APPENDIX D

Biodiversity Assessment Report and Biodiversity Offset Strategy

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Environment and Heritage

Dendrobium Mine – Plan for the Future: Coal for Steelmaking

Biodiversity Assessment Report

Prepared for Illawarra Coal Holdings Pty Ltd (Illawarra Coal) – South32 Limited

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Cover photograph: Sedgeland-Heath Complex in Upland Swamp DEN117 (November 2016)

Executive Summary

Context

The Dendrobium Mine (the Mine) is an existing underground coking coal mine located in the Southern Coalfield of New South Wales (NSW). The Dendrobium Mine was approved in 2001 and has operated since that time under approvals from both the NSW Government (under the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act)) and the Commonwealth Government (under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)).

The Mine is located in the Southern Coalfield of New South Wales approximately 8 kilometres west of Wollongong. The Mine is owned and operated by Illawarra Holdings Pty Ltd (Illawarra Coal), a wholly owned subsidiary of South32 Limited (South32).

South32 is seeking Development Consent to gain access to additional coal reserves within two future mining areas within Consolidated Coal Lease (CCL) 776, known as 'Area 5' and 'Area 6', referred to as the Dendrobium Mine – Plan for the Future: Coal for Steelmaking (the Project). The underground mining areas will be serviced by associated infrastructure such as ventilation shafts and the existing infrastructure at the Mine. Additional personnel will use the new Dendrobium Pit Top Carpark.

Aims

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by South32 to assess the ecological values and impacts associated with the Project and provide a Biodiversity Assessment Report (BAR) and Biodiversity Offset Strategy (BOS) in accordance with the *Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects* (FBA) (OEH 2014). The BAR describes and assesses potential impacts to biodiversity values from the Project, particularly threatened biodiversity listed under the *NSW Biodiversity Conservation Act 2016* (BC Act). This report has also assessed the potential impacts of the Project on Matters of National Environmental Significance (MNES) under the EPBC Act. In addition to requirements under the FBA and Commonwealth environmental approvals process, this biodiversity assessment addresses specific requirements provided in the Secretaries Environmental Assessment Requirements (SEARs) for the State Significant Development application relating to biodiversity.

The assessment has utilised the findings of other specialist studies in preparation of the impact assessment, in particular that of Mine Subsidence Engineering Consultants (MSEC) (2019) in regards to the subsidence predictions associated with the Project.

Study Area

The Study Area refers to the proposed mining area (Area 5 and Area 6 collectively, including a 600 m buffer from the edge of the proposed longwalls) as well as surface infrastructure areas including:

- The development and underground mining of two new mining domains called Area 5 and Area 6. The areas potentially subject to subsidence effects associated with Area 5 and Area 6 are approximately 2,958 hectares (ha) and 1,075 ha respectively.
- The surface infrastructure associated with the Project including four ventilation shafts and an extension of the existing Dendrobium Pit Top Carpark off Cordeaux Road, Kembla Heights, totalling an area of 19.0 ha.
- Additional service boreholes totalling an area of 5 ha.

- Electricity Transmission Lines associated with the ventilation shaft sites totalling an area of 4.5 ha.

In total, 28.5 ha of native vegetation may be cleared for the Project.

Survey Overview

The Study Area has been the subject of extensive targeted biodiversity surveys since 2016 using relevant State and Commonwealth threatened biodiversity survey guidelines, and the FBA. The survey effort concentrated on areas that would be directly impacted by the clearing associated with surface infrastructure, and natural features that may be susceptible to subsidence related impacts i.e. Coastal Upland Swamps, watercourses and cliff lines.

Native Vegetation Assessment and Threatened Ecological Communities

Vegetation within the Study Area has been mapped previously as part of the National Parks and Wildlife Service (NPWS) (2003) Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments. Niche has revised the NPWS (2003) vegetation mapping of the ventilation shaft areas and carpark area to reflect the vegetation recorded on-site using the BioBanking plots and rapid data points.

For the mapping of Coastal Upland Swamps, Niche has revised all the NPWS (2003) Coastal Upland Swamp boundaries and sub-vegetation types (Tea-Tree Thicket, Sedgeland-Heath Complex (including Sedgeland, Restioid Heath and Cyperoid Heath), Banksia Thicket, and Fringing Eucalypt Woodland), with Fringing Eucalypt Woodland being excluded from the Coastal Upland Swamps threatened ecological community complex.

The validation confirmed that the vegetation present within the surface infrastructure sites contained the following Plant Community Types (PCT):

- PCT1083 Red Bloodwood – scribbly gum heathy woodland (HN566);
- PCT1245 Sydney Blue Gum x Bangalay – Lilly Pilly moist forest (ME044);
- PCT1250 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest (HN651); and
- PCT1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest (HN556).

Two Threatened Ecological Communities (TEC) listed under the BC Act and EPBC Act were recorded in the Study Area:

- Shale Sandstone Transition Forest of the Sydney Basin Bioregion – A total of 173.5 ha has been mapped within the Study Area.
- Coastal Upland Swamps of the Sydney Basin Bioregion – A total of 37.9 ha of Coastal Upland Swamps (satisfying the threated community listing) were mapped by Niche within the Study Area.

Threatened Flora Species

No threatened flora species listed under the BC Act or EPBC Act were recorded within the Study Area during the field survey. However, *Pultenaea aristata, Pomaderris brunnea, Epacris purpurascens var. purpurascens* and *Leucopogon exolasius* have previously been recorded in the Study Area.

Whilst not detected during the current field survey for the Project, eight threatened flora species are considered to have a moderate to high (to known) likelihood of occurrence within the Study Area. These species include: *Acacia bynoeana, Cynanchum elegans, Grevillea parviflora subsp. Parviflora, Leucopogon exolasius, Pomaderris brunnea, Persoonia hirsuta* and *Pultenaea aristata.* All these species have relatively extensive habitat throughout the Study Area. Of these species, only *Epacris purpurascens var. purpurascens, Pomaderris brunnea and Pultenaea aristata* was determined to have potential habitat within habitat types sensitive to subsidence.

Threatened Fauna

Fourteen threatened fauna were recorded during the field survey from the Study Area: Eastern Bentwing-bat, Eastern False Pipistrelle, Eastern Freetail-bat, Golden-tipped Bat, Greater Broad-nosed Bat, Greater Glider, Koala, Little Bentwing-bat, Littlejohn's Tree Frog, Rosenberg's Goanna, Scarlet Robin, Varied Sittella, White-bellied Sea-Eagle and Yellow-bellied Sheathtail-bat. Whilst not detected, a further nine species have a known or high likelihood of occurrence within the Study Area from previous surveys: Broad-headed Snake, Eastern Pygmy-possum, Gang-gang Cockatoo, Giant Burrowing Frog, Giant Dragonfly, Glossy Black-Cockatoo, Grey-headed Flying-fox, Powerful Owl and Red-crowned Toadlet.

In total, six of the recorded or highly likely to occur threatened fauna are 'species credit' fauna (Giant Burrowing Frog, Littlejohn's Tree Frog, Broad-headed Snake, Giant Dragonfly, Red-crowned Toadlet, Koala), and seven are considered 'dual credit' species (Grey-headed Flying Fox, Gang-gang Cockatoo, Glossy Black Cockatoo, White-bellied Sea Eagle, Powerful Owl, Eastern Bentwing-Bat, Little Bentwing-Bat) whereby the species credit component is triggered if breeding or other important habitat is impacted. The remaining species are regarded as 'ecosystem credit' species and are therefore, assumed present within the habitats of the Study Area and offset concurrently with impacts to vegetation types.

Impacts – Clearing of Native Vegetation

The Project would result in direct impact to approximately 28.5 ha of native vegetation associated with clearing for surface infrastructure.

The vegetation to be cleared for the ventilation shaft sites and the Dendrobium Pit Top Carpark includes:

- 18.8 ha of PCT1083 Red Bloodwood – scribbly gum heathy woodland (HN566); and
- 0.2 ha of PCT1245 Sydney Blue Gum x Bangalay – Lilly Pilly moist forest (ME044).

Vegetation that may be cleared for the additional service boreholes includes:

- Up to 4 ha of native vegetation that does not align to a TEC or Coastal Upland Swamp under both NSW and Commonwealth legislation, anticipated to be PCT1083 Red Bloodwood – scribbly gum heathy woodland (HN566).
- Up to 1 ha of PCT1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest (HN556), which aligns to the Shale Sandstone Transition Forest TEC under both NSW and Commonwealth legislation.

Vegetation that may be cleared for the transmission lines includes:

- Up to 4 ha of native vegetation that does not align to a TEC or Coastal Upland Swamp under both NSW and Commonwealth legislation, anticipated to be approximately 3 ha of PCT1083 Red Bloodwood – scribbly gum heathy woodland (HN566) and approximately 1 ha of PCT1250 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest (HN651).
- Up to 0.5 ha of PCT1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest (HN556), which aligns to the Shale Sandstone Transition Forest TEC under both NSW and Commonwealth legislation.

An offset for the impact to the PCTs impacted by the vegetation clearing has been provided in this assessment in accordance with the requirements of the FBA.

Impacts – Subsidence Related Impacts to Native Vegetation (Non-Swamp)

Subsidence from the Project may result in the following impacts to non-swamp native vegetation:

- Vegetation die-back around strata gas emission/drainage sites within creeks.
- Changes to the floristic composition of vegetation communities immediately adjacent to creeks/ponds where fracturing may result in changes to water flow and water retention periods.
- Destruction/smothering of vegetation/tree fall by rock falls and/or slippage of earth and rocks down steep slopes.

However, based on subsidence predictions by MSEC (2019) and previous events in the Southern Coalfield, the likelihood for such an event to occur and result in detrimental change to native vegetation is highly unlikely.

Impacts – Subsidence Related Impacts to Coastal Upland Swamps

MSEC (2019) determined that Coastal Upland Swamps partially or entirely located above the proposed longwalls are expected to experience the full range of predicted subsidence movements, compared to Coastal Upland Swamps located outside the extent of the proposed longwalls which will experience reduced levels of subsidence. It is not expected that there would be adverse changes in the levels of ponding or scouring of the Coastal Upland Swamps based on the predicted mining induced tilt, or significant changes in the distribution of surface waters due to mining induced tilt or vertical subsidence.

Based on assessments of water levels and recession rates around past mining in Areas 2, 3A and 3B, it was concluded by Watershed (2019) that hydrographs from swamp piezometers directly above or within 60 m of longwalls exhibit a mining effect, be that through a reduction in the water table to below pre-mining levels and/or increased recession (drainage) rate. Effects on swamp water tables were not reported at distances greater than 60 m from a longwall panel.

Of the 46 Coastal Upland Swamps recorded within the Study Area, 25 are located above longwalls or occur within 60 metres (m) of the proposed longwalls.

The predicted mining effects at the 25 Coastal Upland Swamps have the potential to result in hydrological changes, which have the potential to result in the following key changes:

1. Reduction in groundwater levels or desaturation of the upland swamp sediments; and/or
2. Transition of the Coastal Upland Swamp to a drier vegetation type; and/or

3. Desaturation of soil particles exposing the swamp to peat desiccation; and/or
4. Exposure to greater bushfire intensity due to loss of inundation; and/or
5. Increased scour and erosion events.

Each of these potential impacts in relation to the Coastal Upland Swamps of the Study Area has been discussed in an impact assessment provided in Appendix 8.

The remaining Coastal Upland Swamps (located more than 60 m from the longwalls) are predicted to be unlikely to experience a change in vegetation that requires offsetting under the FBA.

Impacts – Threatened Flora Species

No threatened flora species were recorded within the area to be directly disturbed for the ventilation shaft sites or carpark. Furthermore, biodiversity due diligence assessments would be completed during the additional service borehole establishment and design of the transmission line alignments to ensure that no threatened flora species would be impacted by the works. The Project would therefore not result in the clearing of any threatened flora species.

Through an analysis of MSEC (2019) subsidence predictions and known habitat for threatened flora species in the Study Area, it was determined that subsidence impacts resulting in loss of threatened flora species is unlikely.

Impacts – Threatened Fauna

Six species credit fauna were determined to be impacted by the Project, and therefore require offsetting as a result of subsidence related impacts or through clearing associated with the surface infrastructure. Species include: Broad-headed Snake, Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Giant Dragonfly and Koala. Species polygons as per the FBA have been provided in the assessment in order to facilitate the offset liability for each species. Threatened fauna surveys would be required for the transmission line easements after the final alignment has been determined, as well as determination of any required offsets.

The remainder of threatened fauna considered to be affected by the Project are regarded as ecosystem credit fauna and as such, are offset through the vegetation types offset by the Project.

Those threatened fauna which are listed under the EPBC Act that may be impacted include: Littlejohn's Tree Frog, Giant Burrowing Frog, Greater Glider, Koala and Grey-headed Flying-fox. An EPBC Act Assessment of Significance for each of these species has been completed. Based on the results of the Assessments, a significant impact to the Giant Burrowing Frog and Littlejohn's Tree Frog was considered likely. A significant impact to other threatened fauna listed on the EPBC Act is considered unlikely.

Avoidance and Minimisation

A number of key constraints and longwall setbacks have been considered in the development of the Project surface infrastructure, and underground mining layout, based on previous mining experience at the Dendrobium Mine, review and analysis of available monitoring data from other operations across the Woronora Plateau and stakeholder feedback.

Primary constraints dictated that the Project underground mining areas were located within the following:

- Existing extent of CCL 768; and
- Mineable areas of the coal seams as determined by geological constraints (e.g. igneous intrusions, thickness of the coal seams etc.).

In addition, a number of longwall setbacks from both built and natural features were developed and incorporated within the design to minimise the potential for impacts to surface infrastructure and the environment.

The proposed location of the ventilation shaft sites was subject to an initial preliminary biodiversity constraints assessment to avoid areas of TECs (including Coastal Upland Swamps) and watercourses. The proposed sites were then inspected and modified where such features occurred. A larger footprint was inspected for each ventilation shaft site to inform the site layout. Each of the sites were positioned adjacent to existing fire roads to minimise additional disturbance within native vegetation areas for access roads.

Mitigation and Management

The Project will reduce impacts to biodiversity through a series of mitigation measures as proposed in section 9 of this assessment.

Quantifying Offset of Impacts

The Project would require a biodiversity offset in accordance with the FBA and NSW *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence* (OEH 2016) for the following:

- Native vegetation clearing;
- Habitat clearing, potentially impacting Koala habitat;
- Potential subsidence related impacts to Coastal Upland Swamps; and
- Potential subsidence related impacts to habitat associated with Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Broad-headed Snake and Giant Dragonfly.

Under the EPBC Act, only those threatened entities that may be significantly impacted by the Project are required to be offset. Details of the EPBC Act Assessments of Significance are provided in Appendix 7. The Project would therefore require an offset for the following potentially significant impacted entities:

- Coastal Upland Swamps of the Sydney Basin Bioregion;
- Giant Burrowing Frog; and
- Littlejohn's Tree Frog.

The maximum offset credit liability required to offset the Project was completed using the BioBanking calculator. The credits required include the following:

Impacted Entity	Area (ha)	Credits Required
HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin	25.8	1022
HN651 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion	1.0	80
HN556 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	1.5	120
Coastal Upland Swamps: HN560 Needlebush - banksia wet heath on sandstone plateau of the Sydney Basin Bioregion / HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin	20.9	305
ME044 Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	0.2	6
Broad-headed Snake	0.28	9
Littlejohn's Tree Frog	32.74	851
Giant Burrowing Frog	32.74	426
Red-crowned Toadlet	7.21	94
Giant Dragonfly	13.93	1073
Koala	1.50	39

Offset Strategy

South32 has provided an offset strategy to address the maximum offset liability for the Project in section 11 of this assessment. Due to a variety of factors, most notably the approach to offsetting the NSW and Commonwealth Coastal Upland Swamps impacts, South32 proposes a biodiversity offset package that employs a combination of offsetting opportunities including the following:

1. Retirement of FBA credits through existing South32 BioBank sites;
2. Establishment of Stewardship sites on South32 landholdings;
3. Direct offset actions, such as the rehabilitation of Coastal Upland Swamps impacted by surface disturbance;
4. Payment into the Biodiversity Conservation Trust (BCT) Payment Fund; and
5. Other direct offset and supplementary measures.

Each component of the Biodiversity offset package is detailed in section 11. The offset liability would be refined and included in the Extraction Plans as required by the NSW *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence* (OEH 2016).

Glossary and Abbreviations

Abbreviation	Definition
Area 5	Dendrobium Area 5
Area 6	Dendrobium Area 6
BAR	Biodiversity Assessment Report
BBAM	BioBanking Assessment Methodology
BBCC	BioBanking Credit Calculator
BC Act	*NSW Biodiversity Conservation Act 2016*
BCT	Biodiversity Conservation Trust
BOS	Biodiversity Offset Strategy
BVT	BioMetric Vegetation Type
CCL	Consolidated Coal Lease
CEEC	Critically Endangered Ecological Community
CEM	Canopy Elevation Model
CHM	Canopy Height Model
CMA	Catchment Management Authority
CPP	Coal Production Plant
DP&E	Department of Planning and Planning and Environment
EEC	Endangered Ecological Community
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FBA	*Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects*
FSLs	Full Supply Levels
ha	Hectare/s
IBRA	Interim Biodiversity Region of Australian
Local population	The population of a particular threatened species that occurs in the locality
Locality	The area within 5 km of the Study Area
MNES	Matters of National Environmental Significance listed under the EPBC Act
MSEC	Mine Subsidence Engineering Consultants
OEH	Office of Environment and Heritage
PCT	Plant Community Type
SEARS	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy

Abbreviation	Definition
Study Area	The Study Area includes the proposed underground mining areas (up to 600 m from the proposed longwalls) and surface infrastructure areas, as illustrated in Figure 2
TEC	Threatened Ecological Community as listed under the BC Act and or EPBC Act. Collective term to describe vulnerable, endangered and critically endangered ecological communities

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1. Introduction

1.1 Overview

The Dendrobium Mine (the Mine) is an existing underground coking coal mine located in the Southern Coalfield of New South Wales. The Dendrobium Mine was approved in 2001 and has operated since that time under approvals from both the NSW Government (under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act)) and the Commonwealth Government (under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)).

The Dendrobium Mine is located in the Southern Coalfield of New South Wales approximately 8 kilometres (km) west of Wollongong (Figure 1). The Mine is owned and operated by Illawarra Holdings Pty Ltd (Illawarra Coal), a wholly owned subsidiary of South32 Limited (South32). South32 is seeking development consent to gain access to additional coal reserves within two future underground mining areas within Consolidated Coal Lease (CCL) 776, known as 'Area 5' and 'Area 6'. The underground mining areas will be serviced by associated infrastructure such as ventilation shafts and the existing infrastructure at the Mine. Additional personnel will use the new Dendrobium Pit Top Carpark. The location of the proposed mining areas and ventilation shafts is shown in Figure 2. The proposed works are known as the Dendrobium Mine – Plan for the Future: Coal for Steelmaking Project (the Project).

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by South32 to assess the ecological values and impacts associated with the Project and provide a Biodiversity Assessment Report (BAR) and Biodiversity Offset Strategy (BOS) in accordance with the *Framework for Biodiversity Assessment - NSW Biodiversity Offsets Policy for Major Projects* (FBA) (OEH 2014). The BAR describes and assesses the impacts to biodiversity values within the Study Area and surrounds, particularly threatened biodiversity listed under the NSW *Biodiversity Conservation Act 2016* (BC Act). The BOS provides a proposed strategy to the required biodiversity offset. This document (herein referred to as "This BAR") satisfies the requirements of both a BAR and a BOS.

