x		x	x	x	x			x	x	x
Chironomidae/Tanypodinae	x		x	x	x	x	x	x		x		x		x	x		
Chrysomelidae																x	x
Cladocera												x			x	x	x
Coenagrionidae	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Coleoptera		x		x						x		x				x	x
Copepoda								x	x			x			x		x
Corbiculidae/Sphaeriidae		x					x	x		x			x				
Corduliidae	x	x	x				x	x		x							x
Cordulephyidae				x	x		x	x		x				x		x	x
Corixidae	x	x	x	x	x	x			x	x	x	x		x	x		
Corydalidae																	x
Culicidae							x	x	x	x	x						
Cyclopoida unidentified							x			x							
Diptera unidentified								x		x							
Dixidae							x		x						x		
Dolichopodidae																	x
Dugesiidae	x	x					x	x		x		x			x	x	x
Dytiscidae	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Ecnomidae	x			x		x	x	x		x		x	x		x	x	x
Elmidae						x	x	x		x					x		
Empididae																	x
Entomobryidae/Isotomidae								x		x							
Epiproctophora					x					x						x	
Gelastocoridae	x	x	x		x		x	x	x			x					x
Gerridae		x	x		x					x							
Glacidorbidae								x		x						x	
Glossiphoniidae	x			x	x	x	x			x							
Glossosomatidae	x															x	x

Continued...

Appendix 5: Continued.

Reference	TEL (2002a)	TEL (2002b)		TEL (2004b)			TEL (2006)			TEL (2005)	TEL (2007)	TEL (2008a)	Bioanalysis (2009)		TEL (2008c)	CEL (2010)	CEL (2012)
Location	Sites 1-6	Marhynes Hole		Marhynes Hole			Marhynes Hole			Sites 1-6	Sites 3 and 4	Sites 1-9, 12	GR1	GR2	Sites 1-12	Sites 1-11	Sites 5-12
Survey Date	May 02	Oct 02	Oct 02	Jan 03	Jan 04	May 04	June 04	Jun 05	Spr 05	Mar 05	Mar 07	Nov 08	May 08	Dec 08	Sep 08	May 10	Nov 11
Gomphidae	x	x	x	x		x	x	x	x	x	x	x		x	x		
Gripopterygiidae																x	x
Gyrinidae	x			x	x	x	x	x		x		x			x	x	
Haliplidae	x					x	x	x	x	x	x	x					
Helicopsychidae								x		x						x	x
Hemicorduliidae			x	x	x	x	x	x	x	x	x	x			x		
Hemiphlebiidae					x					x						x	x
Hydracarina	x	x					x	x	x	x	x	x			x	x	
Hydraenidae									x	x	x					x	
Hydrobiosidae	x	x	x				x			x							
Hydrochidae								x		x						x	
Hydrometridae						x	x	x	x	x	x					x	x
Hydrophilidae	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Hydropsychidae											x					x	x
Hydroptilidae	x				x	x	x	x		x		x					
Hypogastruridae								x		x						x	x
Isostictidae	x	x	x	x	x	x	x	x		x		x			x		
Isotomidae					x	x				x						x	x
Leptoceridae	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Leptophlebiidae	x	x	x	x	x	x	x	x		x		x	x	x	x		
Lestidae						x	x	x	x	x	x			x		x	x
Libellulidae	x	x	x	x	x	x	x	x	x	x	x	x		x	x		
Libelluloidea								x		x							
Lymnaeidae										x				x			
Lumbriculidae		x															
Macromiidae			x	x			x			x						x	x
Megapodagrionidae	x	x	x	x	x	x	x	x	x	x	x	x		x	x		
Mesoveliidae																x	
Muscidae																	x
Naucoridae				x						x						x	
Nemertea												x					
Nepidae														x	x	x	x
Notonectidae	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Ochteridae										x	x						
Odontoceridae		x	x				x			x							
Oeconesidae					x					x						x	
Oligochaeta unidentified	x			x	x	x	x		x	x	x	x		x	x		
orbiculidae	x															x	x
Ostracoda unidentified	x			x			x	x	x	x	x	x			x		
Paramelitidae								x		x							x
Parastacidae								x		x							x
Philorheithridae							x	x		x						x	x
Physidae	x	x	x	x	x	x	x	x	x			x		x	x		
Pisauridae							x										
Planorbidae										x		x					
Planorbidae/Physidae										x							
Pleidae								x		x	x						

Continued...