This assessment also includes detailed historic analysis completed by Watershed (2019) of Dendrobium Mine Coastal Upland Swamps and swamp piezometer data following longwall mining (Appendix 12)

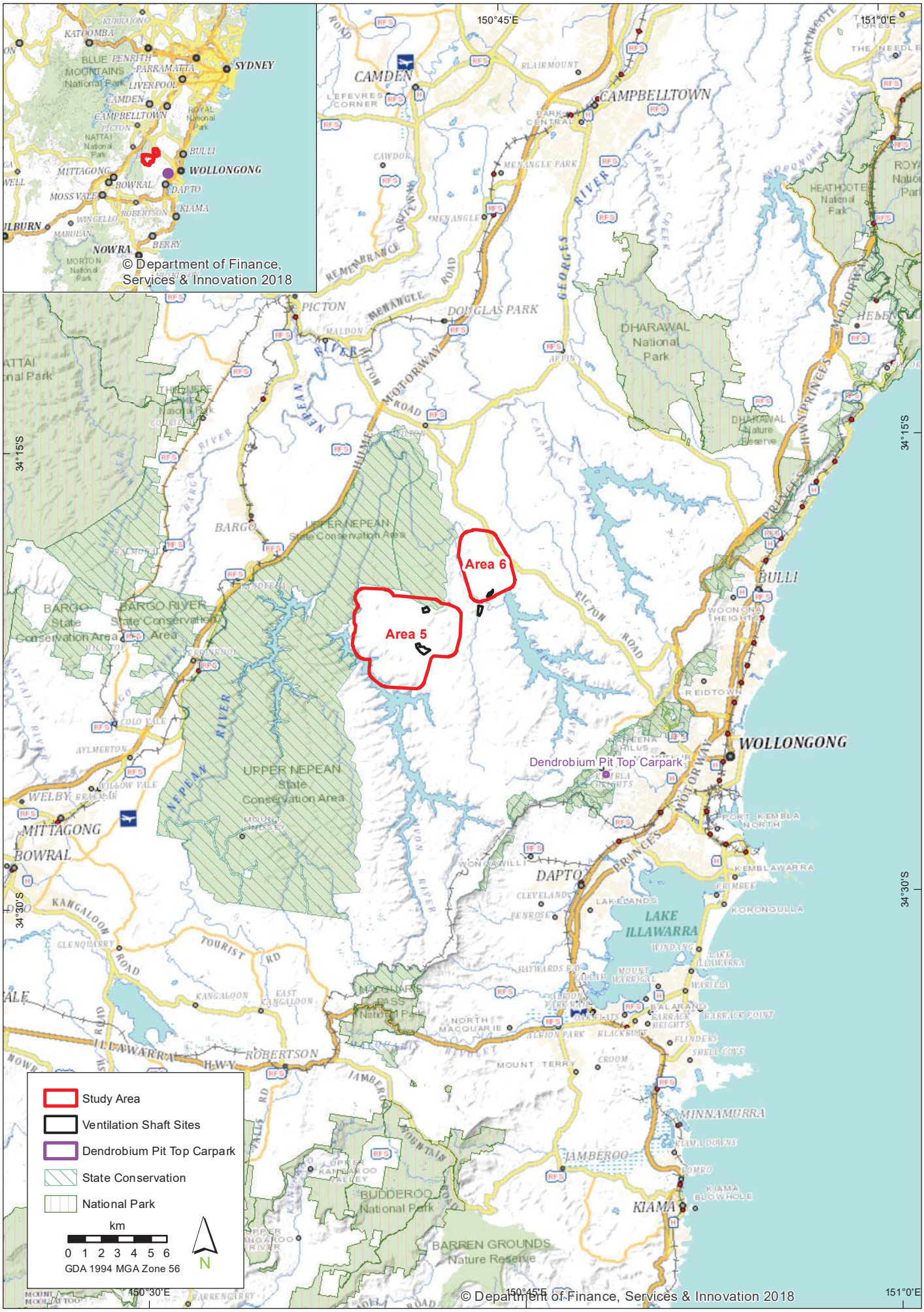
1.2 The Project

1.2.1 Study Area

The Study Area refers to the proposed underground mining area (Area 5 and Area 6, collectively) as well as surface infrastructure areas detailed below and shown in Figure 2.

Mining Area

The Project involves the development and underground mining of two new mining domains called Area 5 and Area 6. The areas potentially subject to subsidence effects associated with Area 5 and Area 6 are approximately 2,958 ha and 1,075 ha respectively.



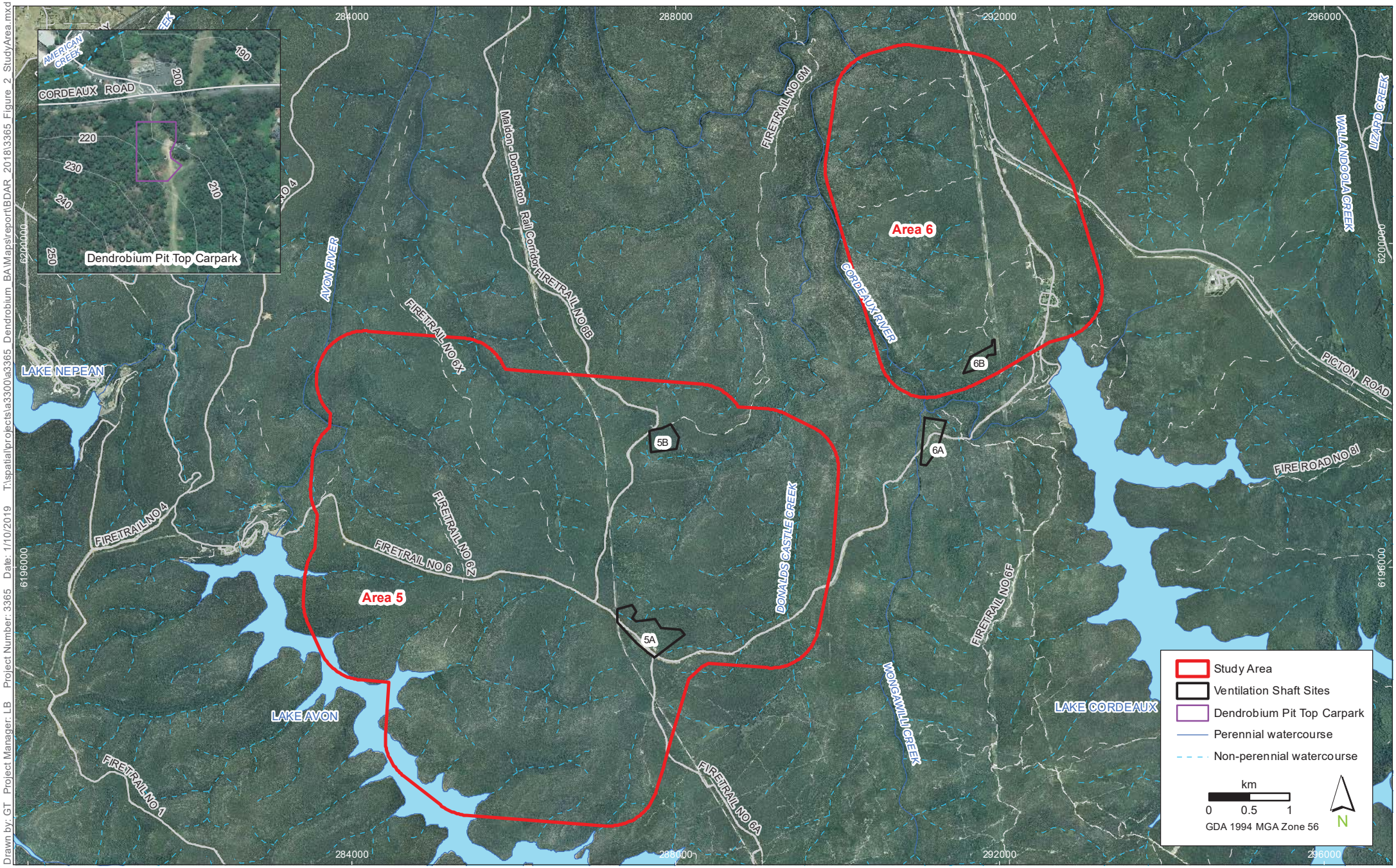
Regional context

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

Source: Illawarra Coal and Niche

FIGURE 1

niche Environment and Heritage



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Study Area

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 2

Imagery: (c) S32 2009

Surface Infrastructure Area

The surface infrastructure associated with the Project includes four ventilation shaft sites as shown on **Figure** 2. The ventilation shaft sites range from approximately 3 ha to 7.5 ha in area (Table 1). The total area of disturbance from the ventilation shafts will be 18.8 ha.

An extension of the existing Dendrobium Pit Top Carpark off Cordeaux Road, Kembla Heights is proposed to increase the capacity. In total, the area of disturbance is approximately 0.3 ha of which 0.2 ha of native vegetation occurs within the Project footprint.

It should be noted that the carpark is a component of the Study Area but is not shown on the mining area figures due to the distance from Area 5 and 6. The carpark is located approximately 12 km south-east of Area 5 and Area 6 and as shown in **Figure** 2.

A total of 19.0 ha of native vegetation will be impacted in in the surface infrastructure area (Table 1).

Table 1: Ventilation Shaft Site and Car Park Disturbance Footprint

Site	Area of Disturbance (ha)	Area of Native Vegetation Impacted (ha)
Ventilation Site No 5A	7.5	7.5
Ventilation Site No 5B	3.0	3.0
Ventilation Site No 6A	4.3	4.3
Ventilation Site No 6B	4.0	4.0
Carpark	0.3	0.2
Total Area	19.1	19.0

Ventilation Shaft Transmission Lines

An electricity transmission line would be required to service each of the ventilation shaft sites. To date, the precise transmission line easements have not been determined, however it is envisaged that much of the alignments would follow existing Fire Roads, with an 8 m buffer required either side of the transmission lines. Only vegetation above an approximate height of 2 m within the transmission line corridors would be cleared and maintained via slashing. Notwithstanding, a full loss scenario has been assumed for the purposes of this assessment and offset strategy.

To account for the impacts to native vegetation and habitat associated with the transmission lines, Niche have assumed that the impacts associated with the transmission lines are limited to:

- A maximum of 4.5 ha of vegetation disturbance outside of the proposed surface infrastructure sites;
- Impacts would avoid Coastal Upland Swamps Threatened Ecological Communities (TECs);
- Impacts for threatened fauna and threatened flora requiring species credits would be assessed and offset accordingly once the final design has been determined (indicative calculations provided in section 10.1); and
- Impact to the Shale Sandstone Transition Forest in the Sydney Basin Bioregion TECwould be limited to 0.5 ha of disturbance.

Additional Service Boreholes

Services such as compressed air, diesel and water required by advancing longwall operations would be delivered from the surface via the Dendrobium Pit Top, Cordeaux Pit Top and service boreholes.

As the mining operations progress, additional service boreholes would be installed, and would generally be located adjacent to other surface infrastructure areas (e.g. new ventilation shafts), resulting in minimal additional disturbance. The location of the additional service boreholes has not yet been determined however, typically each service borehole would consist of a 0.25 ha area located where possible within a previously disturbed area.

If required outside of the proposed ventilation shaft site disturbance areas, the installation of service boreholes and related surface infrastructure would be subject to environmental assessment studies. These studies and any associated management measures would be detailed in a Surface Services Management Plan. The Surface Services Management Plan would be prepared to the satisfaction of the Secretary of the Department of Planning and Environment (DP&E).

This assessment has assumed that the impacts associated with the additional service boreholes is limited to:

- A maximum of 5 ha of vegetation disturbance outside of the proposed surface infrastructure sites;
- Impacts would avoid Coastal Upland Swamps TECs; and
- Impact to the Shale Sandstone Transition Forest TEC would be limited to 1 ha of disturbance.

1.3 Approval Process

1.3.1 Application of the FBA

This BAR has applied the FBA to describe and assess the ecological values within the Study Area and surrounds and determine how the Project is likely to have an impact on threatened biodiversity listed under the BC Act.

This assessment has been completed using the BioBanking Credit Calculator (BBCC) Version 4.0 (4 December 2018) by Accredited Assessors listed in section 1.5.

1.3.2 Commonwealth Requirements

An approval under the Commonwealth EPBC Act is required for the Project due to identified impacts on listed Matters of National Environmental Significance (MNES). A Referral has been submitted to the Commonwealth Department of the Environment and Energy in accordance with the requirements of Part 8 of the EPBC Act, to which the Commonwealth has declared the Project a Controlled Action (EPBC 2017/7855).

This BAR has addressed the Commonwealth Secretary's Environmental Assessment Requirements (SEARs)and provides a biodiversity offset strategy that satisfies the Commonwealth Offsetting Principles (section 11).

1.3.3 Secretary Environmental Assessment Requirements

In preparing this BAR, the SEARs issued for the Project on 6 February 2017, which were revised on 18 September 2018, have been addressed. The key matters raised by the Secretary that are applicable to this BAR, and the section within this report which addresses each of the SEARs, is outlined in Appendix 1.

1.4 Assessment Objectives

The primary objective of this assessment is to use the guidelines and methodology provided in the FBA to determine the impact the Project will have on biodiversity, and to calculate the Project's biodiversity offset requirement. This assessment also considers the OEH (2016) *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence* and SEARs for the Project.

1.5 Assessment Resources and Assessor Qualifications

This BAR has been prepared by the following accredited assessors:

- Simon Tweed (Senior Ecologist): fauna field survey, data management, data entry, credit calculations, review of credit calculations, report preparation.
- Luke Baker (Senior Botanist): flora field survey, data management, data entry, credit calculations, review of credit calculations, report preparation.
- Evelyn Craigie (Senior Ecologist): credit calculations and report preparation.

Other specialist staff involved in preparing the assessment include:

- Matthew Richardson (Director): report review, quality assurance.
- Alex Christie (Botanist): report preparation.
- Dr Ross Jenkins (Team Leader GIS and Systems Analyst): mapping.
- Greg Tobin (GIS Analyst): mapping.
- Matthew Stanton (Research Ecologist): field survey, Anabat analysis.

2. Background Review

2.1 Defining Threatened Biodiversity for Assessment

In completing this BAR, a number of threatened species databases and previous documents relevant to the Project have been reviewed in order to determine a list of threatened biodiversity that may occur within the Study Area and assist with project survey planning and avoidance of natural features.

Database searches and literature that have been reviewed include the following:

- OEH (2018) Atlas of NSW Wildlife searches of threatened flora within 10 km and fauna within a 5 km radius of the Study Area (obtained from the Atlas of NSW Wildlife in September 2018). The results of the search have been included in Appendix 2.
- Department of the Environment (2018a) Protected Matters Search was carried out for flora within a 10 km area and fauna within a 5 km area around the Study Area. Results from the database searches have been incorporated into Appendix 2.
- OEH (2011) Archived BioMetric and Threatened Species Profiles Datasets.
- OEH BBCC (Version 4.0) (detailed below in section 2.2).
- Records of Woronora Beard Heath (*Leucopogon exolasius*) at Donalds Castle Creek recorded by Biosis (2016).

The list generated was further refined by considering the likelihood of occurrence and the likelihood of impacts for each species.

Five categories for 'likelihood of occurrence' (Table 2) were attributed to the list of threatened 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 were those in the 'Known' to 'Moderate' categories and where impacts for the species could reasonably occur from the Project.

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 common habitat for this species which the species would not rely on for its on-going local existence such as limited breeding habitat resources.
None	The species has not been recorded within the Study Area and habitat within the Study Area is unsuitable for the species.	The species has not been recorded within the Study Area and habitat within the Study Area is unsuitable for the species.

2.2 BioBanking Credit Calculator

Threatened species predicted to occur within the Catchment Management Authority (CMA) subregion (BioBanking Threatened Species Profile Database) were reviewed and included within the Threatened Species Likelihood of Occurrence Tables (Appendix 2). The list of species predicted to occur within the CMA Subregion was refined for the Study Area within the BBCC. This involved refining the list on the basis of answering a series of 'Geographic and habitat feature' questions within the BBCC, which further filtered the threatened species that are likely to be relevant to the habitats present within the development footprint. The details of the inputs to generate the list are provided below.

Table 3 outlines the responses to geographic/habitat feature questions in the BBCC. The results have been further detailed in section 5 and section 6.

Table 3. Project relevant geographic and habitat questions

Question Does any part of the development impact on:	Answer
land within 250 m of termite mounds or rock outcrops	Yes
heath or eucalypt forest on sandstone with a build-up of litter or other debris and containing, or within 40 m of, ephemeral or intermittent drainage lines	Yes
land containing escarpments, cliffs, caves, deep crevices, old mine shafts or tunnels	Yes
land within 40 m of heath, woodland or forest	Yes
land within 500 m of sandstone escarpments with hollow-bearing trees, rock crevices or flat sandstone rocks on exposed cliff edges and sandstone outcropping	Yes
land within 100 m of permanent rocky streams with thick fringing vegetation	Yes
moist heath	Yes
land within 100 m of coastal or Coastal Upland Swamps, bogs or wetlands	Yes
land within 40 m of dense multi-layered coastal heath with patches that have been unburnt for 3 years or more	Yes
land within 100 m of emergent aquatic or riparian vegetation	Yes
rainforest or tall open wet forest with understorey and/or leaf litter and within 100 m of streams	Yes
land within 40 m of freshwater and estuarine wetlands, in areas of permanent water and dense vegetation or emergent aquatic vegetation	No

The responses to the geographic and habitat questions generated the following list of species credit predicted species for consideration in this assessment along with the suggested survey time (Table 4).

Table 4: Predicted Threatened Species for Consideration

Common Name	Scientific Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Acacia baueri subsp. aspera	*Acacia baueri subsp. aspera*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bargo Geebung	*Persoonia bargoensis*	Yes	Yes	Yes	Yes	Yes							Yes
Broad-headed Snake	*Hoplocephalus bungaroides*			Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Rufous Pomaderris	*Pomaderris brunnea*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bynoe's Wattle	*Acacia bynoeana*	Yes	Yes	Yes						Yes	Yes	Yes	Yes
Deane's Paperbark	*Melaleuca deanei*	Yes	Yes										Yes
Eastern Ground Parrot	*Pezoporus wallicus subsp. wallicus*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Eastern Pygmy-possum	*Cercartetus nanus*												
Epacris purpurascens subsp. purpurascens	*Epacris purpurascens subsp. purpurascens*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Giant Burrowing Frog	*Heleioporus australiacus*	Yes	Yes	Yes	Yes	Yes				Yes	Yes	Yes	Yes
Giant Dragonfly	*Petalura gigantea*	Yes											Yes
Green and Golden Bell Frog	*Litoria aurea*	Yes	Yes	Yes					Yes	Yes	Yes	Yes	Yes
Hairy Geebung	*Persoonia hirsuta*	Yes	Yes	Yes	Yes	Yes							Yes
Hibbertia puberula	*Hibbertia puberula*	Yes	Yes							Yes	Yes	Yes	Yes
Koala	*Phascolarctos cinereus*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Large-eared Pied Bat	*Chalinolobus dwyeri*	Yes	Yes	Yes	Yes					Yes	Yes	Yes	Yes
Littlejohn's Tree Frog	*Litoria littlejohni*	Yes	Yes							Yes	Yes	Yes	Yes
Needle Geebung	*Persoonia acerosa*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prickly Bush-pea	*Pultenaea aristata*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Red-crowned Toadlet	*Pseudophryne australis*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rosenberg's Goanna	*Varanus rosenbergi*	Yes	Yes									Yes	Yes
Slaty Leek Orchid	*Prasophyllum fuscum*									Yes	Yes	Yes	Yes
Small-flower Grevillea	*Grevillea parviflora subsp. parviflora*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Southern Brown Bandicoot (eastern)	*Isoodon obesulus subsp. obesulus*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stuttering Frog	*Mixophyes balbus*	Yes	Yes	Yes	Yes	Yes				Yes	Yes	Yes	Yes
Sublime Point Pomaderris	*Pomaderris adnata*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Woronora Beard-heath	*Leucopogon exolasius*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

3. Landscape Assessment

3.1 Overview

The assessment of the landscape features includes identification of a number of landscape features and determining the Landscape Value, i.e. the spatial configuration of vegetation. The Landscape Value includes an assessment of the current state of the landscape around the proposal, and the state of the landscape if the proposal were to proceed. The Landscape Value for this assessment is based on:

- Percent (%) native vegetation cover in the landscape at the 1,500 and 15,000 ha scales;
- Connectivity value; and
- Patch size.

The key landscape features, and the inputs into the BBCC are provided below.

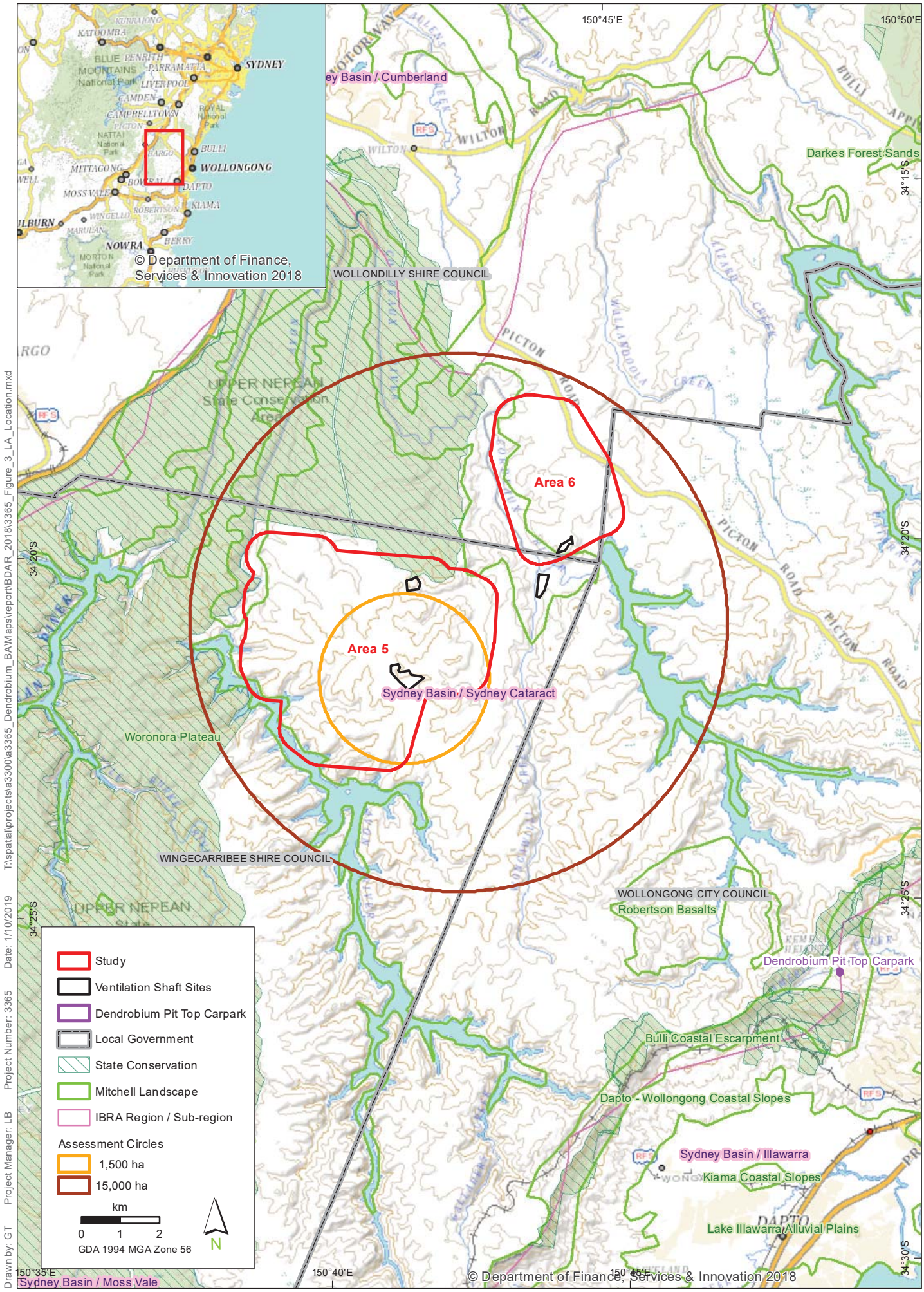
3.2 Identification of Landscape Features

Landscape features have been identified in accordance with Section 4 of the FBA and are provided in Table 5 and shown in Figure 3 and Figure 4.