Appendix 5: Continued.

Reference	TEL (2002a)	TEL (2002b)		TEL (2004b)			TEL (2006)			TEL (2005)	TEL (2007)	TEL (2008a)	Bioanalysis (2009)		TEL (2008c)	CEL (2010)	CEL (2012)
Location	Sites 1-6	Marhynes Hole		Marhynes Hole			Marhynes Hole			Sites 1-6	Sites 3 and 4	Sites 1-9, 12	GR1	GR2	Sites 1-12	Sites 1-11	Sites 5-12
Survey Date	May 02	Oct 02	Oct 02	Jan 03	Jan 04	May 04	June 04	Jun 05	Spr 05	Mar 05	Mar 07	Nov 08	May 08	Dec 08	Sep 08	May 10	Nov 11
Podonominae										x							x
Polycentropodidae								x		x	x					x	x
Protoneuridae					x		x			x	x						
Psephenidae							x			x							
Pseudocorduliidae							x			x							
Pyralidae						x	x	x		x					x		
Richardsonianidae																x	x
Scirtidae (= Helodidae, Cyphonidae)							x	x	x	x	x		x	x	x	x	x
Sialidae	x	x	x	x	x	x	x		x	x	x	x			x	x	
Simuliidae	x							x	x	x	x				x		
Smithuridae															x		
Sphaeridae		x	x	x	x					x							
Staphylinidae													x				
Stratiomyidae				x	x			x		x		x			x		x
Synlestidae				x	x	x			x	x	x				x		
Synthemistidae			x					x		x					x		
Tabanidae	x											x				x	x
Telephlebiidae					x				x	x	x						
Temnocephalidae							x			x							
Tetragnathidae		x	x			x			x	x	x	x					
Thaumaleidae																x	
Tipulidae												x	x	x	x		
Turbellaria unidentified			x	x		x				x							
Tubificidae		x												x			
Unidentified Zygoptera																x	
Veliidae	x	x	x		x	x	x	x		x		x					

Appendix 6: Total number of aquatic macroinvertebrates, OE50 taxa scores and AUSRIVAS bands for sites on the Georges River visited by Cardno Ecology Lab. Orange shading indicates sites within or adjacent to the Study Area for Longwalls 37 and 38. Sites at Marhynes Hole and GR1 are upstream of the study area.

Total Number of Taxa

Reference	TEL (2003)	TEL (2002b)		TEL (2004b)			TEL (2005)	TEL (2008a)	TEL (2008c)	Bioanalysis (2009)		CEL (2010)	CEL (2012)
Survey Date	May 2002[1]	Oct 02(7)	Oct 02	Jan 03	Jan 04	May 04	March 2005[2]	May 2007[3]	September 2008[4]	May 2008	December 2008	May 2010[5]	November 2011[6]
Georges River													
GR1-1										5			
GR1-2										9			
Marhnyes Hole Site 1		14	17	31	16	17							
Marhnyes Hole Site 2		12	11	24	10	22							
Marhnyes Hole Site 3		9	9	30	13	16							
Marhnyes Hole Site 4		11	13	27	17	14							
Marhnyes Hole Site 5		26	25	30	23	19							
Marhnyes Hole Site 6		15	15	23	24	18							
Site 1	22						15	17	18			22	
Site 2	25						11	18	22			24	
Site 3	23						10	17	19			18	
Site 4	18						9	21	25			21	
Site 5	17						14	18	24			26	20
Site 6	23						9	19	25			14	13
Site 7								27	22			21	21
Site 8									20			25	16
Site 9									25			24	25
Site 10								25	31			23	28
GR2-1											12		
GR2-2											21		
Site 11								20	23			19	20
Mallaty Creek													
Site 12								20	25			*No water*	17

AUSRIVAS Band

Survey							March 2005[2]	May 2007[3]	September 2008[4]			May 2010[5]	November 2011[5]
Georges River													
GR1-1										C			
GR1-2										C			
Site 1								B	B			B	
Site 2								B	B			B	
Site 3								B	B			B	
Site 4								B	B			B	
Site 5								B	B			A	B
Site 6								B	B			C	C
Site 7								A	A			B	B
Site 8									B			B	C
Site 9									B			A	B
Site 10								B	A			B	B
GR2-1											C		
GR2-2											B		
Site 11								B	A			B	B
Mallaty Creek													
Site 12								A	A			*No water*	B

Continued...