Table 5: Landscape Features

Landscape Feature	Description
Local Government Area(s)	Wollongong City Council, Wingecarribee Shire Council, Wollondilly Shire Council.
IBRA bioregion	Sydney Basin.
IBRA subregion	Area 5, Area 6 and Ventilation Shaft Sites: Sydney Cataract. Carpark: Illawarra.
Mitchell Landscape	Area 5 and Area 6: Woronora Plateau (majority of Study Area), Upper Nepean Gorges. Carpark: Bulli Coastal Escarpment.
Rivers, streams and estuaries	Avon River (5th order stream) lies to the west of Area 5. Cordeaux River (5th order stream) is located on the western boundary of Area 6. Donalds Castle Creek and Wongawilli Creek are also situated on the perimeter of the Study Area. Watercourses are shown on Figure 5.
Wetlands	There are no Coastal Wetlands in the Study Area, in accordance with State Environmental Planning Policy (SEPP) (Coastal Management) 2018 (previously known as SEPP 14 Coastal Wetlands). Coastal Upland Swamps occur in the Study Area and are described in section 4.2.2 and shown in Figure 7.
Native Vegetation Extent	Inner Assessment Circle = 1,456 ha Outer Assessment Circle = 14,667 ha
State or regionally significant biodiversity links	The Study Area is within the Nattai-Woronora Regional Corridor, which links the Woronora Plateau in the east to the Nattai Plateau in the west. The Project would not affect the utility of this corridor.

In summary, the Study Area predominately occurs within the Sydney Basin Interim Biodiversity Region of Australia (IBRA), and predominately the Sydney Cataract IBRA subregion. The Woronora Plateau Mitchell Landscape occurs across the majority of the Study Area.

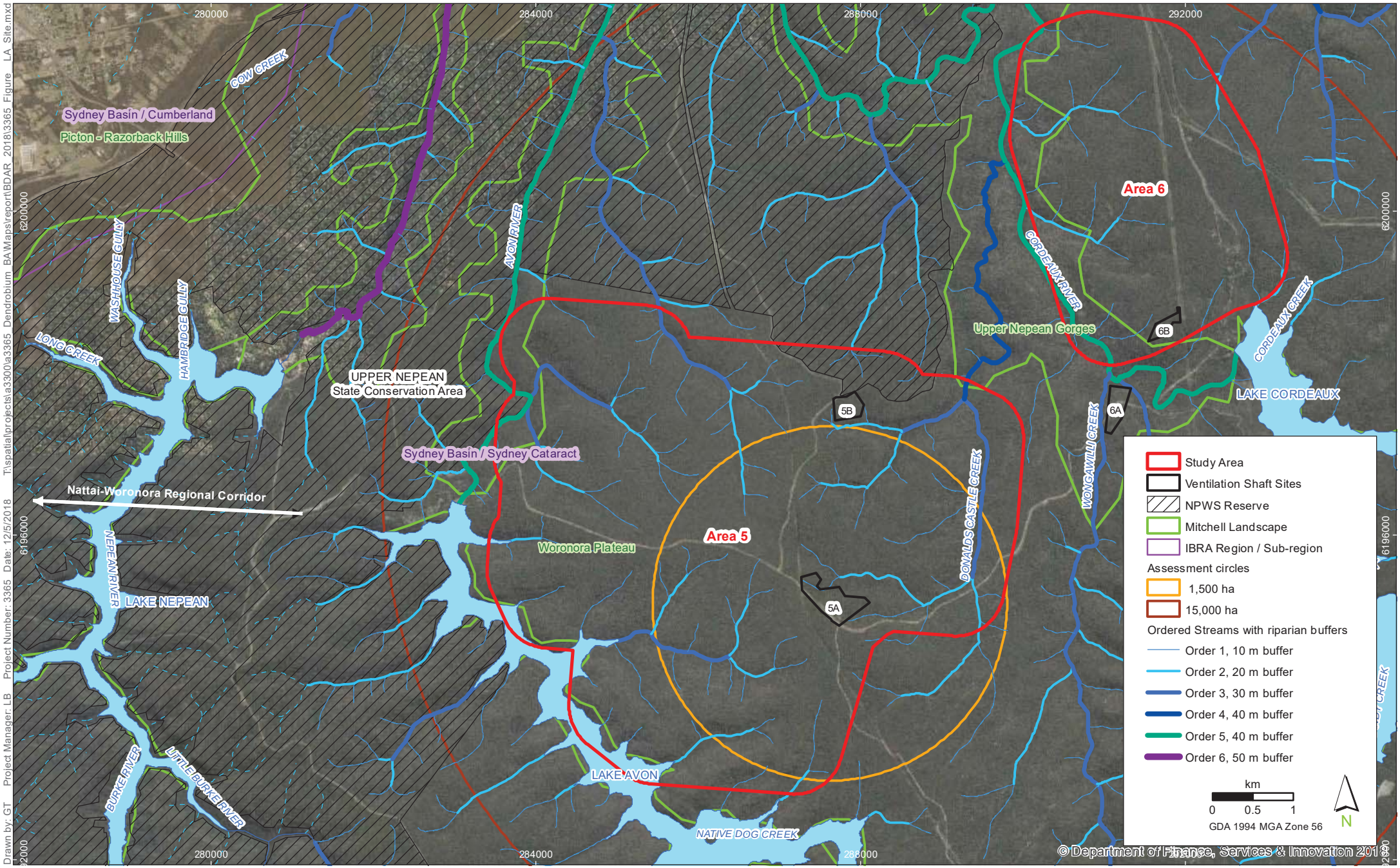


Landscape Assessment - Location context

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

Source: Illawarra Coal and Niche

FIGURE 3



Landscape Assessment - Site map

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 4

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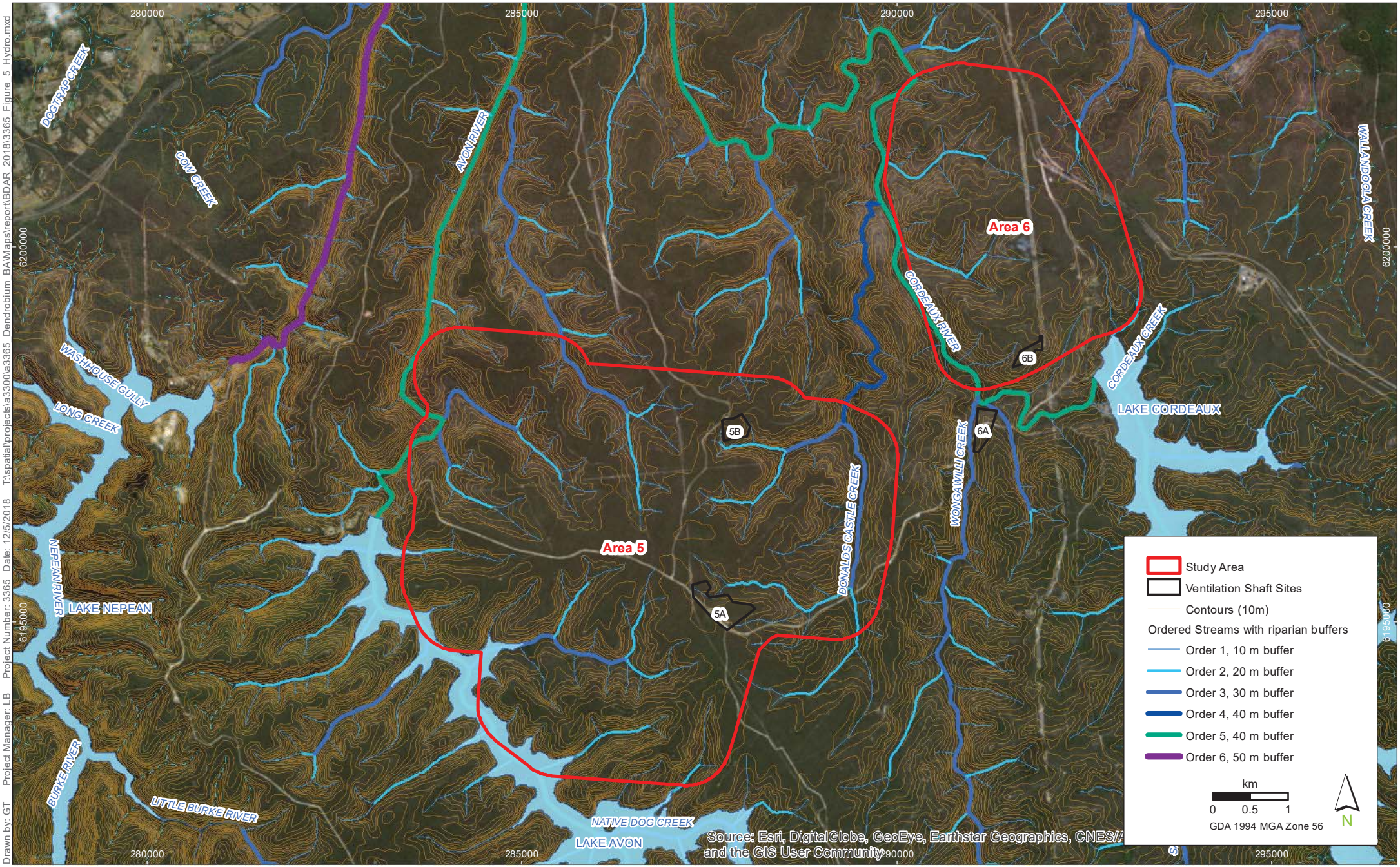

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Watercourses within the Study Area

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 5

Imagery: (c) Digitalglobe 2108/01/11

Important natural features that occur within, or immediately adjacent to the Study Area include:

- Avon River – which occurs immediately to the west of Area 5;
- Cordeaux River – which occurs on the western perimeter of Area 6;
- Coastal Upland Swamps mapped throughout Area 5 and 6;
- Extensive native vegetation throughout the Study Area; and
- Lake Avon located immediately to the south of Area 5, and Lake Cordeaux located immediately to the south of Area 6.

3.3 Landscape Value

The Landscape Value score has been generated based on the 'site-based' method as specified in the FBA. The 'site-based' method accounts for the percentage decrease in vegetation clearing within the Assessment Circles, and the impact that the development may have on connectivity width.

The Project's surface disturbance footprint is largely attributed to the ventilation shaft sites. Given the distance of the ventilation shaft sites from each other, and the uniformity of the landscape in the surrounding area, a 1,500 ha inner assessment circle has been placed over the largest ventilation shaft location (Site No. 5A), with a corresponding 15,000 ha outer assessment circle (Figure 3). Separate assessment circles have not been provided for the carpark area as this would require the BBCC to be run separately. This is not considered necessary as the carpark area is small (0.2 ha of native vegetation) and would not result in a change to the per cent native vegetation cover before and after development.

The inputs into the BBCC have been provided in Table 6, with the relevant Landscape Value components shown in Figure 3 and Figure 4.

Table 6: Landscape Value Components

Landscape Value Score Component	Description
Percent native vegetation cover	There is no change in the extent of native vegetation as a result of the surface infrastructure: 1,500 ha assessment circle: 96 – 100% (before and after development). 15,000 ha assessment circle: 96 – 100% (before and after development).[1]
Connectivity value	A riparian buffer of a 5th order stream (Avon River and Cordeaux River) was entered into the calculator (before and after development) as this feature occurs in the Study Area and may be impacted by subsidence related impacts.
Patch size	Given the extensive native vegetation within the Study Area, the patch size is greater than the maximum patch size score (2,000 ha) within the BBCC.

[1] The extent of native vegetation within assessment circles has not been shown on a Figure given the scale of the Study Area. Based on the extensive native vegetation, the native vegetation cover would be 96-100% cover.

The information presented in the above sections was entered into the BBCC, resulting in a landscape score calculation of 21.0 for the Project.

4. Assessing Native Vegetation

4.1 Overview

The assessment of native vegetation detailed the survey effort and identification and distribution of native vegetation in the Study Area. This section details the plots completed in accordance with the FBA and provides alignment to TECs.

The BioMetric Vegetation Types (BVTs) are entered into the BBCC along with the attribute data collected from the flora plots. This data is used in the BBCC to determine the current 'site value' score.

4.2 Vegetation Verification

The flora survey methodology followed the FBA with additional information recorded (abundance, structure etc.) on the basis of current best practice flora survey guidelines for assessment of a large site, particularly OEH's Working Draft *Threatened Biodiversity Survey and Assessment – Guidelines for Developments and Activities* (DEC 2004a) and OEH (2016) *NSW Guide to Surveying Threatened Plants*.

The flora methodology was applied over the Study Area on the following dates:

- 24th October to the 27th of October 2016;
- 31st October to the 2nd November 2016;
- 4th November 2016;
- 10th November 2016;
- 17th and 18th of November 2016;
- 10th to 13th of May 2017;
- 16th to 18th of May 2018; and
- 1st June 2018.

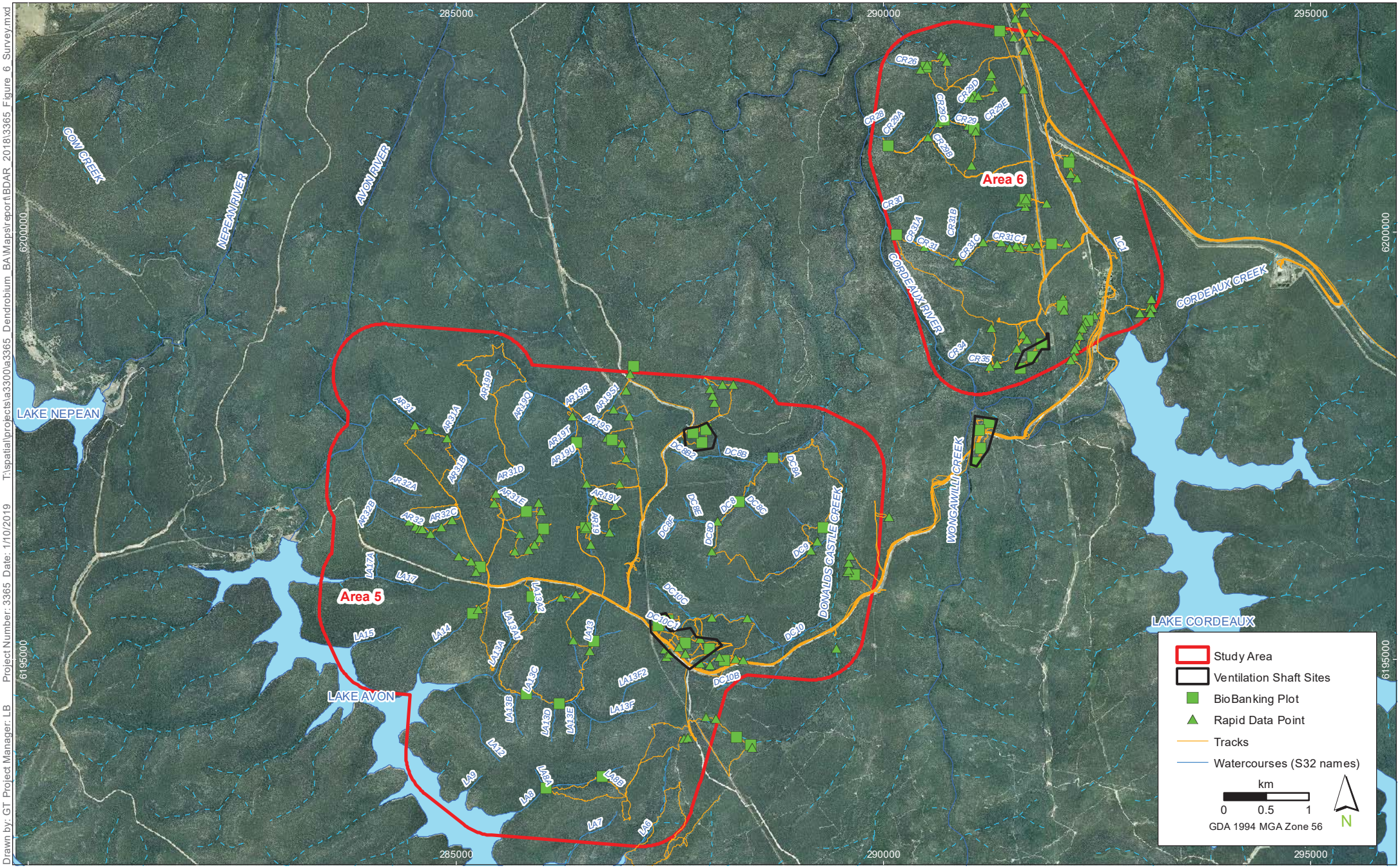
The field survey concentrated on searches for threatened flora that occur within habitat that may be impacted by subsidence impacts, and the validation of the NPWS (2003) vegetation mapping within Plant Community Types (PCTs) and BVTs likely to be impacted by subsidence or impacted by surface infrastructure. The validation of the PCTs was achieved by completing the required number of floristic plots consistent with the methods specified in the FBA.

In summary, the core areas that have been validated include:

- Coastal Upland Swamps/Groundwater Dependant Ecosystems.
- Riparian vegetation.
- Areas of vegetation disturbance associated with the proposed surface infrastructure sites.

The aim was to adequately sample each of the PCTs across the Study Area using a combination of vegetation quadrats, transects, rapid data points and driving transects or walking meanders.

The number of plots surveyed within the Study Area is provided in Table 7 and locations shown in Figure 6.



Vegetation and flora survey effort (Niche 2016-2018)

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 6

Imagery: (c) S32 2009

Table 7: Flora Survey Effort and Plot Requirements

Plant Community Type ID	Biometric Vegetation Type	Condition	Study area total (ha)[1]	Total plots required (FBA)	Total plots conducted in Study Area
Coastal Upland Swamps					
978	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion (Banksia Thicket)	Moderate/good	3.7	3	3
1804	HN662 Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin (Tea Tree Thicket)	Moderate/good	9.1	3	6
978	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion (Sedgeland Complex)	Moderate/good	0.4	1	1
978	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion (Restioid Heath)	Moderate/good	23.4	4	8
1804	HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin (Cyperoid Heath)	Moderate/good	1.3	2	2
978	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion (Eucalypt Fringing Woodland)	Moderate/good	30.7	4	4
Riparian zones[2]					
1083	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion	Moderate/good	66.6	5	11
Ventilation shaft sites					
1083	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion	Moderate/good	45.1	4	12
		Moderate/good_high	2.3	2	2
		Moderate/good_other	0.3	1	1
Pit Top Carpark					
1245	Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	Moderate/good_low	0.2	1	1

1 Restricted to the areas for the ventilation shaft sites, car park, Coastal Upland Swamps (HN560 & HN662) and riparian zones. Note that the areas inspected for the ventilation shaft sites is much larger than that proposed to be impacted by the Project.

2 Based on existing mapping, a total length of approximately 66 km of riparian habitat has been estimated within the Study Area. Assuming a riparian corridor width of 10 m, the area of riparian habitat can be reasonably estimated at 66.6 ha across the Study Area.

BioBanking plots collected the following attributes:

- Native species richness (20 x 20 m).
- Native over-storey cover (projective foliage cover at 5 m intervals along 50 m transect).
- Native mid-storey cover (projective foliage cover at 5 m intervals along 50 m transect).
- Native ground cover (grasses) (frequency tally at 1 m intervals along 50 m transect).
- Native ground cover (shrubs) (frequency tally at 1 m intervals along 50 m transect).
- Native ground cover (other) (frequency tally at 1 m intervals along 50 m transect).
- Exotic cover (as for native over-storey, mid-storey and groundcover).
- Over-storey regeneration (proportion of overstorey dominants present as immature recruitment).
- Number of trees with hollows (within 50 x 20 m plot).
- Total length of fallen logs (within 50 x 20 m plot).

In addition to the prescribed BioBanking plot methodology above, within each 20 x 20 m plot all vascular plant species were identified (to species level where sufficient plant material was available) and assigned a cover abundance score using a six point scale:

1. Rare, few individuals (three or less) present and cover <5%.
2. Common (consistent throughout plot) and <5%.
3. Cover 6-20%.
4. Cover 21-50%.
5. Cover 51-75%.
6. Cover >75%.

4.3 Detailed Vegetation Mapping

Following the field survey, Niche has revised the NPWS (2003) vegetation mapping of the ventilation shaft areas to reflect the vegetation recorded on-site using the BioBanking plots and rapid data points. The validation of the Dendrobium Pit Top Carpark was added to the vegetation layer.

For the mapping of Coastal Upland Swamps, Niche has revised all the NPWS (2003) Coastal Upland Swamps boundaries and sub-vegetation types (Tea-Tree Thicket, Sedgeland-Heath Complex (including Sedgeland, Restioid Heath and Cyperoid Heath), Banksia Thicket, Fringing Eucalypt Woodland) using the methods described below.

4.3.1 Coastal Upland Swamps Validation

4.3.1.1 Pre-Processing

Prior to undertaking the validation of Coastal Upland Swamp mapping, the following data was obtained from South32 and overlayed in ARCGIS:

- LiDAR data was supplied in the form of LAS files covering the majority of the Study Area.
- Aerial imagery (2009, 2015).
- Preliminary swamp boundaries derived from Woronora vegetation mapping (NPWS 2003) and modified by South32 where there were obvious discrepancies.

Inspection of the existing mapped swamp boundaries (i.e. the Woronora vegetation and related vector data) indicated that those swamp polygons were either displaced from the boundaries clearly distinguishable on orthophotography, did not capture the sensible extent of the swamp, or extended into non-swamp woodland.

A consequent first step was to roughly re-align the swamp boundaries to better represent swamp dimension in order to:

- guide first approximation of the swamp extent for Canopy Height Model (CHM) editing (described below); and
- provide a representative swamp extent for internal swamp vegetation community delineation.

4.3.1.2 Data Development

LAS files were converted to raster surfaces using ArcGIS for Desktop v10.4 software using the <LAS Dataset to Raster> command. Command parameters for point to raster interpolation are as follows:

- Binning (bare earth DEM) – cell assignment is average, void fill method is natural neighbour.

- Binning (canopy elevation model - CEM) – cell assignment is maximum, void fill method is none.
- Floating decimal point output and 1 m cell size (for both DEM and CEM).

A CHM was then generated by subtracting the DEM from the CEM.

4.3.1.3 Swamp Delineation

Height stratification of the CHM to represent swamp boundaries was determined by trial and error. This was required as there are in-swamp features, later identified typically as Banksia Thicket, that were greater than 5 m elevation, so a low elevation as used by Jenkins and Frazier (2010) was not applicable. A 10 m stratification, on visual examination, captured the full extent of swamps, however also captured many instances of inter-connected tree canopy gaps. Consequently, a manual editing effort was required to restrict the 'swamp' CHM to a margin adjacent to swamps.

Manual editing involved visual comparison of aerial imagery (typically 2009) with the CHM stratified (> 10 m) dataset. For editing purposes, the CHM raster was converted to vector, without polygon simplification (i.e. all 1 m 'step-wise' boundaries were retained).

In the first instance, edits to eliminate non-swamp polygons were undertaken at the polygon narrowest gap, which was usually one-two pixels wide. Edits were constructed to form north to south, or east to west boundaries, in order to preserve the pixel dimensions for future comparison.

Discrimination of swamp versus non-swamp vegetation was taken on characteristic swamp vegetation texture and colour, along with absence of on-ground woody vegetation typical of eucalypt woodland. In general, a fringe of woodland was retained (later classified as Upland Swamp: Fringing Eucalypt Woodland) in order to fully delineate the swamp boundary.

No attempt to delineate the extent of Coastal Upland Swamp: Fringing Eucalypt Woodland was made using GIS. Field validation of the boundary was difficult given that Coastal Upland Swamps: Fringing Eucalypt Woodland transitions gradually with the surrounding Exposed Sandstone Scribbly Gum Woodland and/or Sydney Peppermint Gully Forest communities. Edits to boundaries where no narrow polygon gap was available were also constructed using east to west, or north to south boundaries where possible, except in locations where this would clearly not represent a sensible boundary. In the latter case, boundaries are typically a minimum of 20 m in length and are clearly discernible against the 'pixel dimension' background.

In many locations, scattered trees are present and surrounded by swamp vegetation. Individual trees or clusters of a small number of trees were retained as a non-threatened community ('in-swamp tree') in order to avoid data discontinuities. Separation of scattered 'in-swamp' trees and Coastal Upland Swamps: Fringing Eucalypt Woodland was based on an approximate 30% canopy cover cut off.

The final product resulted in a Coastal Upland Swamp detailed vegetation mapping layer, that has been incorporated into the final vegetation mapping for the Study Area.

4.4 Vegetation Zones

A total of 10 PCTs (vegetation zones) were identified in the Study Area based on the results of the field inspection, NPWS (2003) mapping, and detailed Coastal Upland Swamp mapping. Each of the PCTs, along with corresponding BVT, Keith Formation and Class, and areas within the Study Area, has been provided in Table 8 and shown on Figure 7. Three condition classes (forming different vegetation zones) were assigned to PCT1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin Bioregion (HN566).

Four vegetation zones have been recorded within the area potentially impacted by the Project (Table 9) which is discussed further in section 4.4.1.

A description for each of the PCTs have been provided in Appendix 3.

4.4.1 Vegetation within Surface Infrastructure Areas

Based on the result of the field survey, two PCTs occur in areas that are subject to direct impact (vegetation clearing) for the construction of the ventilation shaft sites, and the carpark.

The PCT to be impacted by clearing for the ventilation shaft sites is PCT1083 Red Bloodwood - scribbly gum heathy woodland (HN566), which is the dominant vegetation community of the sandstone plateaus within the Metropolitan Water Catchment (MU29). A description for PCT1083 Red Bloodwood - scribbly gum heathy woodland (HN566) and the other PCTs in the Study Area is provided in Appendix 3.

Three separate zones were established within the PCT1083 Red Bloodwood - scribbly gum heathy woodland (HN566), areas that occur within the ventilation shaft site areas, reflecting differences in condition or structure. The zones were mapped separately as required in the FBA and separate plot data was collected for each zone for use within the BBCC.

The different PCT1083 Red Bloodwood - scribbly gum heathy woodland (HN566), zones to be impacted include:

- The largest zone to be cleared consists of a largely undisturbed form of the community with typical structure in terms of canopy cover. This zone was given the attribute name ‘moderate/good’.
- A naturally open zone was also defined at Ventilation Shaft Site No 5A (generally lacked canopy, and midstorey cover due to influence by a drainage line) was given the attribute name ‘moderate/good_high’.
- A regenerating condition class was defined for regenerating areas (along road easements for example). Road easement vegetation recorded at Ventilation Shaft Site No 5B, Site No 6A, and Site No 5A was given the attribute name ‘moderate/good_other’.

The native vegetation at the Pit Top car park location consists of PCT1245 Sydney Blue Gum x Bangalay - Lilly Pilly moist forest (ME044). A single low condition zone was present with vegetation highly modified (no large native mature trees, isolated native shrubs and a mix of introduced ground cover).

Table 8: Plant Community Types in the Study Area

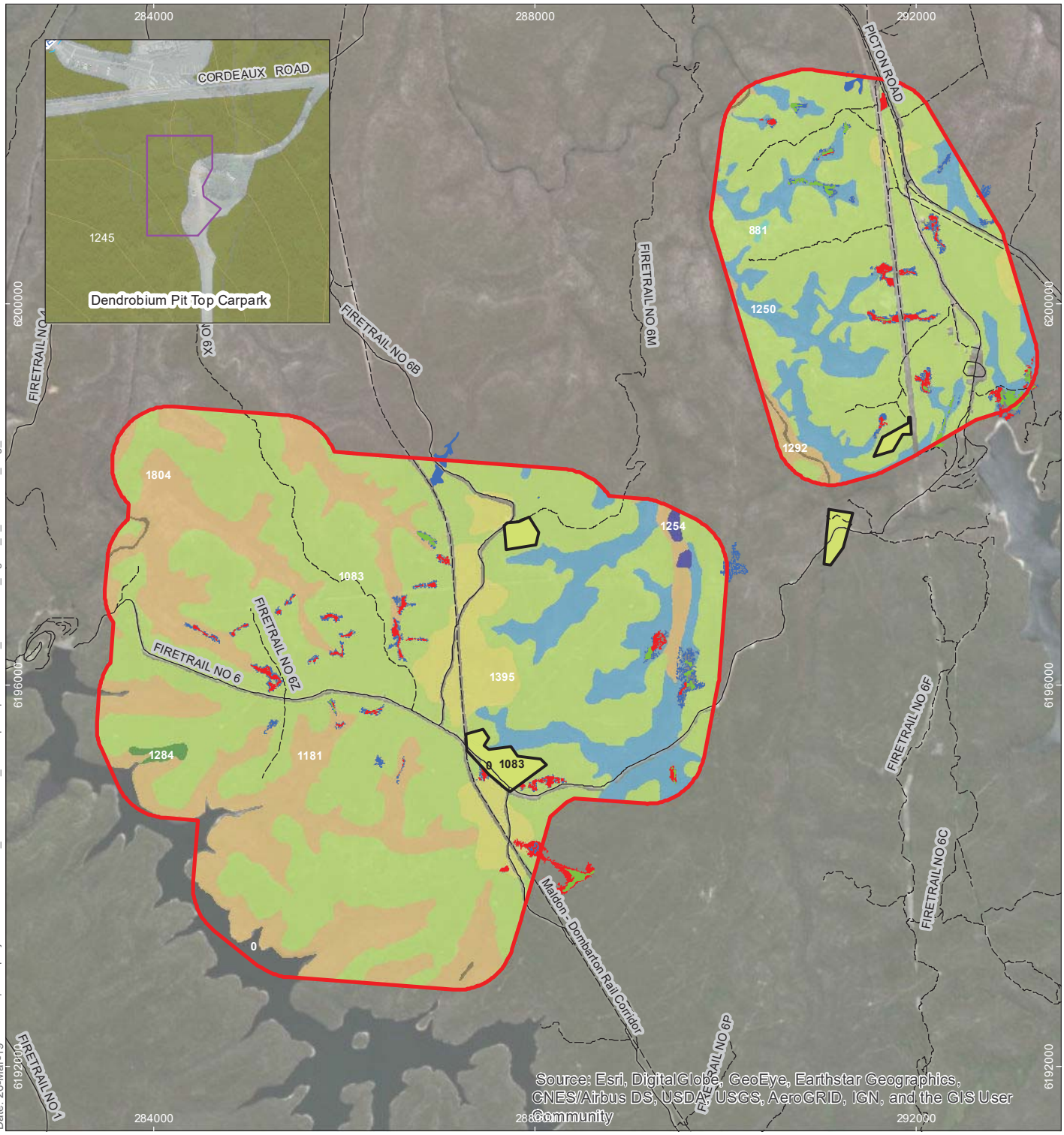
NPWS Vegetation mapping	Vegetation Community (NPWS 2003)	PCT Code	BVT Code	BVT Name	Keith Formation	Keith Class	Corresponding TEC	Area 5 (ha)			Area 6 (ha)			Carpark	Total
								Area 5	Site No 5B[1]	Site No 5A	Area 6	Site No 6B	Site No 6A		
MU18	Highlands Shale Tall Open Forest	1254	HN601	Sydney Peppermint - White Stringybark moist shrubby forest on elevated ridges, Sydney Basin Bioregion	Wet Sclerophyll Forests (Shrubby sub-formation)	Southern Escarpment Wet Sclerophyll Forests	Not listed[2]	6.5	0.0	0.0	0.0	0.0	0.0	0.0	6.5
MU22	Transitional Shale Dry Ironbark Forest	1395	HN556	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Grassy Woodland	Coastal Valley Grassy Woodlands	Shale Sandstone Transition Forest TEC listed under BC Act and EPBC Act.	27.2	0.0	0.0	0.3	0.0	0.0	0.0	27.5
MU23	Transitional Shale Stringybark Forest	1395	HN556	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Grassy Woodland	Coastal Valley Grassy Woodlands	Shale Sandstone Transition Forest TEC listed under BC Act and EPBC Act.	130.8	0.0	0.0	15.2	0.0	0.0	0.0	146.0
MU26	Sandstone Gully Peppermint Forest	1250	HN651	Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion	Dry Sclerophyll Forests (Shrubby sub-formation)	Sydney Coastal Dry Sclerophyll Forests	Not listed	218.5	0.0	0.0	212.2	0.0	0.0	0.0	430.7
MU27	Nepean Sandstone Gully Forest	1181	HN586	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Dry Sclerophyll Forests (Shrubby sub-formation)	Sydney Coastal Dry Sclerophyll Forests	Not listed	689.2	0.0	0.0	23.6	0.0	0.0	0.0	712.8
MU29	Exposed Sandstone Scribbly Gum Woodland (moderate/ good)	1083	HN566	Red Bloodwood - scribbly gum heathy woodland on sandstone plateau, Sydney Basin Bioregion	Dry Sclerophyll Forests (Shrubby sub-formation)	Sydney Coastal Dry Sclerophyll Forests	Not listed	1,697.2	3.0	20.6	725.3	5.4	10.0	0.0	2,461.5
MU29	Exposed Sandstone Scribbly Gum Woodland (moderate/ good_high)	1083	HN566	Red Bloodwood - scribbly gum heathy woodland on sandstone plateau, Sydney Basin Bioregion	Dry Sclerophyll Forests (Shrubby sub-formation)	Sydney Coastal Dry Sclerophyll Forests	Not listed	0.0	0.0	1.6	0.0	0.0	0.7	0.0	2.3
MU29	Exposed Sandstone Scribbly Gum Woodland (moderate/ good other)	1083	HN566	Red Bloodwood - scribbly gum heathy woodland on sandstone plateau, Sydney Basin Bioregion	Dry Sclerophyll Forests (Shrubby sub-formation)	Sydney Coastal Dry Sclerophyll Forests	Not listed	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.3

NPWS Vegetation mapping	Vegetation Community (NPWS 2003)	PCT Code	BVT Code	BVT Name	Keith Formation	Keith Class	Corresponding TEC	Area 5 (ha)			Area 6 (ha)			Carpark	Total
								Area 5	Site No 5B[1]	Site No 5A	Area 6	Site No 6B	Site No 6A		
MU38	Rock Pavement Heath	881	HN540	Hairpin Banksia - Kunzea ambigua - Allocasuarina distyla heath on coastal sandstone plateau, Sydney Basin Bioregion	Heathlands	Sydney Coastal Heaths	Not listed	0.0	0.0	0.0	1.8	0.0	0.0	0.0	1.8
MU4	Sandstone Riparian Scrub	1292	HN607	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	Dry Sclerophyll Forests (Shrub/grass sub-formation)	Cumberland Dry Sclerophyll Forests	Not listed	3.2	0.0	0.0	4.3	0.0	0.0	0.0	7.5
MU42	Coastal Upland Swamps: Banksia Thicket	978	HN560	Needlebush - banksia wet heath on sandstone plateau of the Sydney Basin Bioregion	Freshwater Wetlands	Coastal Heath Swamps	Coastal Upland Swamps of the Sydney Basin Bioregion (BC Act and EPBC Act)	2.0	0.0	0.0	1.7	0.0	0.0	0.0	3.7
MU43	Coastal Upland Swamps: Tea-Tree Thicket	1804	HN662	Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin	Freshwater Wetlands	Coastal Heath Swamps	Coastal Upland Swamps of the Sydney Basin Bioregion (BC Act and EPBC Act)	2.1	0.0	0.0	7.0	0.0	0.0	0.0	9.1
MU44a	Coastal Upland Swamps: Sedgeland-Heath Complex (Sedgeland)	978	HN560	Needlebush - banksia wet heath on sandstone plateau of the Sydney Basin Bioregion	Freshwater Wetlands	Coastal Heath Swamps	Coastal Upland Swamps of the Sydney Basin Bioregion (BC Act and EPBC Act)	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4
MU44b	Coastal Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)	978	HN560	Needlebush - banksia wet heath on sandstone plateau of the Sydney Basin Bioregion	Freshwater Wetlands	Coastal Heath Swamps	Coastal Upland Swamps of the Sydney Basin Bioregion (BC Act and EPBC Act)	14.9	0.0	0.0	8.5	0.0	0.0	0.0	23.4
MU44c	Coastal Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)	1804	HN662	Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin	Freshwater Wetlands	Coastal Heath Swamps	Coastal Upland Swamps of the Sydney Basin Bioregion (BC Act and EPBC Act)	1.1	0.0	0.0	0.2	0.0	0.0	0.0	1.3
MU45	Coastal Upland Swamps: Fringing Eucalypt Woodland	978	HN560	Needlebush - banksia wet heath on sandstone plateau of the Sydney Basin Bioregion	Freshwater Wetlands	Coastal Heath Swamps	Not Listed	18.1	0.0	0.0	12.6	0.0	0.0	0.0	30.7
MU9	Nepean Gorge Moist Forest	1284	HN606	Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion	Wet Sclerophyll Forests (Shrubby sub-formation)	North Coast Wet Sclerophyll Forests	Not listed	7.7	0.0	0.0	0.0	0.0	0.0	0.0	7.7
-	Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes,	1245	ME044	Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	Wet Sclerophyll Forests (Shrubby sub-formation)	North Coast Wet Sclerophyll Forests	Not listed	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
MU49	Weeds and exotic		-	-	-	-	Not listed	0.0	0.0	0.0	5.4	0.0	0.0	0.0	5.4

NPWS Vegetation mapping	Vegetation Community (NPWS 2003)	PCT Code	BVT Code	BVT Name	Keith Formation	Keith Class	Corresponding TEC	Area 5 (ha)			Area 6 (ha)			Carpark	Total
								Area 5	Site No 5B[1]	Site No 5A	Area 6	Site No 6B	Site No 6A		
MU52	Water		-	-	-	-	Not listed	49.0	0.0	0.0	0.0	0.0	0.0	0.0	49.0
MU53	Cleared		-	Cleared land	-	-	Not listed	53.7	0.1	1.4	48.2	0.2	0.4	0.1	104.1
TOTAL								2,925.1	3.1	23.9	1,068.7	5.6	11.1	0.3	4,037.8
TOTAL Native Vegetation								2,818.5	3.0	22.5	1,013.1	5.4	10.7	0.2	3,873.4

1 Note – a larger area was surveyed for the ventilation shaft sites. The disturbance footprint associated with each ventilation shaft site is provided in Table 1. Minor differences in totals can be attributed to mining.

2 The BVT is associated with Southern Highlands Shale Woodlands in the Sydney Basin Bioregion TEC which is listed under the BC Act and EPBC Act. However, the location of the study area is not within the distribution location of the TEC, and as such does not align to it.



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Date: 26-Mar-19

Project Number: 3365

Project Manager: LB

Drawn by: GT

Study Area

Ventilation Shaft Sites

Upland Swamps (Niche Validated)

- 978: Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion (TEC: BC Act and EPBC Act)
- 978: Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion (Not TEC)
- 1804: Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin (TEC: BC Act and EPBC Act)

Vegetation (Niche validated)

- 1083: Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux, Sydney Basin
- 1245: Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion

Woronora Vegetation (NPWS 2003) PCT

- 881: Hairpin Banksia - Kunzea ambigua - Allocasuarina distyla heath on coastal sandstone plateaux, Sydney Basin
- 1083: Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux, Sydney Basin
- 1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin
- 1250: Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin
- 1254: Sydney Peppermint - White Stringybark moist shrubby forest on elevated ridges, Sydney Basin Bioregion
- 1284: Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion
- 1292: Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin
- 1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin (TEC: BC Act and EPBC Act)
- 1804: Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin (TEC: BC Act and EPBC Act)

km
0 0.5 1

N

GDA 1994 MGA Zone 56

Validated vegetation

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 7

Imagery: (c) Digitalglobe 2108/01/11

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4.4.2 Vegetation Associated with Additional Service Boreholes and Transmission Line

The precise location of the additional service boreholes and the transmission lines have not been determined. As such, Niche have not confirmed the PCTs that may be present at each of the service borehole sites or the transmission line easements.

South32 propose to install the service boreholes and transmission lines, where possible, within the disturbance footprint of the proposed surface infrastructure sites and existing Fire Roads.

Any clearing outside of these areas for the additional Service Boreholes, would be kept to a maximum area of 5 ha of native vegetation, including up to 1 ha of Shale Sandstone Transition Forest (PCT1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest (HN556)). The remaining 4 ha is likely to be PCT1083 Red Bloodwood - scribbly gum heathy woodland (HN566) given this PCT occupies the majority of the Study Area (Table 9).