Appendix 6: Continued.

Reference	TEL (2003)	TEL (2002b)		TEL (2004b)			TEL (2005)	TEL (2008a)	TEL (2008c)	Bioanalysis (2009)		CEL (2010)	CEL (2012)
Survey Date	May 2002[1]	Oct 02(7)	Oct 02	Jan 03	Jan 04	May 04	March 2005[2]	May 2007[3]	September 2008[4]	May 2008	December 2008	May 2010[5]	November 2011[6]
SIGNAL 2 Score													
Survey							March 2005[2]	May 2007[3]	September 2008[4]			May 2010[5]	November 2011[5]
Georges River													
Site 1							3.7	4.1	4.0			4.2	
Site 2							3.7	3.9	3.4			4.3	
Site 3							3.5	3.8	2.3			4.0	
Site 4							3.8	3.8	3.0			3.9	
Site 5							3.5	3.8	2.4			4.3	1.5
Site 6							3.9	4.3	4.2			3.6	4.7
Site 7								3.7	3.0			3.9	2.2
Site 8									2.9			3.9	1.0
Site 9									2.8			3.8	2.0
Site 10								3.6	4.1			4.5	2.7
Site 11								3.8	3.5			3.9	2.2
Mallaty Creek													
Site 12								3.4	4.1			*No water*	3.0
OE50 Taxa Score													
Survey							March 2005[2]	May 2007[3]	September 2008[4]			May 2010[5]	November 2011[5]
Georges River													
GR1-1										0.26			
GR1-2										0.46			
Site 1								0.69	0.63			0.74	
Site 2								0.73	0.68			0.74	
Site 3								0.77	0.67			0.56	
Site 4								0.74	0.76			0.71	
Site 5								0.80	0.71			0.84	0.53
Site 6								0.67	0.65			0.35	0.32
Site 7								1.00	0.87			0.58	0.56
Site 8									0.80			0.77	0.44
Site 9									0.74			0.71	0.78
Site 10								0.70	0.93			0.78	0.79
GR2-1											0.46		
GR2-2											0.69		
Site 11								0.78	0.90			0.60	0.62
Mallaty Creek													
Site 12								0.86	0.86			*No water*	0.57

Appendix 7a: Macroinvertebrates collected from replicate pool rocks from 6 sites near Marhynes Hole in the Georges River October 2002

Site	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6
Replicate	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii
Taxa																		
Acarina unidentified	2	3	3	1	1				2			1	1	1		2		
Aeshnidae													1	1				1
Amphipod unidentified																		
Ancylidae																		
Araneae unidentified											1							
Atyidae																		
Austrocorduliidae																		
Baetidae																1	1	26
Caenidae	1	6	21				1				2		22	50	8	6	5	
Calamoceratidae														1			4	1
Centropagidae											1							
Ceratopogonidae										12			18	4	3		1	
Chironomidae	19	33	8		1	1	35	6	16	150	57	19	75	75	45	17	20	55
Coenagrionidae																		
Copepoda unidentified																		
Cordulephyidae																		
Corduliidae																		
Corixidae			1	5										1				
Corydalidae																		1
Culicidae							1						7				1	
Diphlebiidae													2	1				
Diptera unidentified																	1	
Dytiscidae	1	1					1	1	1	10	6	2	7	6	1	2	2	1
Ecnomidae	1		1										3	3	4		1	
Elmidae				1									1					6
Epiproctophora unidentified									1									
Glossiphoniidae																		
Gomphidae																		
Gyrinidae														1		1		
Hydrophilidae		16	27	6	4	5		1	1	2		3	29	14	5	2		1
Hydroptilidae				1						3	3			1		2	2	
Isostictidae															3			
Isotomidae							1											
Leptoceridae	2	1	5						1		1			1	3			
Leptophlebiidae		1	1										10	9		11	47	5
Libellulidae																		
Megapodagrionidae																		
Nemertea unidentified		1																
Oligochaeta unidentified				1														
Ostracoda unidentified			1								1							
Philorheithridae																		
Physidae							13	1	5	1	1			1		2		1
Psephenidae													1	3	2	1	1	3
Pyralidae																		
Scirtidae (= Helodidae, Cyphonidae)																		
Simuliidae													1					
Sphaeriidae																		
Stratiomyidae							1											
Tubificidae																		
Turbellaria unidentified																		
Veliidae																		
Zygoptera unidentified							1									1	9	