Any clearing and/or slashing outside of these areas for the transmission lines, would be kept to a maximum area of 4.5 ha of native vegetation, including up to 0.5 ha of Shale Sandstone Transition Forest (PCT1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest (HN556)). The remaining 4 ha is likely to be PCT1083 Red Bloodwood - scribbly gum heathy woodland (HN566) and PCT1250 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest (HN651) given both PCTs occupy the majority of the Study Area (Table 9).

South32 would implement the Vegetation Management Protocol which would be provided in the Surface Services Management Plan to aid in determining the location of the sites to reduce impacts to biodiversity.

Table 9: Vegetation Zones within the Study Area

PCT ID	BVT Code	PCT/BVT Name	Keith Formation	Keith Class	Condition	Corresponding TEC	Area in Study Area (ha)	Area in areas of Direct Impact (ha)
978	HN560	Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin	Freshwater Wetlands	Coastal Heath Swamps	Moderate_Good	Coastal Upland Swamps of the Sydney basin bioregion (BC Act and EPBC Act)	27.5	0.0
		Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin	Freshwater Wetlands	Coastal Heath Swamps	Moderate_Good	Not listed	30.7	0.0
1804	HN662	Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin	Freshwater Wetlands	Coastal Heath Swamps	Moderate_Good	Coastal Upland Swamps of the Sydney basin bioregion (BC Act and EPBC Act)	10.4	0.0
1083	HN566	Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin	Dry Sclerophyll Forests (Shrubby sub-formation)	Sydney Coastal Dry Sclerophyll Forests	Moderate_Good	Not listed	2,461.5	25.8[1]
1250	HN651	Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest	Dry Sclerophyll Forests (Shrubby sub-formation)	Sydney Coastal Dry Sclerophyll Forests	Moderate_Good	Not listed	430.7	1.0[2]

PCT ID	BVT Code	PCT/BVT Name	Keith Formation	Keith Class	Condition	Corresponding TEC	Area in Study Area (ha)	Area in areas of Direct Impact (ha)
1395	HN556	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Grassy Woodland	Coastal Valley Grassy Woodlands	Moderate_Good	Shale Sandstone Transition Forest (BC Act and EPBC Act)	173.5	1.5[3]
1245	ME044	Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	Wet Sclerophyll Forests (Shrubby sub-formation);	North Coast Wet Sclerophyll Forests	Moderate_Good	Not listed	0.2	0.2

[1] This area is made up of the ventilation shaft site disturbance footprints (18.8 ha), and 4 ha of disturbance that may be associated with the additional service boreholes, and 3 ha of disturbance associated with the transmission lines.

[2] This area is made up of disturbance that may be associated with the transmission lines (1 ha).

[3] This area is made up of the additional service boreholes (1 ha) and transmission lines (0.5ha).

4.5 Threatened Ecological Communities

Based on the desktop review, eight TECs have the potential to occur within 10 km of the Study Area. A further three TECs were also identified in the SEARs (see point A of Attachment B of the submission from the OEH to the DP&E) requiring further consideration in the BAR. The three TECs in the SEARs include:

- Shale Sandstone Transition Forest in the Sydney Basin Bioregion Critically Endangered Ecological Community (CEEC).
- River-flat Eucalypt Forest on Coastal Floodplain of the NSW North Coast, Sydney Basin and South East Corner Bioregions (EEC).
- Swamp Oak Floodplain Forest on the NSW North Coast, Sydney Basin and South Easter Corner Bioregions (EEC).

Details in regards to the characteristics and potential occurrence of the TECs generated from the desktop review and the SEARs, has been provided in Appendix 2. Based on the background analysis, and result of the field survey, only two TECs are known to occur within the Study Area:

- Shale Sandstone Transition Forest, which is listed as Critically Endangered under the BC Act and EPBC Act; and
- Coastal Upland Swamps, which is listed as Endangered under the BC Act and EPBC Act.

The occurrence within the Study Area for both of these TECs are discussed in detail below.

4.5.1 Shale Sandstone Transition Forest

Shale Sandstone Transition Forest TEC is listed as Critically Endangered under the BC Act and EPBC Act.

The State listing and description for the TEC is described in NSW Scientific Committee (2014) *Final Determination - Shale Sandstone Transition in the Sydney Basin Bioregion*, whilst the Commonwealth listing and description is detailed in DoE (2014a) *Approved Conservation Advice (including listing advice) for Shale Sandstone Transition Forest of the Sydney Basin Bioregion*.

Both documents described the community in the same manner, however Shale Sandstone Transition Forest is only listed as Critically Endangered under the EPBC Act if it meets the condition classes/condition thresholds provided in DoE (2014a).

Vegetation units - Transitional Shale Dry Ironbark Forest, and Transitional Shale Stringybark Forest mapped within the Study Area (Figure 8) align to both the State and Commonwealth listing for Shale Sandstone Transition Forest TEC due to the following:

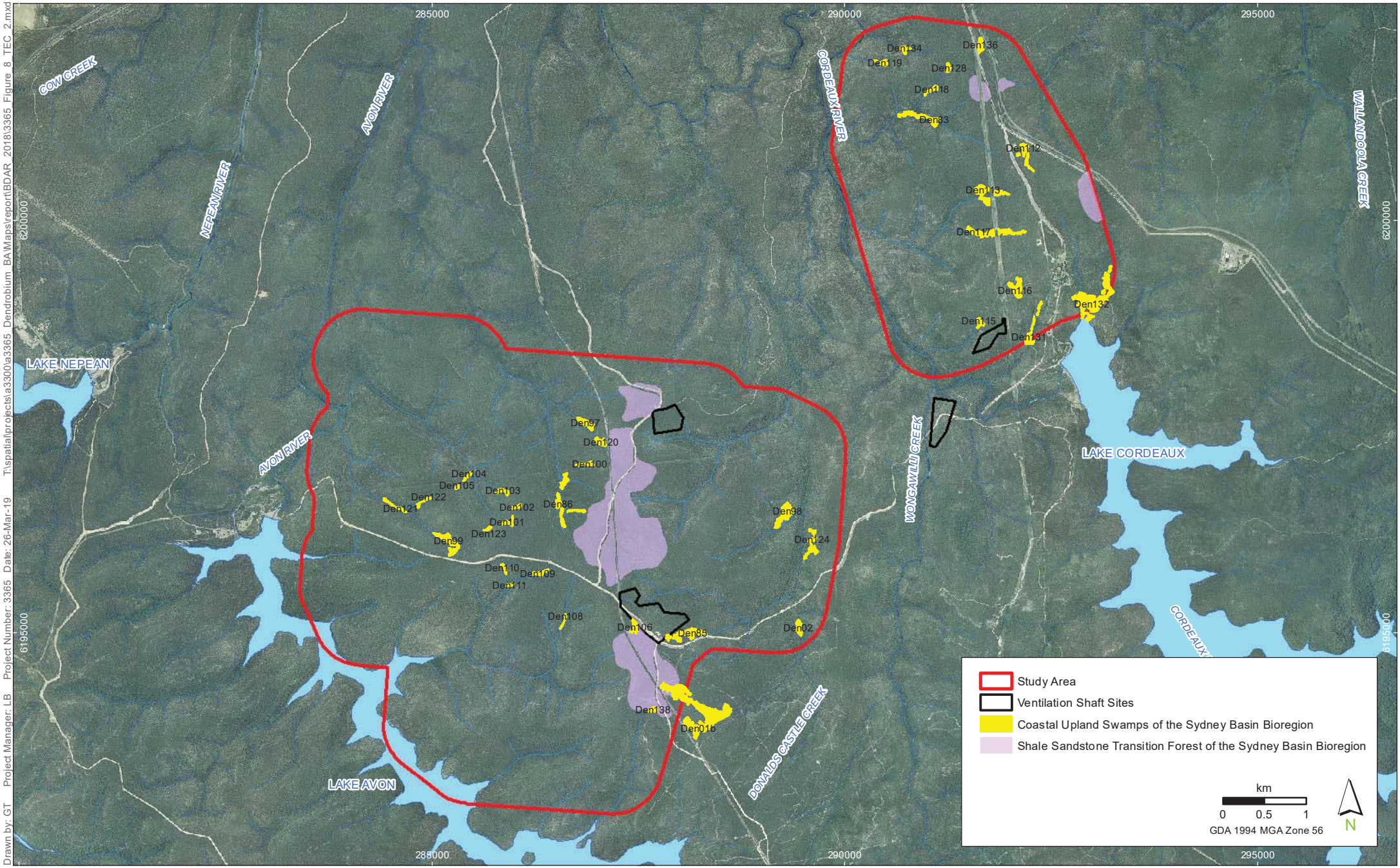
- Characteristic species listed under both Scientific Committee (2014) and DoE (2014a) which occur within Transitional Shale Dry Ironbark Forest and Transitional Shale Stringybark Forest include *Eucalyptus punctata, Eucalyptus globoidea, Eucalyptus eugenioides,* and *Eucalyptus crebra.*
- The Study Area occurs within the known distribution for the TEC.
- The shrub layer of both Transitional Shale Dry Ironbark Forest and Transitional Shale Stringybark Forest are consistent with the Scientific Committee (2014) and DoE (2014a) descriptions. Both communities contained diverse, shrub layer consisting of *Kunzea ambigua, Persoonia linearis* and *Bursaria spinosa,* and ground layer dominated by *Austrostipa pubescens, Entolasia stricta, Themeda australis, Lepidosperma laterale, Aristida vagans* and *Pomax umbellata.*
- Under the DoE (2014a) condition classes/condition thresholds, both Transitional Shale Dry Ironbark Forest and Transitional Shale Stringybark Forest would be classified as 'high condition' given the vegetation communities are part of an extensive patch of native vegetation. As such, Transitional Shale Dry Ironbark Forest and Transitional Shale Stringybark Forest are regarded as the TEC under the EPBC Act.
- The vegetation descriptions for both Transitional Shale Dry Ironbark Forest and Transitional Shale Stringybark Forest in NPWS (2003) state that both communities 'form a component of Shale Sandstone Transition Forest listed on Part 3 of Schedule 1 of the BC Act'.

In total, 173.5 ha of Shale Sandstone Transition Forest TEC has been mapped within the Study Area (Figure 8).

The Shale Sandstone Transition Forest TEC predominantly occurs within Area 5. A total of 158 ha of the Shale Sandstone Transition Forest TEC occurs within Area 5 and has been mapped adjacent to the Maldon Dombarton railway corridor within the centre of Area 5. In Area 6, a total of 15.5 ha of the Shale Sandstone Transition Forest TEC occurs. The patch occurs to the north of Area 6 adjacent to the existing transmission line easement.

4.5.2 Coastal Upland Swamps

Coastal Upland Swamps are listed as Endangered under the BC Act and EPBC Act. The State listing and description for the TEC is described in NSW Scientific Committee (2012) *Final Determination – Coastal Upland Swamps in the Sydney Basin Bioregion*, whilst the Commonwealth listing and description is detailed in DoE (2014b) *Approved Conservation Advice (including listing advice) for Coastal Upland Swamps of the Sydney Basin Bioregion*.



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Threatened Ecological Communities

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 8

Imagery: (c) S32 2009

Both documents provide similar descriptions for Coastal Upland Swamps and list the following NPWS (2003) mapping units as aligning to the TEC - 'Coastal Upland Swamps Banksia Thicket' (MU42), 'Coastal Upland Swamps Tea-tree Thicket' (MU43) and 'Coastal Upland Swamps Sedgeland-Heath Complex' (MU44).

A total of 46 Coastal Upland Swamps were mapped by Niche within the Study Area (Figure 7).

Each Coastal Upland Swamp is generally a mosaic of more than one sub-unit of Upland Swamp vegetation, consisting 'Coastal Upland Swamps Banksia Thicket' (MU42), 'Coastal Upland Swamps Tea-tree Thicket' (MU43) and 'Coastal Upland Swamps Sedgeland-Heath Complex' (MU44[1]) and 'Coastal Upland Swamps Eucalypt Fringing Woodland' (MU45). The vegetation description for each of the Coastal Upland Swamp sub units is provided in Appendix 3. 'Coastal Upland Swamps Eucalypt Fringing Woodland' (MU45) is not a component of the TEC. It is not listed on either the Scientific Committee (2014) or DoE (2014b) as a vegetation mapping unit aligning to the TEC.

Therefore, 37 of the Coastal Upland Swamps recorded within the Study Area contain the mapping units equivalent to the TEC listing, and therefore would be regarded as Endangered under the BC Act and EPBC Act. These 37 Coastal Upland Swamps (excluding the non-threatened portions) are shown on Figure 8.

These Coastal Upland Swamps in the Study Area also meet the NSW Scientific Committee (2012) and DoE (2014b) Determination due to the following:

- The Coastal Upland Swamps in the Study Area occur on Hawkesbury sandstone plateaus.
- The Coastal Upland Swamps are within the known distribution for Coastal Upland Swamps TECs.
- The Study Area is within the Woronora plateau, which according to NSW Scientific Committee (2012) 'represents the greatest extent and one of the oldest recorded occurrences of upland wetlands on the Australian mainland'.
- The following characteristic species as detailed in both the Scientific Committee (2012) and DoE (2014b) determination listing were recorded during the field survey across the majority of Coastal Upland Swamps: *Actinotus minor, Baeckea imbricata, Baeckea linifolia, Banksia ericifolia, Banksia robur, Bauera microphylla, Boronia parviflora, Cassytha glabella, Dampiera stricta, Dillwynia floribunda, Drosera binata, Drosera spathulata, Empodisma minus, Entolasia stricta, Epacris microphylla, Epacris obtusifolia, Lepidosperma limicola, Leptocarpus tenax, Leptospermum juniperinum, Leptospermum squarrosum, Lepyrodia scariosa, Ptilothrix deusta, Schoenus brevifolius, Selaginella uliginosa* and *Sprengelia incarnata.*

The Coastal Upland Swamps in the Study Area comprise two fundamental geomorphic types:

1. Headwater Swamps are the majority of the Coastal Upland Swamps within the Woronora Plateau, and are generally situated in areas near catchment divides where plateau incision is weak and topographic grades are shallow.
2. Valley Infill Swamps form as isolated pockets blanketing the floor of incised second or third order stream valleys and therefore tend to be elongated downstream (Tomkins and Humphreys 2006). They are believed to be initiated by rapid transportation of sediment material downstream and equally rapid deposition possibly as a result of channel profile-restriction. Once initiated, the swamps are probably self-reinforcing, trapping more sediment, raising the water table and fostering the growth of organics and formation of peat (Tomkins and Humphreys 2006).

[1] Coastal Upland Swamps Sedgeland-Heath Complex (MU44) is composed of three sub-units reflecting vegetation sub structure including MU44a, MU44b and MU44c. Reference to MU44 may refer to any one of these sub-units or a composite.

The identification of Valley Infill Swamps and Headwater Swamps for each Coastal Upland Swamp recorded in the Study Area was completed using GIS analysis. Headwater Swamps were attributed to those swamps that did not occur within creeklines, or, were elevated above first order streams on relatively flat terrain. Valley Infill Swamps were attributed to incised depressions with clearly identified drainage lines. The alignment of each Coastal Upland Swamp is provided in Table 10.

Table 10: Coastal Upland Swamps within the Study Area, partially within the Study Area or 'Coastal Upland Swamps Banksia Thicket' (MU42), 'Coastal Upland Swamps Tea-tree Thicket' (MU43) and 'Coastal Upland Swamps Sedgeland-Heath Complex' (MU44).

Swamp	Type	Area of Upland Swamp Vegetation Units (ha)[1]						Grand Total (ha)	Total area of EEC[2] (ha)
		MU42 – Banksia Thicket	MU43 – Tea-tree Thicket	MU44a – Sedgeland	MU44b – Restioid Heath	MU44c – Cyperoid Heath	MU45 – Eucalypt Fringing Woodland		
Den01b	Headwater	0.1	0.0	0.0	9.0	2.2	0.4	11.7	11.3
Den02	Headwater	0.6	0.3	0.0	0.0	0.0	0.0	0.9	0.9
Den100	Headwater	0.0	0.0	0.0	0.5	0.0	0.4	0.8	0.5
Den101	Headwater	0.0	0.0	0.0	0.4	0.0	0.4	0.8	0.4
Den102	Headwater	0.0	0.0	0.0	0.3	0.0	0.2	0.5	0.3
Den103	Headwater	0.0	0.0	0.0	0.5	0.0	0.6	1.1	0.5
Den104	Valley In-fill	0.0	0.0	0.0	0.2	0.0	0.3	0.5	0.2
Den105	Headwater	0.0	0.0	0.0	0.2	0.0	0.2	0.4	0.2
Den106	Headwater	0.0	0.0	0.0	0.7	0.0	0.4	1.0	0.7
Den107	Headwater	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0
Den108	Valley In-fill	0.1	0.0	0.0	0.0	0.0	0.3	0.4	0.1
Den109	Headwater	0.0	0.0	0.0	0.4	0.0	0.5	0.9	0.4
Den110	Headwater	0.0	0.2	0.0	0.1	0.0	0.2	0.5	0.3
Den111	Valley In-fill	0.0	0.0	0.0	0.2	0.0	0.2	0.4	0.2
Den112	Headwater	0.0	0.0	0.0	1.0	0.0	1.5	2.5	1.0
Den113	Headwater	0.0	0.0	0.0	2.4	0.0	1.0	3.4	2.4
Den114	Headwater	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0
Den115	Headwater	0.0	0.0	0.0	0.4	0.0	0.7	1.1	0.4
Den116	Headwater	0.0	0.0	0.0	1.3	0.2	0.7	2.2	1.5
Den117	Headwater	0.0	0.2	0.0	2.3	0.0	1.5	4.0	2.5
Den118	Valley In-fill	0.0	0.4	0.0	0.1	0.0	0.4	0.9	0.5
Den119	Headwater	0.0	0.0	0.4	0.0	0.0	0.2	0.6	0.4
Den120	Headwater	0.0	0.0	0.0	0.6	0.0	0.2	0.8	0.6
Den121	Valley In-fill	0.0	0.0	0.0	0.5	0.0	0.7	1.2	0.5
Den122	Headwater	0.0	0.0	0.0	0.4	0.0	0.3	0.6	0.4
Den123	Headwater	0.0	0.0	0.0	0.1	0.0	0.3	0.4	0.1

Swamp	Type	Area of Upland Swamp Vegetation Units (ha)[1]						Grand Total (ha)	Total area of EEC[2] (ha)
		MU42 – Banksia Thicket	MU43 – Tea-tree Thicket	MU44a – Sedgeland	MU44b – Restioid Heath	MU44c – Cyperoid Heath	MU45 – Eucalypt Fringing Woodland		
Den124	Valley In-fill	0.0	0.0	0.0	0.4	1.1	4.5	5.9	1.4
Den126	Headwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Den127	Headwater	0.0	0.0	0.0	0.0	0.0	3.3	3.3	0.0
Den128	Valley In-fill	0.0	0.3	0.0	0.0	0.0	0.1	0.4	0.3
Den129	Headwater	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.0
Den130	Valley In-fill	0.0	0.0	0.0	0.0	0.0	1.2	1.2	0.0
Den131	Headwater	0.0	1.3	0.0	0.0	0.0	0.2	1.5	1.3
Den132	Valley In-fill	2.4	4.1	0.0	0.0	0.0	1.1	7.6	6.5
Den133	Valley In-fill	0.0	0.0	0.0	0.0	0.0	1.3	1.3	0.0
Den134	Headwater	0.0	0.5	0.0	0.0	0.0	0.4	0.9	0.5
Den135	Valley In-fill	0.0	0.0	0.0	0.0	0.0	2.1	2.1	0.0
Den136	Headwater	0.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0
Den137	Headwater	0.0	0.0	0.0	0.0	0.0	4.2	4.2	0.0
Den138	Headwater	0.0	0.0	0.0	0.5	0.0	0.5	1.0	0.5
Den83	Headwater/ Valley In-fill	0.0	1.7	0.0	0.0	0.0	1.0	2.7	1.7
Den85	Headwater	0.0	0.0	0.0	2.1	0.0	0.4	2.5	2.1
Den86	Headwater	0.0	0.0	0.0	2.4	0.0	2.0	4.3	2.4
Den97	Headwater	0.0	1.0	0.0	0.0	0.0	0.3	1.3	1.0
Den98	Valley In-fill	1.3	0.6	0.0	0.4	0.0	0.7	2.9	2.2
Den99	Headwater	0.0	0.0	0.0	2.0	0.0	1.0	3.0	2.0
Grand Total		4.6	10.6	0.4	30.0	3.4	37.5	86.5	49.4

1 Note that the boundary of some Coastal Upland Swamps extends outside of Area 5 and Area 6. The area calculations within this table have taken this into consideration. Minor difference in totals can be attributed to rounding.

2 Coastal Upland Swamp TEC includes the following vegetation units: MU42 – Banksia Thicket, MU43 – Tea-tree Thicket, MU44a – Sedgeland, MU44b – Restioid Heath, and MU44c – Cyperoid Heath. It does not include MU45 – Eucalypt Fringing Woodland.

4.5.3 Significance of Coastal Upland Swamps

To assist in the environmental assessment process in regards to Coastal Upland Swamps, OEH has provided the following guideline - OEH (2012) *Upland Swamp Environmental Assessment Guidelines – Guidance for the underground mining industry operating in the Southern Coalfield*.

The guideline was designed by OEH to provide proponents with a step-by-step method to undertake environmental assessment and impact mitigation. The guideline provides a list of criteria to be used to assess Coastal Upland Swamps in terms of 'significance'.

Coastal Upland Swamps that are deemed to be of 'special significance' are considered by OEH to be of greater biological and ecological value which may require further avoidance, mitigation and monitoring measures.

To determine if an Upland Swamp in the Study Area is of 'special significance' the Upland Swamp must satisfy three of the criteria from OEH (2012), provided in Table 11.

Niche has undertaken an independent assessment for each Coastal Upland Swamp in regards to the criteria, as the NPWS (2003) mapping was further refined by Niche for this assessment.

Table 11: Significance Criteria

Significance Criteria	Significance Criteria Descriptions OEH (2012) Upland Swamp Environmental Assessment Guidelines Guidance for the Underground Mining Industry Operating in the Southern Coalfield
Statutory thresholds, indicated by the presence of TECs or threatened species	A swamp is significant under criterion 2.3 of OEH (2012) if it is determined to be of National and/or State significance. If using the OEH assessment, all Coastal Upland Swamps on the Woronora Plateau with the vegetation types MU42, MU43 or MU44 in the regional vegetation map (NPWS 2003) are of State significance under this criterion. If using an independent assessment, the vegetation types within swamps would need to be sampled, then assessed against the criteria in the State listing for Coastal Upland Swamp TEC. If using an independent assessment, the swamp is of State significance if it contains habitat for any recorded threatened species. A swamp is of National significance if the relevant Commonwealth authority makes such a determination.
Substantial size	A swamp is significant under criterion 2.4 of OEH (2012) if its size is greater than 7.4 ha. 10% of swamps in the region exceed this threshold. If using the OEH assessment, all swamps from the regional vegetation mapping (NPWS 2003) that are larger than this threshold have been identified in Map 3 in Appendix 1 of OEH (2012). If using an independent assessment, the boundary of individual swamps can be verified by field assessment, and their area calculated by methods such as GIS. The threshold remains 7.4 ha in either instance.
Unusual complexity	A swamp is significant under criterion 2.5 of OEH (2012) if it contains the full range of regionally occurring swamp vegetation communities. If using the OEH assessment, a significant swamp is indicated by the presence of Tea-Tree Thicket (MU 43) in the regional vegetation map (NPWS 2003). Swamps with MU43 have been identified in Map 4 in Appendix 1 of OEH (2012). This approach should apply if this vegetation mapping is used without field verification. If using an independent assessment to identify the vegetation types within a swamp by field assessment, a significant swamp is indicated by the presence of all of MU42, MU43 and MU44.
Closely proximate habitat	A swamp is significant under criterion 2.6 of OEH (2012) if it occurs in one of the four key clusters of swamps shown in Map 5 in Appendix 1 of OEH (2012), including: • Maddens Plains (O'Hares and Cataract catchments); • Wallandoola Creek (Cataract catchment); • North Pole (southern Avon catchment); and • Stockyard (southern Nepean catchment). The assessment of significance for this criterion is the same regardless of whether the OEH assessment or an independent assessment is used.

Significance Criteria	Significance Criteria Descriptions OEH (2012) Upland Swamp Environmental Assessment Guidelines Guidance for the Underground Mining Industry Operating in the Southern Coalfield
Scientific research importance	A swamp is significant under criterion 2.7 of OEH (2012) if it is a site of scientific research importance. Significant swamps include: • The swamps in Map 6; and • Reference swamps with no mining underneath that have been paired with a swamp(s) that is subject to underground mining. The assessment of significance for this criterion is the same regardless of whether the OEH assessment or an independent assessment is used.

An assessment of each Coastal Upland Swamp recorded in the Study Area in relation to the significance criteria is provided in Table 12. Based on the results, one Coastal Upland Swamp – Den98 met three of the significant criteria and are therefore regarded as of special significance. As discussed further in section 7.1, additional monitoring is proposed for Den98.

Table 12: Coastal Upland Swamps in Study Area Compared to Significance Criteria

	Significant criteria					Does swamp meet three of the significant criteria, and is therefore regarded as of special significance?
Swamp	Statutory thresholds[1]	Substantial size	Unusual complexity	Closely proximate habitat	Scientific research importance	
Den83	Yes	No	No	No	No	No
Den85	Yes	No	No	No	No	No
Den86	Yes	No	No	No	No	No
Den97	Yes	No	No	No	No	No
Den98	Yes	No	Yes	Yes	No	**Yes**
Den99	Yes	No	No	No	No	No
Den100	Yes	No	No	No	No	No
Den101	Yes	No	No	No	No	No
Den102	Yes	No	No	No	No	No
Den103	Yes	No	No	No	No	No
Den104	Yes	No	No	No	No	No
Den105	Yes	No	No	No	No	No
Den106	Yes	No	No	No	No	No
Den107	Yes	No	No	No	No	No
Den108	Yes	No	No	No	No	No
Den109	Yes	No	No	No	No	No
Den110	Yes	No	No	No	No	No
Den111	Yes	No	No	No	No	No
Den112	Yes	No	No	No	No	No
Den113	Yes	No	No	No	No	No
Den114	Yes	No	No	No	No	No
Den115	Yes	No	No	No	No	No
Den116	Yes	No	No	No	No	No
Den117	Yes	No	No	No	No	No
Den118	Yes	No	No	No	No	No
Den119	Yes	No	No	No	No	No
Den120	Yes	No	No	No	No	No
Den121	Yes	No	No	No	No	No
Den122	Yes	No	No	No	Yes	No
Den123	Yes	No	No	No	No	No
Den124	Yes	No	No	Yes	No	No
Den125	Yes	No	No	No	No	No

Swamp	Significant criteria					Does swamp meet three of the significant criteria, and is therefore regarded as of special significance?
	Statutory thresholds[1]	Substantial size	Unusual complexity	Closely proximate habitat	Scientific research importance	
Den126	Yes	No	No	No	No	No
Den127	Yes	No	No	No	No	No
Den128	Yes	No	No	No	No	No
Den129	Yes	No	No	No	No	No
Den130	Yes	No	No	No	No	No
Den131	Yes	No	No	Yes	No	No
Den132	Yes	No	No	Yes	No	No
Den133	Yes	No	No	No	No	No
Den134	Yes	No	No	No	No	No
Den135	Yes	No	No	No	No	No
Den136	Yes	No	No	No	No	No
Den137	Yes	No	No	No	No	No
Den01b	Yes	No	No	Yes	No	No
Den02	Yes	No	No	Yes	No	No
Den138	Yes	No	No	Yes	No	No

[1] All swamps have been included based on the potential for threatened species habitat.

4.6 Site Value Scoring

The Site Value score used in the BBCC are obtained from the collection of transects and plots completed for each of the PCTs and condition classes within the Study Area that would be impacted by surface infrastructure, and in this case, subsidence.

The Site Value scores are used to determine the present condition of the PCT that occurs in the Study Area.

4.6.1 Flora

During the field survey 241 flora were recorded across 59 families. No introduced species were recorded in the floristic plots, however, were recorded opportunistically along the edge of the Fire Roads in the Study Area and the Maldon Dombarton railway corridor. Common weeds included: *Ageratina riparia, Plantago lanceolata* and *Hypochaeris radicata*.

A list of the flora recorded during the survey along with the BioBanking plot data has provided in Appendix 4.

4.6.2 Site Values

The Site Value assessment was carried out by entering the data obtained from transects and plots into the BBCC. The data provides quantitative measures of 10 site attributes (section 5.1) for each vegetation zone that occurs within the surface infrastructure footprint. The BBCC compares the benchmark for the vegetation type or class to provide the Site Value score. This score represents the overall condition of the vegetation compared against the benchmark.

Vegetation that would be cleared for surface infrastructure, was then assigned a future Site Value score of zero given the biodiversity values in these areas would be lost.

The score from these inputs, coupled with other data in the following section of this report, is used to determine the number of ecosystem credits that are required to offset the biodiversity impacts associated with the Project.

5. Assessing Threatened Flora and Populations

5.1 Overview

All threatened flora are regarded as 'species credit' species in the FBA. Targeted surveys are required for those identified by database searches, BBCC and the SEARs. This section details the survey effort used to detect the presence/absence of threatened flora and their habitats within the Study Area. Any threatened flora with potential habitat which is likely to be impacted by the Project is detailed further in the impact assessment for the Project (section 7.5).

5.2 Database Analysis

Thirty-two threatened flora have previously been recorded or have modelled habitat within a 10 km radius of the Study Area (Appendix 2). Of the 32 species:

- Two species are listed as Critically Endangered under the BC Act, and one under the EPBC Act.
- 16 species are listed as Endangered under the BC Act, and nine under the EPBC Act.
- 13 species are listed as Vulnerable under the BC Act and 17 under the EPBC Act.

The BBCC has also identified the following species requiring survey within the Study Area:

- *Acacia baueri subsp. Aspera;*
- Bargo Geebung (*Persoonia bargoensis*);
- Rufous Pomaderris (*Pomaderris brunnea);*
- Bynoe's Wattle (*Acacia bynoeana*);
- Deane's Paperbark (*Melaleuca deanei*);
- *Epacris purpurascens subsp. purpurascens;*
- Hairy Geebung (*Persoonia hirsuta*);
- *Hibbertia puberula;*
- Needle Geebung (*Persoonia acerosa*);
- Prickly Bush-pea (*Pultenaea aristata*);
- Slaty Leek Orchid (*Prasophyllum fuscum*);
- Small-flower Grevillea (*Grevillea parviflora subsp. parviflora*);
- Sublime Point Pomaderris (*Pomaderris adnata*); and
- Woronora Beard-heath (*Leucopogon exolasius*).

5.3 Threatened Flora Surveys

The threatened flora generated from the database searches aided in determining the flora survey effort, in conjunction with OEH (2016) *NSW Guide to Surveying Threatened Plants*, and the requirements of the FBA.

The Study Area was subject to flora and fauna surveys as part of Niche (2016) *Review of Environmental Factors (REF): Dendrobium Areas 5 and 6 Landscape, Surface Water and Groundwater Monitoring, Prepared for Illawarra Coal*. Niche completed over 100 hours of threatened flora survey within Area 5 and over 20 hours of threatened flora survey within Area 6 within the Study Area for this Project as part of the REF process. Most of the flora and vegetation survey completed as part of the Niche (2016) assessment was within ridgetop forest and gully habitat with only a small amount of surveys undertaken within Upland Swamp habitat.

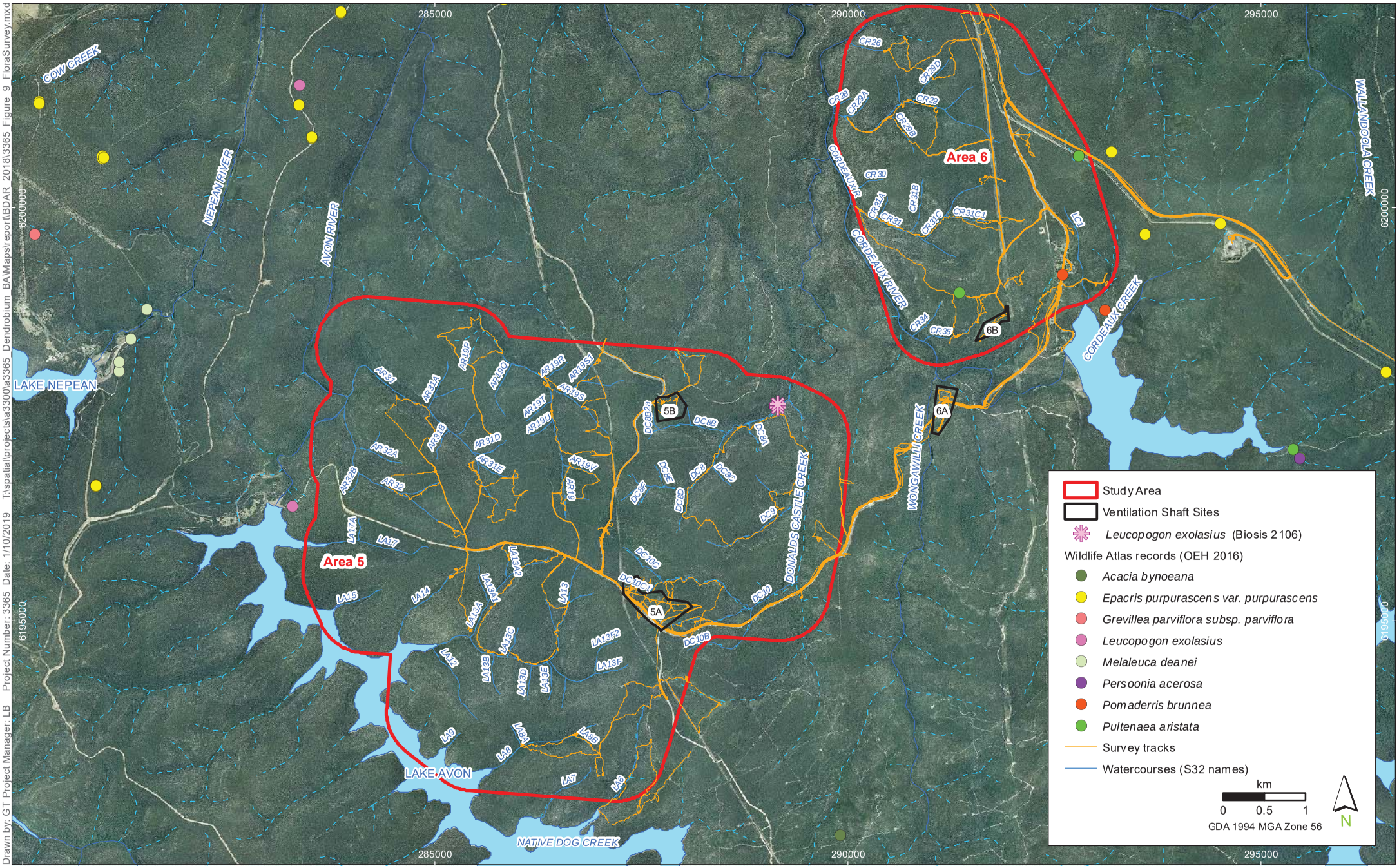
To add to the rigour of the already completed field survey, two botanists from Niche completed an additional 104 hours of threatened flora survey effort during the survey complete on the following dates:

- 24th October to the 27th of October 2016;
- 31st October to the 2nd November 2016;
- 4th November 2016;
- 10th November 2016;
- 17th and 18th of November 2016;
- 10th to 13th of May 2017;
- 16th to 18th of May 2018; and
- 1st June 2018.

This additional survey focused on those areas that may be subject to subsidence impacts (such as Coastal Upland Swamps, riparian vegetation) and direct vegetation clearing for surface infrastructure. Detail of the survey effort completed during the current assessment is provided in Table 13 and shown on Figure 9.

Table 13: Threatened Flora Survey Effort

Threatened Flora Habitat Types	Threatened Flora with Potential or High Occur Based on Likelihood of Occurrence	Likely to be Impacted by Subsidence?	Survey Effort
Ridgetop Woodland/ Forest Habitat	*Acacia bynoeana, Epacris purpurascens var. purpurascens, Grevillea parviflora subsp. parviflora, Leucopogon exolasius, Melaleuca deanei, Persoonia acerosa*.	Unlikely	Approximately 42 hours of transects were completed throughout ridgetop/woodland and forest habitat whilst traversing to riparian habitat sites and Upland Swamp locations. Approximately 19 hours were spent by two ecologists completing transects and plots within the ventilation shaft sites. Over 150 hours of survey hours has previously been completed for these species within the Dendrobium Area 5 and 6 mining areas.
Coastal Upland Swamps	*Pultenaea aristata, Epacris purpurascens var. purpurascens.*	Possible	Approximately 32 hours of were spent by two ecologists completing traverse and plot surveys throughout all the Coastal Upland Swamps in the Study Area.
Riparian Vegetation	*Leucopogon exolasius, Epacris purpurascens var. purpurascens, Pomaderris brunnea.*	Possible	Approximately 55 hours were spent by two ecologists completing threatened flora transects between riparian vegetation plot surveys.
Threatened Orchids	*Caladenia tessellata* and *Pterostylis saxicola*	Highly Unlikely	Both species are highly unlikely to occur within the Study Area. However, flora survey was undertaken during the flowering time of both species and was done in conjunction with the above survey effort.



Threatened flora survey effort and previous records

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 9

Imagery: (c) S32 2009

niche Environment and Heritage

Niche's approach to the threatened flora survey has taken into consideration the OEH (2016) *NSW Guide to Surveying Threatened Plants*, by:

- Using qualified botanists experienced with threatened flora of the Illawarra area for the field surveys;
- Using two botanists to traverse the length of each Upland Swamp within the Project Area;
- Completing the survey in October/November which coincide with the flowering time for most species listed in Appendix 2. However, it should be noted that most of the threatened flora listed in Appendix 2 can be readily detected outside of flowering times; and
- Completing surveys of the entire ventilation shaft disturbance area and carpark disturbance area for threatened flora.

It should be noted that five threatened orchids have been identified from the database search as occurring or having potential to occur within the general locality. They are *Caladenia tessellata, Cryptostylis hunteriana, Pterostylis gibbosa, Pterostylis saxicola* and *Thelymitra* spp. *Kangaloon*. None of these species have been recorded in any of the previous surveys undertaken within the Study Area that have occurred within the past 15 years. A discussion regarding the lack of habitat within the Study Area for each of the five threatened orchids is provided in Appendix 2.

5.4 Survey Limitations

Whilst the targeted surveys and floristic plots were undertaken during the warmer months to satisfy threatened flora survey requirements, some non-threatened plants may not be readily detected during the floristic plots if not flowering. However, many of these species are conspicuous as discussed in Appendix 1, and are unlikely to remain detected. As such, the field survey has addressed and satisfied the survey requirements for threatened flora survey.

Field survey was undertaken during months when most of the targeted species are known to be active. However, the abundance and activity levels (and thus detectability) of many species changes from year to year in response to a range of variables (e.g. timing and intensity of rainfall, and temperature).

Two records of the threatened plant *Leucopogon exolasius* were recorded by Biosis Research (2016) along Donalds Castle Creek towards the far north-east corner of Area 5. Both records were within relatively close proximity to each other. Niche undertook a survey in this Section of the creek however were unable to find the location of the plants due to this portion of the creek containing steep rocky outcrops along the banks and dense vegetation along the edges of the creekline. This assessment has therefore assumed that the two plants are present within the Study Area, in addition to those identified in surveys undertaken for the Survey 16 Exploration REF Addendum (Niche 2019).

No targeted survey has been completed within the transmission line easement as the precise location has not yet been confirmed. Impacts to threatened flora would be avoided where possible. Should any threatened flora be identified within the disturbance footprint, impacts would be offset accordingly.

5.5 Threatened Flora Survey Results

None of these species, nor any other threatened flora listed under the BC Act or EPBC Act were recorded within the Study Area during the field survey. However, records for *Pultenaea aristata*, *Pomaderris brunnea, Epacris purpurascens* var. *purpurascens* and *Leucopogon exolasius* have previously been recorded in the Study Area.

Pultenaea aristata which is listed as Vulnerable under BC Act and EPBC Act had been previously mapped by Biosis (2016) as occurring within the Study Area (Figure 9). Records of this species occur adjacent to an existing access track within PCT1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus (HN566) within Area 6. The location of the record and vicinity surrounding it was surveyed, however the plant(s) were not found during the field survey.

Pomaderris brunnea which is listed as Vulnerable under the EPBC Act and Endangered under the BC Act had been previously mapped by Bionet (2016) as occurring within the Study Area (Figure 9). Records of this species occur adjacent to an existing access track setback from a creekline within PCT1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus (HN566) within Area 6. The record is from the 1950s, and it is unclear if the identification is correct, given *Pomaderris brunnea* is generally found 'in a very limited area around the Colo, Nepean and Hawkesbury Rivers, including the Bargo area and near Camden' (OEH 2016b). The record also seems to be an outlier when compared to the other records for the species which are centred around the Picton area, approximately 12 km from the record within the Study Area. Regardless, a precautionary approach has been taken given the previous record and it has been assumed that some potential habitat may occur within the gullies of the Study Area to which this species is known to have similar habitat preferences. The location of the record and vicinity surrounding it was surveyed, however the plant(s) were not found during the field survey.

Leucopogon exolasius which is also listed as Vulnerable under the BC Act and EPBC Act had previously been recorded by Biosis (2016) at two locations in the far north-east corner of Area 5 (Figure 9). Both records were within relatively close proximity to each other along Donalds Castle Creek within vegetation mapped as PCT1250 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies (HN651). As discussed in section 5.4, the plant(s) were not found during the field survey despite survey undertaken in the same portion of the creek (Figure 9). This was likely attributed to the dense vegetation within this area and the steep rocky outcrops along both sides of the creek which made some sections impenetrable. More recently, numerous *Leucopogon exolasius* individuals were recorded in Area 5 by Niche (2019) during surveys for the Survey 16 Exploration REF Addendum (Niche 2019). These records do not occur within areas proposed for surface disturbance or within areas that are sensitive to subsidence.