Appendix 7b: Macroinvertebrates collected from replicate pool rocks from 6 sites near Marhynes Hole in the Georges River January 2003

Site	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6
Replicate	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii
Taxa																		
Acarina unidentified	1		1		2		1	5		1			1	3	2	1	1	
Aeshnidae							1	1										
Amphipod unidentified				1														
Ancylidae																		
Araneae unidentified																		
Atyidae							1											
Austrocorduliidae								2							1			
Baetidae			1				4	7	8	32	19	13	12	1	5	5		21
Caenidae	41	1	19		1	34	78	183	80	17	5	14	39	20	19	40	37	9
Calamoceratidae																		
Centropagidae																		
Ceratopogonidae	18	100	4	30	43		6		10		6	2	20	40	34			1
Chironomidae	103	48	118	53	23	15	78	53	189	36	279	13	401	567	681	336	127	119
Coenagrionidae											1				1			
Copepoda unidentified																		
Cordulephyidae							1					1						
Corduliidae																		
Corixidae																		
Corydalidae										1								
Culicidae																		
Diphlebiidae																		
Diptera unidentified																		
Dytiscidae	1	1		1									1		1		1	
Ecnomidae	1		2				3	5	8	1	13	4	7	6	17	2	1	5
Elmidae													1			10	1	4
Epiproctophora unidentified																		
Glossiphoniidae	1		3				1			2							1	
Gomphidae													1	1				
Gyrinidae													2					
Hydrophilidae	58	6	20	2	11	7	9	2	12	13	1	12	92	103	28	25	47	
Hydroptilidae		1											2	2	4	4		6
Isostictidae																		
Isotomidae																		
Leptoceridae	5					2												
Leptophlebiidae							1	4		30	6	3	2	7	4	20		10
Libellulidae									5					2		2		
Megapodagrionidae														2				
Nemertea unidentified																		
Oligochaeta unidentified	52		4		7	19	20	9	17		6	2	14	17	8		7	1
Ostracoda unidentified	12		3			8						3					3	
Philorheithridae																		
Physidae													1			1		
Psephenidae									3	1		1	1			1		6
Pyralidae																		
Scirtidae (= Helodidae, Cyphonidae)																		
Simuliidae																		
Sphaeriidae	2				1	3											6	
Stratiomyidae																		
Tubificidae																		
Turbellaria unidentified													5	8	8	7	3	2
Veliidae																1		
Zygoptera unidentified																		

Appendix 7c: Macroinvertebrates collected from replicate pool rocks from 6 sites near Marhynes Hole in the Georges River January 2004