Epacris purpurascens var. *purpurascens* which is listed as Vulnerable under the BC Act had been previously mapped by Bionet (2016) as occurring within the Study Area (Figure 9). The record was made at the same location as a *Pultenaea aristata* record. The record does not occur within an area proposed for surface disturbance or within areas that are sensitive to subsidence.

An assessment of the likelihood for threatened flora to occur within the Study Area taking into account the results of the field survey and previous records is provided in Appendix 2. Whilst not detected during the field survey, the assessment indicated that eight threatened flora are considered to have a moderate to high likelihood of occurrence within the Study Area. These species include: *Acacia bynoeana, Cynanchum elegans, Epacris purpurascens var. purpurascens, Grevillea parviflora subsp. parviflora, Leucopogon exolasius, Pomaderris brunnea, Persoonia hirsuta* and *Pultenaea aristata*. All these species have relatively extensive habitat throughout the Study Area, and whilst not detected during the field survey, cannot be ruled out in the Study Area due to the Study Area size. These species are listed in Table 14.

It should be noted that whilst the threatened species listed above have been given a moderate to high likelihood of occurrence within the Study Area, the threatened flora were unlikely to remain undetected during the intensive coverage and survey effort within the Ventilation Shaft Sites and Dendrobium Pit Top Carpark site as the species are relatively conspicuous. As such, it is highly unlikely any threatened flora would occur within the habitat of the surface infrastructure.

Of those species in Table 14, only *Epacris purpurascens* var. *purpurascens, Pomaderris brunnea* and *Pultenaea aristata* may occur within habitat types sensitive to subsidence. As such, these species are further discussed in section 7.5.

Given the known populations of *Leucopogon exolasius* recorded within the Study Area, and the nomination of this species in the SEARs, this species has been considered further in section 7.5.

The remaining species - *Acacia bynoeana, Cynanchum elegans, Grevillea parviflora subsp. parviflora, and Persoonia hirsuta*, are unlikely to occur within the surface infrastructure sites, nor occur within habitat types that may be susceptible to subsidence. These species are therefore not considered further in this assessment.

5.6 EPBC Act Listed Threatened Flora

As discussed above, no EPBC Act listed threatened flora were recorded during the targeted survey within the surface infrastructure disturbance areas or habitats that may be susceptible to subsidence related impacts.

However, due to the large area of habitat within the Study Area, seven EPBC Act listed species have been attributed to a moderate to high likelihood of occurrence in the Study Area: *Acacia bynoeana, Cynanchum elegans, Grevillea parviflora ssp. parviflora, Leucopogon exolasius, Pomaderris brunnea, Persoonia hirsuta* and *Pultenaea aristata*.

As discussed in Table 14, of the species there is potential for *Pultenaea aristata* to have habitat within Upland Swamp habitat that may be impacted by subsidence, and given the known location of *Leucopogon exolasius* population within the Study Area, and the isolated record for *Pomaderris brunnea,* further assessment of potential impacts to these species is provided in section 7.5.3.

Table 14: Threatened Flora with a Moderate to High Likelihood of Occurrence

Species	EPBC Act	BC Act	Likelihood of occurrence within Study Area	Likelihood of occurrence within proposed surface infrastructure sites	Likelihood to occur within subsidence sensitive habitat
Acacia bynoeana Bynoe's Wattle	V	E	High – not detected during field survey but suitable habitat present along fire roads, transmission line, and within Exposed Sandstone Scribbly Gum Woodland.	Unlikely – not detected during field survey. Relatively conspicuous when not flowering. Traverses throughout ventilation shaft sites and along fire roads immediately adjacent to ventilation shaft sites did not record species.	Unlikely. Potential habitat not within Coastal Upland Swamps or riparian areas.
Cynanchum elegans White-flowered Wax Plant	E	E	Moderate – not detected during field survey. No previous records within Study Area.	Unlikely – not detected during field survey. Relatively conspicuous. Ventilation shaft sites do not occur within gullies where this species is likely to occur. No previous records within Study Area.	Unlikely. Potential habitat not within Coastal Upland Swamps or riparian areas.
Epacris purpurascens var. *purpurascens*	-	V	High – not detected during field survey but suitable habitat present along fire roads, transmission line, and within all vegetation types of the Study Area. A record obtained from Bionet (2016) occurs within in Area 6 adjacent to an access track.	Unlikely – not detected during field survey. Relatively conspicuous when not flowering. Traverses throughout ventilation shaft sites and along fire roads immediately adjacent to ventilation shaft sites did not record the species. However, the species is known to occur within Exposed Sandstone Scribbly Gum Woodland.	Possible. Species may occur within Coastal Upland Swamps and riparian zones, however it should be noted that the species was not recorded during the targeted survey within Coastal Upland Swamps or the riparian areas surveyed.
Grevillea parviflora ssp. *parviflora* Small-flower Grevillea	V	V	High – not detected during field survey but suitable habitat present along fire roads, transmission line, and within Shale Sandstone Transition Forest within the Study Area.	Unlikely – not detected during field survey. Habitat is unlikely in Exposed Sandstone Scribbly Gum Woodland. Relatively conspicuous when not flowering. Unlikely to remain undetected during field survey.	Unlikely. Potential habitat not within Coastal Upland Swamps or riparian areas.
Leucopogon exolasius Woronora Beard-heath	V	V	Known – not detected during field survey but previously recorded by Biosis Research (2016) within MU26, Sandstone Gully Peppermint Forest adjacent to Donalds Castle Creek. The species may occur on sandstone vegetation and along creek banks within the Study Area.	Unlikely – not detected during field survey. Relatively conspicuous when not flowering. Unlikely to remain undetected during field survey. Traverses throughout ventilation shaft sites and along fire roads immediately adjacent to ventilation shaft sites did not record the species.	Unlikely. Known habitat for the species occurs along the upper banks of watercourses away from the natural water inundation area of watercourses.
Persoonia hirsuta	E	E	Moderate – relatively conspicuous and not detected during field survey. No previous records within Study Area.	Unlikely – relatively conspicuous and not detected during field survey. No previous records within Study Area. Unlikely to remain undetected during field survey.	Unlikely. Potential habitat not within Coastal Upland Swamps or riparian areas.
Pultenaea aristate Prickly Bush-pea	V	V	High – not detected during field survey. A previous record existing in the Study Area adjacent to an existing access track however the record was not found during the field survey. The species is known to occur within Coastal Upland Swamps within the Woronora Plateau.	Unlikely – relatively conspicuous and not detected during field survey. Unlikely to remain undetected during field survey.	Possible. However the species was not recorded within the Coastal Upland Swamps during the survey.

Species	EPBC Act	BC Act	Likelihood of occurrence within Study Area	Likelihood of occurrence within proposed surface infrastructure sites	Likelihood to occur within subsidence sensitive habitat
Pomaderris brunnea Rufous Pomaderris	V	E	Moderate - not detected during field survey. A previous record exists in the Study Area adjacent to an existing access track. The record is from the 1950s, and it is unclear if the identification is correct, given *Pomaderris brunnea* is generally found 'in a very limited area around the Colo, Nepean and Hawkesbury Rivers, including the Bargo area and near Camden' (OEH 2016). The record also seems to be an outlier when compared to the other records for the species which are centred around the Picton area, approximately 12 km from the record within the Study Area. Regardless, a precautionary approach has been taken given the previous record and it has been assumed that some potential habitat may occur within the gullies of the Study Area to which this species is known to have similar habitat preferences.	Unlikely – relatively conspicuous and not detected during field survey. Unlikely to remain undetected during field survey.	Possible. Species may occur within gully environments near riparian zones, however it should be noted that the species was not recorded during the targeted survey within riparian areas surveyed.

6. Assessing Threatened Fauna and Populations

6.1 Overview

Unlike threatened flora species, only some threatened fauna are regarded as 'species credit' species in the FBA, with the remaining regarded as 'ecosystem credit' species. However, some threatened fauna also need to be considered and surveyed due to their listing on the EPBC Act.

This section details the survey effort used to detect the presence/absence of threatened fauna and their habitats within the Study Area. Threatened fauna with potential habitat to be impacted by the Project is detailed further in the impact assessment for the Project (section 7.6).

6.1 Database Analysis

47 threatened fauna have previously been recorded or have modelled habitat within a 5 km radius of the Study Area (Appendix 2). Of the 47 species:

- Two species are listed as Critically Endangered under the EPBC Act, and one under the BC Act.
- 10 species are listed as Endangered under the BC Act, and four under the EPBC Act.
- 33 species are listed as Vulnerable under the BC Act and 13 under the EPBC Act.

The BBCC has also identified the following threatened species requiring survey within the Study Area (section 2.2) including:

- Broad-headed Snake;
- Eastern Ground Parrot;
- Eastern Pygmy-possum;
- Giant Burrowing Frog;
- Giant Dragonfly;
- Green and Golden Bell Frog;
- Koala;
- Large-eared Pied Bat;
- Littlejohn's Tree Frog;
- Red-crowned Toadlet;
- Southern Brown Bandicoot (eastern); and
- Stuttering Frog.

6.2 Threatened Fauna Survey

Field survey was designed according to the two main impacts of the proposed mining extension, which are:

1. Potential subsidence throughout Area 5 and Area 6 with the potential to adversely impact specific habitats such as waterbodies (swamps and creeks), cliffs, caves and rock outcrops.
2. Vegetation clearing and habitat removal for proposed ventilation shaft sites and other surface infrastructure as well as associated potential indirect impacts.

A list of target species (Table 15) was generated prior to the field survey after consideration of potential impacts from the Project and analysis of the results of the database and literature review. For all target species relevant guidelines were consulted in order to assist with determining the survey methods, effort and timing. Any limitations to implementing survey guidelines (e.g. conflicting guidelines or limitations due to timing of survey) were identified and considered in the context of previous experience in detection of target species within the locality.

The following guidelines or documentation were consulted to assist with establishing the survey plan:

- *Threatened Species – Field Survey Methods* (OEH, 2015).
- *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities Working Draft* (NSW Department of Environment and Conservation, 2004b).
- *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna – Amphibians* (Department of Environment and Climate Change, 2009).
- *Survey Guidelines for Australia's Threatened Frogs* (Department of the Environment, Water, Heritage and the Arts, 2010a).
- *Survey Guidelines for Australia's Threatened Bats* (Department of the Environment, Water, Heritage and the Arts, 2010b).
- *Survey Guidelines for Australia's Threatened Birds* (Department of the Environment, Water, Heritage and the Arts, 2010c).
- *Survey Guidelines for Australia's Threatened Mammals* (Department of Sustainability, Environment, Water, Population and Communities, 2011).
- *Survey Guidelines for Australia's Threatened Reptiles* (Department of Sustainability, Environment, Water, Population and Communities, 2011).
- State Environmental Planning Policy No. 44 – Koala Habitat Protection.
- Relevant Significant Impact Guidelines and Referral Guidelines for EPBC Act listed species.

In addition to consideration of targeted threatened species, it was also desired that non-target species be detected within the Study Area, particularly within areas prone to subsidence or clearing impacts. The suite of methods used to detect target threatened species was sufficient to detect a large proportion of non-target vertebrate fauna species. Finally, where preferred habitat for threatened species was identified outside of areas prone to subsidence some additional survey effort was employed within these areas to assist with judging the likelihood of occurrence of threatened species within impacted areas and to add confidence to non-detection of threatened species within impacted areas considered less favourable habitats.

Table 15: Target Species for the Dendrobium Baseline Fauna Assessment

Common Name	Scientific Name	Class of Credit	Primary Potential Impact	
			Subsidence related impacts	Clearing impacts (ventilation shafts)
Broad-headed Snake	*Hoplocephalus bungaroides*	Species	Possible subsidence impacts on sheltering sites (rock crevices or flat sandstone rocks on exposed cliff edges or rocky outcrops).	Clearing or removal of sheltering habitat (rock crevices or flat sandstone rocks on exposed cliff edges or rocky outcrops; or hollows in large trees within 500 m of escarpments).
Eastern Bristlebird	*Dasyornis brachypterus*	Species	Subsidence experienced within swamps is unlikely to result in significant habitat degradation for this species.	Clearing of potential habitat if heath areas present.
Eastern Ground Parrot	*Pezoporus wallicus*	Species	Subsidence experienced within swamps is unlikely to result in significant habitat degradation for this species.	Clearing of potential habitat if heath areas present.
Eastern Pygmy-possum	*Cercartetus nanus*	Species	Minimal impacts likely from subsidence as the species is known to occur from all other surrounding vegetation types and is not reliant on habitat impacted by subsidence.	Clearing of potential breeding, sheltering and foraging habitat.
Giant Burrowing Frog	*Heleioporus australiacus*	Species	Potential impacts to non-breeding and breeding habitat within swamps and creeks.	Clearing within woodland habitat which may be used for dispersal and movement, or sheltering, particularly if in close proximity to streams that offer breeding habitat.
Giant Dragonfly	*Petalura gigantea* (incidental survey only as species being assessed as part of aquatic surveys)	Species	Subsidence impacts around swamps particularly with permanent water.	None expected due to absence of preferred swamp types.
Koala	*Phascolarctos cinereus*	Species	Not expected.	Clearing within potential and core Koala habitat.
Littlejohn's Tree Frog	*Litoria littlejohnii*	Species	Subsidence impacts around creeks and swamps (sheltering and breeding habitat).	Clearing within woodland habitat which may be used for dispersal and movement, or sheltering, particularly if in close proximity to streams that offer breeding habitat.
Red-crowned Toadlet	*Pseudophryne australis*	Species	Possible subsidence impacts around minor creeks.	Clearing of potential breeding and sheltering habitat primarily around creeks. Clearing around intermittent watercourses with the potential for indirect impacts or habitat removal.
Southern Brown Bandicoot (eastern)	*Isoodon obesulus*	Species	Minimal impacts likely from subsidence as the species is known to occur from all other surrounding vegetation types and is not reliant on habitat impacted by subsidence.	Clearing within potential woodland habitat.
Southern Myotis	*Myotis macropus*	Ecosystem & Species	Subsidence impacts on foraging habitat (higher order creeks with permanent pools).	Clearing of potential roost habitat (tree hollows) within 200 m of riparian zone.

6.2.1 Threatened Fauna Survey Effort

The majority of field survey was undertaken between the 4th of October 2016 and the 22nd of December 2016, with supplementary surveys incorporating minor design changes completed between the 28th of May and the 12th of June 2018. Survey was conducted over 22 days and nights, with a preference for including warm and humid nights. Weather partly dictated survey techniques employed on any particular day. For example, frog surveys were skewed towards warmer nights and diurnal bird surveys confined to the morning or at dusk on hot days. Daily weather observations for Campbelltown (station 068257) can be viewed in Appendix 6. Field dates and personnel are presented in Table 16 below.

Table 16: Dates of Field Survey and Field Team

Date of survey	Field Team
4th – 7th October 2016	Simon Tweed, Chelsea Hankin
10th – 14th October 2016	Simon Tweed, Matthew Stanton, Chelsea Hankin
31st October – 2nd November 2016	Simon Tweed, Chelsea Hankin
22nd – 25th November 2016	Simon Tweed, Chelsea Hankin
22nd December 2016	Simon Tweed, Chelsea Hankin
3rd – 4th July 2017	Simon Tweed, Alex Christie
28th May 2018	Simon Tweed, Alex Christie
31st of May 2018	Simon Tweed, Luke Baker
12th of June 2018	Simon Tweed, Lucy Porter

Methods and effort for fauna surveys to address the two distinct potential impact scenarios (surface infrastructure impacts, and subsidence impacts) are detailed in Table 17, with additional detail in regard to selected field survey methods provided in section 6.3. Fauna survey within the Dendrobium Pit Top Car Park area was limited to habitat, flora and vegetation survey. No targeted fauna survey was conducted in this area due to the degraded habitat present and relatively small area of impact, therefore it was not warranted nor required.

Table 17: Methodology and Survey Effort for the Dendrobium Baseline Fauna Assessment

Method	Survey Effort for Area 5 and Area 6 (Potential for Subsidence Impacts)	Survey Effort for Surface Infrastructure Areas	Comments
a) Adult frog and tadpole day habitat search	32 hours at 17 sites over 13 days.	2 hours at 2 sites over 2 days.	Primarily targeting tadpoles of difficult to detect threatened species (Giant Burrowing Frog and Littlejohn's Tree Frog). Incorporated call playback survey for Red-crowned Toadlet. Note that there was very little aquatic habitat within infrastructure areas. Some of the survey effort associated with subsidence areas is relevant for potential indirect impacts from ventilation infrastructure areas.
b) Adult frog and tadpole night habitat search	19 hours at 13 sites over 10 nights.	1 hour over 3 nights at or adjacent to ventilation shaft sites.	Swamps with pools and creeks. Note that there was very little aquatic habitat within infrastructure areas. Some of the survey effort associated with subsidence areas is relevant for potential indirect impacts from ventilation infrastructure areas.
c) Frog nocturnal call playback	13 call playback surveys at 13 sites over 10 nights	3 call playback surveys over 3 nights.	Incorporated into nocturnal habitat and watercourse searches. Diurnal call playback incorporated into day frog and tadpole habitat searches.
d) Adult frog and tadpole night watercourse search	42 hours at 17 sites over 12 nights.	3 hours over 3 nights at or adjacent to ventilation shaft sites.	Supplemented with day habitat surveys to enable tadpole identification of cryptic species.
e) Reptile habitat search (Nov-Mar, July)	36 hours along creek lines, swamps and ridgelines but concentrating on ridgelines.	4 hours within four ventilation shaft sites.	Surveys of swamp and riparian habitat (mining area) conducted in conjunction with frog habitat surveys. Additional surveys of rocky outcrops to locate Broad-headed Snake in infrastructure areas only.
f) Bird area search (all year)	26 sites receiving an average of 50 minutes of survey. Total 22 hours.	Two ventilation shaft sites with an average of 75 minutes of survey at each site. Total 150 minutes.	Birds are generally unlikely to be impacted by subsidence however, surveys were completed to gather baseline data. Standard 20 min 2 ha bird surveys were extended at most sites to a minimum of 30 minutes. Selected swamps had surveys of 60 minutes for Eastern Ground Parrot and Eastern Bristlebird.
g) Dusk bird survey	5 swamps each receiving an average of 110 minutes of survey. Total 530 minutes.	N/A	Targeted to Eastern Bristlebird and Eastern Ground Parrot habitat to add certainty around the absence of these species within the Study Area.
h) Call playback (Eastern Bristlebird and Eastern Ground Parrot)	30 minutes at 5 swamps. Total 150 minutes.	N/A	In conjunction with item (f) and (g) above.
i) Nocturnal bird call playback	Some call playback for potentially occurring owls was completed throughout Area 5 and Area 6. Total 40 minutes at four sites.	No large hollows preferred for owl roosting were observed within ventilation shaft sites. Call playback for potentially occurring owl species was done at Ventilation Site No 6B. Total 40 minutes.	Target species unlikely to be impacted by subsidence so survey was limited within proposed mining areas. No roosting habitat within ventilation shaft sites identified, foraging habitat assumed present.
j) Nocturnal bird day habitat search	Conducted during the bird area searches and day habitat searches.	Conducted during the bird area searches and day habitat searches.	Search for potential roost trees for owls, particularly within proposed ventilation shaft sites.
k) Nest boxes – small arboreal mammals (e.g. Eastern Pygmy Possum)	N/A	Three hollow nest boxes installed at each of four ventilation shaft sites. Total of 672 trap nights.	Threatened arboreal species are unlikely to be impacted by subsidence so this method was not performed within proposed mining areas.
l) Infrared cameras medium to large mammals (e.g. Potoroo, Quoll, Bandicoot)	36 camera sites. 1471 nights.	10 sites. 227 nights.	Target species included the Spotted-tail Quoll and Rosenberg's Goanna. Cameras were used in preference to cage traps and Elliot traps due to their greater efficiency.

Method	Survey Effort for Area 5 and Area 6 (Potential for Subsidence Impacts)	Survey Effort for Surface Infrastructure Areas	Comments
m) Spotlighting surveys – foot arboreal and terrestrial mammals	Performed intermittently with other nocturnal survey components. Targeted spotlighting within Sandstone Transition Forest in Area 5 to highlight Koala presence.	10 hours in total – 2.5 hours at each ventilation shaft site.	Target species unlikely to be impacted by subsidence so survey was limited in proposed mining areas.
n) Spotlighting surveys – vehicle arboreal and terrestrial mammals	Performed intermittently between other nocturnal survey components.	Approximately 1 km of vehicle spotlighting performed at ventilation shaft sites. Additional vehicle spotlighting not applicable due to limited vehicle access.	Target species unlikely to be impacted by subsidence so limited survey was performed.
o) Call-playback surveys– Koala	Two to three hours performed within Sandstone Transition Forest in Area 5 to highlight Koala presence.	Call playback at 4 sites over 3 nights – 9 surveys in total.	Target species unlikely to be impacted by subsidence so limited survey was performed within proposed mining areas.
p) Search for scats and signs – all mammals	Incorporated into all survey activities.	Incorporated into all survey activities.	Incorporated into all survey activities.
q) Harp trapping (Oct-Mar) - bats	24 nights from 7 sites.	8 nights (in total) from 4 sites.	Trapping targeted to riparian areas or cliff lines within proposed mining areas.
r) Ultrasonic (Song Meter) call recording (Oct-Mar) - bats	24 nights at 6 sites.	12 trap nights (1 site x 12 nights).	Restricted to cliff line habitat and riparian habitat in proposed mining areas.
s) Spot Assessment Technique (SAT) - Koalas	3 SAT plots were conducted in areas where feed tree species were present, to assist with determining usage by Koalas.	3 SAT plots were conducted in ventilation shaft sites within 500 m to 1 km of core Koala habitat. However, no preferred tree species were present within ventilation shaft sites.	Koala already known to be present and unlikely to be impacted by subsidence so survey not performed in mining areas. SAT searches not carried out in ventilation shaft site sites due to absence of preferred feed trees.