Site	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6
Replicate	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii
Taxa																		
Acarina unidentified	25	1	2										1	8		2		1
Aeshnidae																		
Amphipod unidentified																		
Ancylidae																		1
Araneae unidentified																		
Atyidae																		
Austrocorduliidae																		
Baetidae	3	3	1				1	2		1	2			1			1	
Caenidae	4	1	2				2						1	4	3		60	5
Calamoceratidae																		
Centropagidae																		
Ceratopogonidae	7	1	5	2			3		1		1		3	16	4	6	7	4
Chironomidae	136	19	40	34	12	15	20	24	23	2	4	1	141	342	76	2	49	20
Coenagrionidae	1	1																
Copepoda unidentified	1																	
Cordulephyidae																		
Corduliidae	1								1	1								
Corixidae	1																	
Corydalidae																		
Culicidae																		
Diphlebiidae																		
Diptera unidentified																		
Dytiscidae													1					
Ecnomidae	4														1			
Elmidae															1	6	7	1
Epiproctophora unidentified																		
Glossiphoniidae		2					2			1				1				
Gomphidae																		
Gyrinidae	1																	
Hydrophilidae	5		1				34	4	3	1	10		26	85	61	1	16	1
Hydroptilidae		1													1			
Isostictidae																		
Isotomidae		1																
Leptoceridae	2	1						1					1	1				
Leptophlebiidae	4															1	3	2
Libellulidae																		
Megapodagrionidae											1							2
Nemertea unidentified																		
Oligochaeta unidentified	65	2	41						1								7	2
Ostracoda unidentified																		
Philorheithridae																		
Physidae	1								1	3								3
Psephenidae							1				1			3		11	3	2
Pyralidae																		
Scirtidae (= Helodidae, Cyphonidae)																		
Simuliidae																		
Sphaeriidae																		
Stratiomyidae																		
Tubificidae																		
Turbellaria unidentified	1	4															1	1
Veliidae																		
Zygoptera unidentified													1					

Appendix 7b: Macroinvertebrates collected from replicate pool rocks from 6 sites near Marhynes Hole in the Georges River May 2004

Site	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6
Replicate	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii
Taxa																		
Acarina unidentified		58		2	1		4	1	4				1				1	3
Aeshnidae																		
Amphipod unidentified																		
Ancylidae																		
Araneae unidentified																		
Atyidae																		
Austrocorduliidae									4									
Baetidae	1	24	6		2	2	16	6	12	24	3		4	1	3	1	5	2
Caenidae	26	44	197	110	74	14	200	9	56	8	11	16	21		17	24	50	19
Calamoceratidae																		2
Centropagidae																		
Ceratopogonidae	1	18	12	12	12		44	1	128	24	4	16			1	2	18	5
Chironomidae	80	614	397	730	385	12	548	62	960	504	81	392	26	31	25	150	272	154
Coenagrionidae		2																
Copepoda unidentified																		
Cordulephyidae																		
Corduliidae					1													
Corixidae		2																
Corydalidae								1										
Culicidae																		
Diphlebiidae																		
Diptera unidentified																		
Dytiscidae		6	7		2			2		8	1		2					1
Ecnomidae	5	4	24	8	2	1	4	1		8			3	1	2	4	2	1
Elmidae						1	4			4						2	8	
Epiproctophora unidentified																		
Glossiphoniidae			1				4	2		1			1				1	
Gomphidae							4											
Gyrinidae	1	2						1										
Hydrophilidae	4	28	30	8	41	2	32	20	40	40	3	20	40	1	5	8	22	3
Hydroptilidae		2	1		3	2											1	1
Isostictidae			1		1													3
Isotomidae														1	1			
Leptoceridae	15	132	65	22	47	13	8	5	28	4	6	20	2		5	8	5	15
Leptophlebiidae													1			1		2
Libellulidae									4									
Megapodagrionidae																		
Nemertea unidentified																		
Oligochaeta unidentified	2	12	20			3										45	24	34
Ostracoda unidentified																3	24	16
Philorheithridae																	1	
Physidae																	1	
Psephenidae								1			4					1	4	3
Pyralidae		2																
Scirtidae (= Helodidae, Cyphonidae)																		3
Simuliidae																		
Sphaeriidae																26	16	6
Stratiomyidae																		
Tubificidae																		
Turbellaria unidentified															1		4	3
Veliidae																		
Zygoptera unidentified																		

Appendix 8: Aquatic macroinvertebrate taxa and their relative abundance recorded in the Georges River by Bioanalysis (2009) using quatatative sampling. Orange shadning indicates sites within, or adjacent to, the Study Area for Longwalls 37-38.

Survey	May 2008						Dec 2008					
Location	GR1-1			GR1-2			GR2-1			GR2-2		
Replicate	1	2	3	1	2	3	1	2	3	1	2	3
Taxa												
Aeshnidae	1											
Araneae	1											
Atyidae				2	1							
Austrocordulia refracta		1										
Caenidae							3	16	10	1	4	2
Calamoceratidae											1	3
Ceinidae						1	1					
Ceratopogonidae										1		
Chironomidae						1	1	3	2		2	21
Coenagrionidae	2				1					2	1	
Cordulephyidae							3	1		1		1
Culicidae			1									
Corixidae				1								
Dixidae	2		1	1	1							
Dytiscidae			1	2	10						8	
Glossosomatidae											1	
Gyrinidae		1		1		1	2		2	2	1	
Hydrophilidae		1	1	1			2	1	1			1
Isostictidae									1			
Leptoceridae	12	4	1	2	5		3	3	1			1
Leptophlebiidae	10	11		7	6	10			1		3	2
Libellulidae					1					1		
Megapodagrionidae		3						1				1
Oligochaeta		1										
Physidae							1					
Scirtidae			1	2			4		2			
Sialidae								1				
Stratiomyidae									1	1		
Synlestidae								1				
Telephlebiidae							1	1				
Veliidae							2					

Appendix 9: Macroinvertebrate taxa collected by Cardno Ecology Lab from sites on the Georges within, or adjacent to, the Study Area using quantatative sampling.

Site	6			8			9			10			11			13		
Replicate	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Sub sample size	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/4	1/4	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
Taxa																		
Aeshnidae		0.1																
Ancylidae												1						
Araneae		1					1											
Atyidae													1	2				
Austrocorduliidae (=Corduliidae)										1				1	2			
Baetidae	48	24	20	37	61	20	48	40	26	20	61	52	87	91	81	83	31	98
Caenidae	8	33	37	40	25	23	45	118	36	33	62	64	49	98	179	126	56	74
Calamoceratidae			2	5	1		2	12	6	5	7	7	2	3	9	3	5	2
Ceratopogonidae	2				2	1		11	1	1	1	2		3	1		2	
Chironomidae	100	86	39	69	113	15	42	31	14	40	46	68	14	48	39	51	25	79
Cladocera				1								1						
Coenagrionidae		1		9		1		2		2	7	6					1	
Copepoda					2						5	1			2			
Corbiculidae/ Sphaeriidae																	1	
Corixidae		2							1									
Corydalidae							1		1				2					
Curculionidae			1															
Diphlebiidae (=Amphipterygidae)														1				
Dugesiidae			1							1	2						1	
Dytiscidae	6	7	1	2	3	3	1	2	4				1	1		5		6
Ecnomidae	5	10	4	11	45	12	9	3	2		6	5	7	12	6	5		2
Elmidae	8	36	9		7	1	11	1	50		3	3	37	3	7	3	3	21
Empididae												1						
Entomobryidae						1		1		1								
Epiproctophora																1		
Gerridae														1	1			1
Glossiphoniidae												1				1		
Gomphidae	2				1		3	1	5	3	1	2	3	1	2	3	2	2
Gripopterygiidae	1					1	3	3	1		1							
Gyrinidae	2																	1
Hemicorduliidae (=Corduliidae)					1	1	1	2	2	2	5	2	4		1			3
Hydracarina		3	2		4	1			1	1	2						1	
Hydraenidae (= Limnebiidae)				1														
Hydrobiosidae	3				1		1											
Hydrophilidae			1	1	6	1	8	9	22	2	24	3	4	15	15	3	6	6
Hydropsychidae	16	10	2	2	9	3	1	1	41				9	1				
Hydroptilidae	3	1		2			1	2					1	1	1		1	2
Hypogastruridae				1														
Isostictidae				1							2				2	4	1	
Leptoceridae	2			1		1		7	3	5	10	4		5	79	6	30	10
Leptophlebiidae				1									1	1	5	1	2	2
Megapodagrionidae								3	1	3	2	1	3		4		2	1
Nematoda									1									
Notonectidae		0.1																
Oligochaeta	2					1					3	1			1	2		
Ostracoda			1	1			1		1		1	2	1		3		4	
Physidae						1	1	1	1	3	2	3				3	3	2
Polycentropodidae													1					
Psephenidae											1		2		2			2
Psychodidae								8							1	1	2	
Pyralidae						1					1							
Scirtidae (= Helodidae, Cyphonidae)	3	9	1		13	3	6	6	23	4	2	3	31	7	2	1	1	6
Sialidae						1				1					5		1	
Simuliidae					3				7									
Stratiomyidae									1			1						
Synlestidae									1					1				
Telephlebiidae (=Aeshnidae)									2									
Tipulidae	8	13	8	5	7	1		1				1		1				1
Veliidae														2				

Appendix 10: Fish species recorded in the Georges River.

Reference		Australian Museum	NSW Fisheries (2000)	MPR (1999)	TEL (2002a)	TEL (2003)	TEL (2004b)	TEL (2005)	TEL (2007)	TEL (2008c)	Bioanalysis (2009)		Andrew Bruce, NSW DPI (Fisheries) (Pers. Comm.)	CEL (2010)	CEL (2012)
Survey Date		Historic Records	2000	April 2009	March 02	May 02	May 2004	March 2005	March 2007	Sep 2008	May 2008	Dec 2008	2008	May 2010	Nov 2011
Location		Campbelltown[1] Minto[2] Appin[3]	Holsworthy[1] Macquarie Fields[2] Liverpool[3] Kentlyn[4]	Just above Kings Falls Bridge to Dwyers Crossing	Marhynes Hole	Sites 1-6[1] and Mallaty Creek[2]	Marhynes Hole[1] and sites upstream[2]	GR 1-6	GR 3 and 4 (Bait trap Only)	Sites 1-11	GR1	GR2	Cambeltown	Sites 1,3,5,6,8,10	Sites 6,7,8,10,11
Short-finned eel	*Anguilla australis*						P[2]								
Long-finned eel	*Anguilla reinhardtii*	P[1,2]	P[1,2,3,4]		P	P[1]	P[1,2]	P		P	P	P			P
Freshwater herring	*Potamalosa richmondi*	P[1]													
Galaxids	*Galaxias spp.*	P[1]													
Australian smelt	*Retropinna semoni*		P[2,4]												
Goldfish	*Carassius auratus*		P[1]												
Freshwater catfish	*Tandanus tandanus*		P[2]												
Mosquito fish	*Gambusia holbrooki*		P[4]	P	P	P[1]	P[1,2]	P	P	P	P	P		P	P
Australian bass	*Macquria novemaculata*		P[1,2]												
Golden perch	*Macquria ambigua*	P[3]													
Macquarie perch	*Macquaria australasica*	P[1]											P		
Estuary perch	*Macquria colonorum*	P[1]													
Silver perch	*Bidyanus bidyanus*	P[3]													
Trout cod	*Maccullochella macquariensis*	P[3]													
Sea mullet	*Mugil cephalus*	P[1]													
Striped gudgeon	*Gobiomorphus australis*		P[1,2]		P							P			P
Cox's gudgeon	*Gobiomorphus coxii*	P[1]	P[2]												
Empire gudgeon	*Hypseleortis compressa*		P[1,2]												
Firetailed gudgeon	*Hypseleotris galii*		P[4]	P	P	P[1]	P[1,2]	P		P				P	P
Midgley's carp gudgeon	*Hypseleortis sp.*						P[1,2]								
Hypseleotis sp. *5*	Lake's carp gudgeon														P
Western carp gudgeon	*Hypseleortis klunzingeri*							P							
Flathead gudgeon	*Philynodum grandiceps*		P[2]			P[2]									
Dwarf flathead gudgeon	*Philynodum spp. 1*			P											
Unidentified gudgeon	Eleotridae				P										

Appendix 11: Total number of fish caught in the Georges River using electrofishing, fyke netting and bait trapping techniques at sites adjacent to Longwalls 37 and 38 in May 2012.

Electrofishing

Site		6	8	9	10	11	13
Long Finned Eel	*Anguilla reinhardtii*			1	1	4	2
Mosquito Fish	*Gambusia holbrooki*	3	2	2	4	11	3
Firetail Gudgeon	*Hypseleotris galii*		1		5	5	1
Cox's Gudgeon	*Hypseleotris compressa*						1

Fyke Nets

Site		6	10	13
Firetail Gudgeon	*Hypseleotris galii*	*no fish*	5	19
Mosquito fish	*Gambusia holbrooki*		2	2

Bait Traps

Site		6	10	13
Mosquito Fish	*Gambusia holbrooki*	2	4	*no fish*
Firetail Gudgeon	*Hypseleotris galii*		5	