6.3 Threatened Fauna Field Methodology

Survey methods were selected to detect the target species identified during desktop research (i.e. threatened species with the potential to be impacted by the Project), as well as to employ a broad range of survey techniques that allowed for detection of the variety of fauna species groups. Survey methods and effort is summarised in Table 17 and illustrated in Figure 10.

The field survey program was designed to detect potentially occurring threatened species and allow for an inventory of species to be compiled for the Study Area. Singular sightings of individual species were recorded during targeted survey activities, however repeat observations were not necessarily recorded. Incidental observations were recorded if the species had not been detected during targeted survey, was a threatened species, or was considered rare either within the Study Area or more widely.

A relative abundance measure was assigned to each species after survey activities. The relative abundance measure is an estimate of the species abundance within the Study Area relative to other species of the same trophic level. The following categories of relative abundance were used:

- Common – commonly encountered during field survey. Present in moderate to high numbers throughout most or all habitats within the Study Area.
- Occasional – occasionally encountered from a range of habitats or frequently encountered but confined to specific habitats that are well represented throughout the Study Area.
- Uncommon – not commonly encountered within the Study Area due to general rarity across all habitat types or confinement to specific habitats that are uncommon throughout the Study Area.
- Rare – encountered rarely. May be passing through the Study Area or is confined to specific habitats that are rare within the Study Area. Alternatively, preferred habitat occurs moderately frequently however species is rarely encountered due to its cryptic nature, natural rarity or requirement for particular conditions of the habitat feature in order to occur (such conditions may be poorly known).

6.3.1 Frog and Tadpole Surveys (day)

Diurnal frog and tadpole surveys were conducted along creeks, swamps and rivers of the Study Area, with a focus on collecting tadpoles of cryptic threatened frog species. Call playback for threatened species was conducted during survey, particularly for the Red-crowned Toadlet.

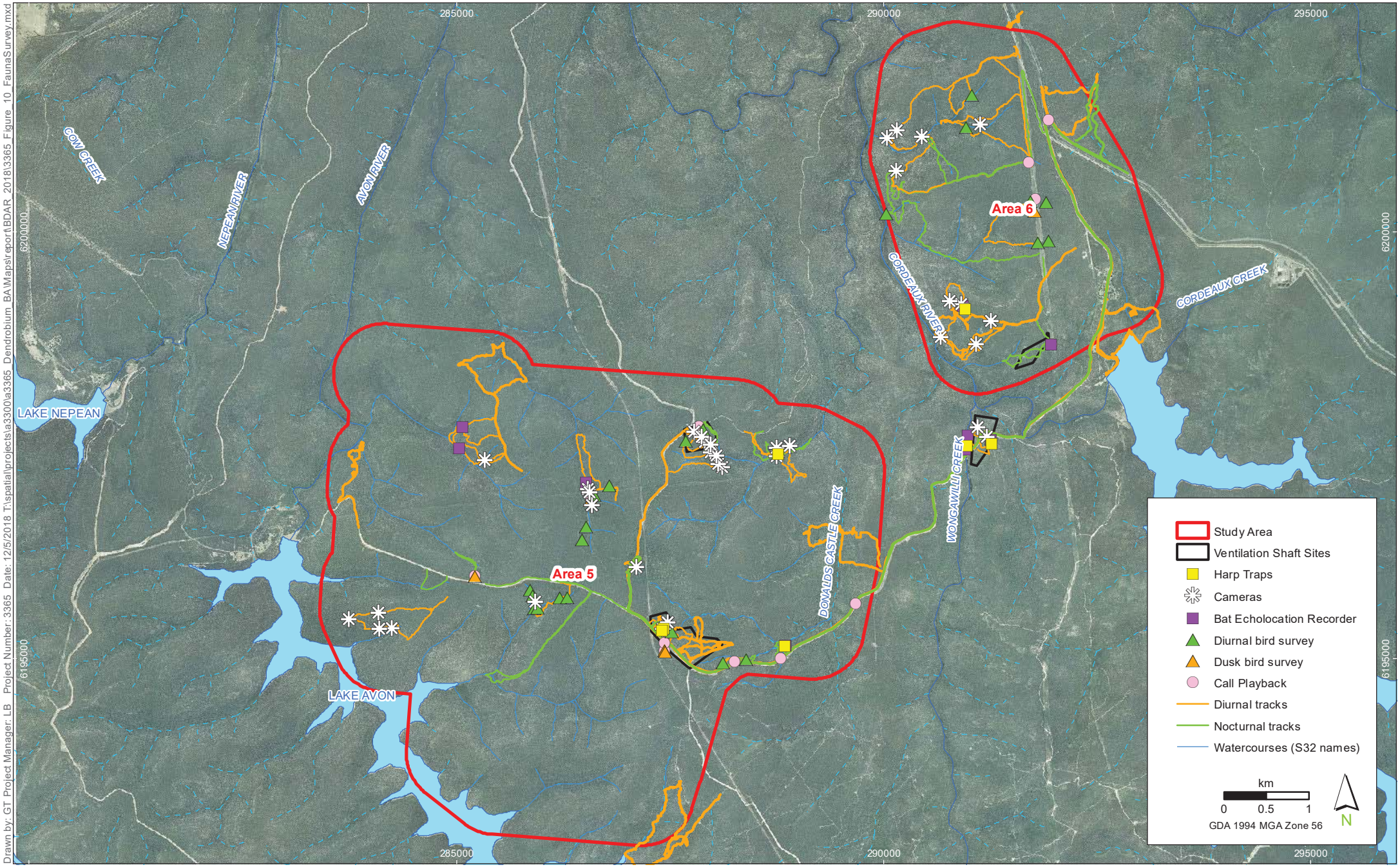
Tadpole specimens were collected with a dip net, stored live and later identified by a tadpole specialist (Marion Anstis).

6.3.2 Frog and Tadpole Surveys (night)

Nocturnal frog surveys were conducted along creeks, swamps and rivers of the Study Area. Survey involved listening for frog calls, active searching of frog habitat such as under rocks and logs, as well as streamside searches using torchlight to detect eye-shine and movement of frogs. Frog species were identified using local knowledge supported by various guides and phone applications. Call playback for threatened species was conducted during survey.

6.3.3 Reptile Surveys

Reptile surveys were conducted throughout the Study Area, particularly where rocky outcrops were identified, with a preference for a north or westerly facing aspect (i.e. habitat for Broad-headed Snake). Survey involved checking under rock plates and partially embedded rocks. Reptile survey for Rosenberg's Goanna was supported by the use of infrared cameras.



niche Environment and Heritage

Threatened fauna survey effort

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 10

Imagery: (c) S32 2009

6.3.4 Bird Survey

Bird surveys using binoculars (10 x 40) were conducted across the Study Area targeting swamp and riparian habitats as well as proposed ventilation shaft sites. Two-hectare bird surveys were conducted at 24 sites, with survey duration ranging from 20 – 60 minutes depending on the level of bird activity. Surveys were generally conducted soon after sunrise until an hour prior to midday. Surveys targeting the Eastern Bristlebird and Eastern Ground Parrot were conducted at dusk for at least an hour where potential habitat occurred. The location of bird surveys was biased towards upland swamp and adjacent creeks as well as proposed ventilation shaft sites as these have been identified as potential impact areas.

Calls of target threatened species were played during bird surveys, particularly in potential habitat for Eastern Bristlebird and Eastern Ground Parrot. Call identification was aided by cross checking with a call reference library in the field.

Additional bird observations (outside of targeted bird survey periods) were recorded throughout the course of the survey if previously unobserved or uncommonly observed birds were encountered.

6.3.5 Nocturnal Call Playback (Mammals and Owls)

Nocturnal call playback was carried out adjacent to proposed ventilation shaft sites and areas of potential Koala habitat (as identified by presence of preferred feed tree species). Calls of targeted species (Koala, Powerful Owl, Masked Owl and Barking Owl) were broadcast for up to five minutes followed by five minutes of listening time. This process was repeated several times for each survey.

6.3.6 Nest Boxes

Nest boxes made of hollow branches approximately 150 mm in diameter and 400 mm long with tin capping and inserted bedding material were affixed to trees adjacent to flowering shrubs (e.g. *Lambertia formosa)* within ventilation shaft sites. Nest boxes were checked twice throughout their deployment and remain in place for future monitoring as needed.

6.3.7 Spotlighting

Spotlighting was carried out during nocturnal survey activities and within each ventilation shaft site. Each spotlighting session lasted for approximately one hour. Each session consisted of a traverse through the site sampling the identified habitats using LED torches.

6.3.8 Infrared Cameras

Infrared cameras were deployed throughout the Study Area with a focus on swamps, riparian habitat, cliff lines and proposed ventilation shaft sites. Cameras were placed on identified tracks and left unbaited, or baited with sardines or honey.

6.3.9 Ultrasonic Call Recording

Ultrasonic bat detectors (SM2+) recorders were set along identified flyways or creeks. The detectors were placed on the ground or elevated up to 1 m where possible and, pointed upwards at approximately a 45° angle and programmed to record from sunset. Recorded calls were later analysed by computer using Kaleidoscope software.

6.3.10 Harp Traps

Harp traps were set at riparian sites and along flyways where there was nearby cliff (and potential cave) habitat or within proposed ventilation shaft sites. Two adjacent harp traps were set at each site to fill identified flyways. Traps were checked daily with bats identified on site.

6.3.11 Koala SAT Surveys

Koala scats were searched for by targeting preferred feed trees consisting of primary feed trees (in subsidence areas with potential Koala habitat) or supplementary feed tree species where primary feed trees were absent (i.e. within vent shaft sites). The bases (0 to 2 m from the trunk) of twenty such trees were searched for evidence of Koala scat by first circling around the tree looking for scats without disturbing the leaf litter (approximately 1 minute), then by raking through the leaf litter for scats (approximately 1 additional minute).

6.3.12 Weather Conditions During Survey

The majority of field survey was undertaken between the 4th of October 2016 and the 22nd of December 2016, with supplementary surveys incorporating minor design changes completed between the 28th of May and the 12th of June 2018. Survey was conducted over 22 days and nights, with a preference for including warm and humid nights. Weather partly dictated survey techniques employed on any particular day. For example, frog surveys were skewed towards warmer nights and diurnal bird surveys confined to the morning or at dusk on hot days. Daily weather observations for Campbelltown (station 068257) can be viewed in Appendix 6.

6.3.13 Survey Limitations

Breeding events and heightened activity for frogs (such as the Giant Burrowing Frog) in response to heavy rain, generally coincide with access restrictions within the Sydney Catchment Special Areas, thus reducing detectability of adults. This limitation was addressed by focussing on tadpole surveys which have been considered a more effective method of detection for the Giant Burrowing Frog (DECC 2009) and have shown to be reliable in assessing presence of Littlejohn's Tree Frog within streams adjacent to the Study Area which are part of long-term monitoring programs (Biosis 2016). Attempts were made to stagger frog survey over a number of months and to include at least some nights when conditions were relatively warm and humid. Survey limitations have been considered in conducting the likelihood of occurrence analysis. Therefore, despite some threatened species not being detected during survey, they have been presumed present (or having a high likelihood of occurrence) where they are cryptic species and where there is a reasonable basis to assume they are likely to be present due to past records.

For safety reasons the survey was also limited by site constraints such as steepness of terrain and accessibility.

6.4 Fauna Results

One-hundred and sixteen fauna species were recorded during the survey comprising 12 frog, 58 bird, 32 mammal and 14 reptile species. A list of fauna recorded in the Study Area is provided in Appendix 5.

Four species of exotic fauna were recorded: Fox, Cat, House Mouse and Rabbit. The exotic fauna are well established within the region and are not newly invasive with all of these species being relatively common and widespread throughout the region. The exotic fauna species were observed to have comparatively lower densities within the Study Area than neighbouring rural lands. This pattern is attributed to the large expanses of consolidated bushland with low levels of fragmentation and the low productivity of the majority of the Study Area.

Of the invasive species recorded, the Fox was most commonly encountered, via detection with infrared cameras. Rabbits were confined to Area 6 in close proximity to cleared areas.

Of the 116 species recorded, 14 species are threatened species listed under the schedules of the BC Act or EPBC Act. The threatened fauna recorded, along with the number of records has been provided in Table 18 and shown in Figure 11. Additional details regarding observations of threatened species throughout the Study Area are included in Appendix 5.

In addition to those threatened fauna species recorded during survey the likelihood of occurrence analysis demonstrated that a further nine threatened species are highly likely to occur or are known to use the Study Area in some capacity (Table 18, Appendix 2).

6.4.1 Threatened Fauna for Further Consideration

In total, six of the recorded or highly likely to occur threatened fauna are 'species credit' fauna, and seven are considered 'dual credit' species, whereby the species credit component is triggered if breeding or other important habitat is impacted. Other species with a species credit component are considered to have a low likelihood of occurrence and no further specific assessment is therefore required.

The remaining threatened species are regarded as 'ecosystem credit' species, and have been assumed present within the habitats of the Study Area and offset concurrently with impacts to vegetation types.

Use of the Study Area and potential impacts from the proposal on threatened species are discussed further in section 7.6.

6.4.2 EPBC Act Listed Fauna

EPBC Act listed threatened fauna that were recorded during the field survey include:

- Greater Glider (vulnerable);
- Grey-headed Flying-fox (vulnerable);
- Koala (vulnerable); and
- Littlejohn's Tree Frog (vulnerable).

A Migratory species, the White-bellied Sea Eagle, was also recorded.

Whilst not detected, the results of the database analysis in Appendix 2 has indicated the following threatened fauna species have a moderate to high likelihood of occurrence within the Study Area:

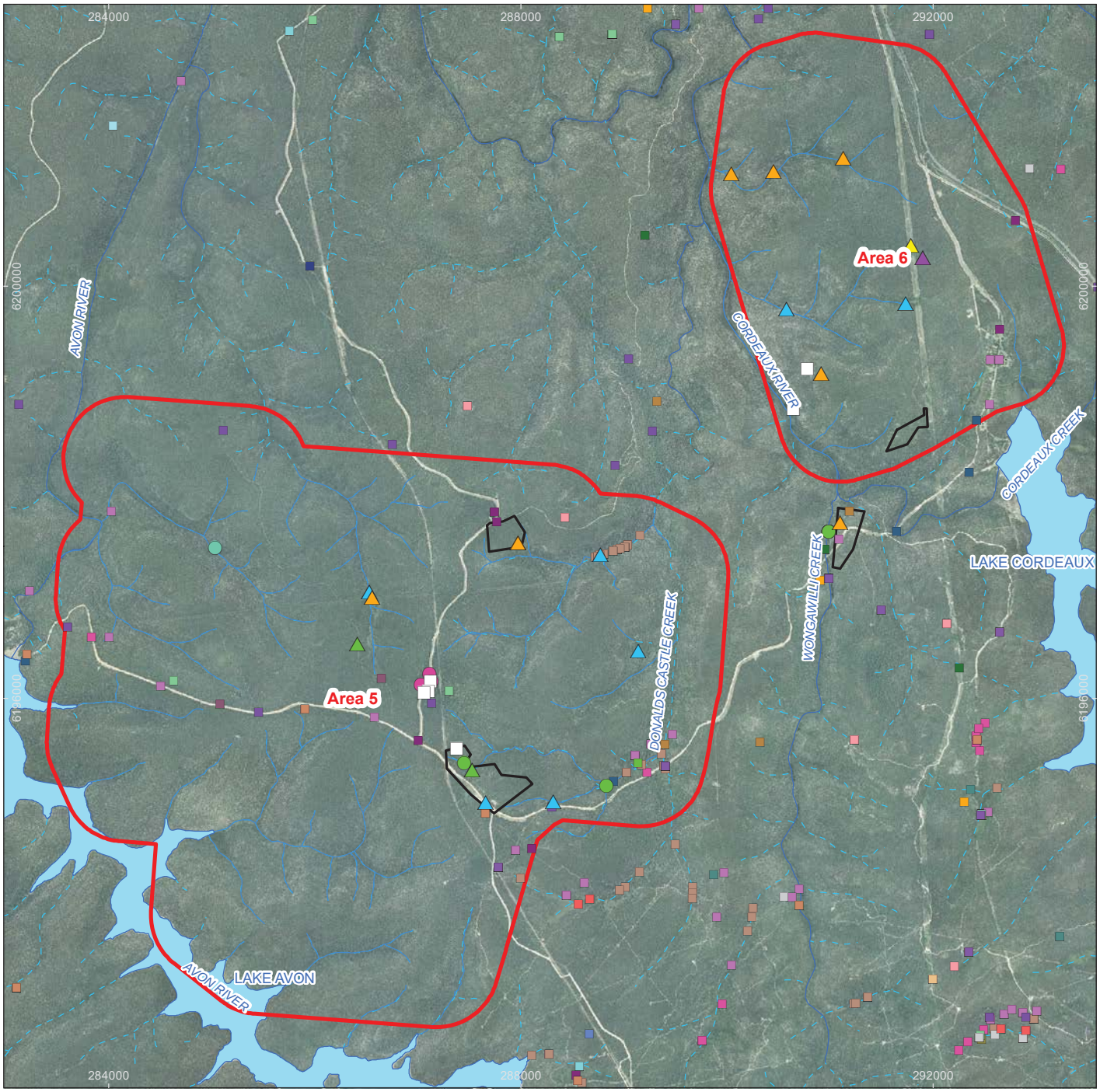
- Broad-headed Snake (vulnerable); and
- Giant Burrowing Frog (vulnerable).

Potential impacts to these species are discussed further in section 7.6.

Table 18: Threatened species recorded during the survey or known or highly likely to occur within the Study Area based on previous surveys.

Common Name	Scientific Name	Credit status	BC Act Status	EPBC Act Status	No. of observations	Potential to occur in surface disturbance footprint	Potential to occur in subsidence sensitive environments
Recorded during current survey							
Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis*	Ecosystem and Species	V	-	2	High	High
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	Ecosystem	V	-	1	High	High
Eastern Freetail-bat	*Mormopterus norfolkensis*	Ecosystem	V	-	1	High	High
Golden-tipped Bat	*Kerivoula papuensis*	Ecosystem	V	-	1	Low (prefers gullies)	High – likely restricted to preferred parts of Study Area
Greater Broad-nosed Bat	*Scoteanax rueppellii*	Ecosystem	V	-	3	High	High
Greater Glider	*Petauroides volans*	N/A	-	V	3	Low	Low
Koala	*Phascolarctos cinereus*	Species	V	V	6	High	Moderate
Little Bentwing-bat	*Miniopterus australis*	Ecosystem and Species	V	-	1	Moderate	Moderate
Littlejohn's Tree Frog	*Litoria littlejohni*	Species	V	V	6	Low but with potential to move through	High
Rosenberg's Goanna	*Varanus rosenbergi*	Ecosystem	V	-	8	High	High
Scarlet Robin	*Petroica boodang*	Ecosystem	V	-	2	High	High
Varied Sittella	*Daphoenositta chrysoptera*	Ecosystem	V	-	1	Moderate	High
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Ecosystem and Species	V	M	1	Low	Moderate
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	Ecosystem	V	-	1	High	High
Species with a known or high likelihood of occurrence within Study Area from previous surveys							
Broad-headed Snake	*Hoplocephalus bungaroides*	Species	E	V	N/A	Habitat not present	Low
Eastern Pygmy-possum	*Cercartetus nanus*	Ecosystem	V	-	N/A	Low	Moderate
Gang-gang Cockatoo	*Callocephalon fimbriatum*	Ecosystem and Species	V	-	N/A	High	High
Giant Burrowing Frog	*Heleioporus australiacus*	Species	V	V	N/A	Low	High
Giant Dragonfly	*Petalura gigantean*	Species	E	-	N/A	Habitat not present	Known
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	Ecosystem and Species	V	-	N/A	Low	Moderate
Grey-headed Flying-fox	*Pteropus poliocephalus*	Ecosystem and Species	V	V	N/A	High	High
Powerful Owl	*Ninox strenua*	Ecosystem and Species	V	-	N/A	Moderate	Moderate
Red-crowned Toadlet	*Pseudophryne australis*	Species	V	-	N/A	Low	High

Key: TSPD = Threatened Species Profile Database; Eco = Ecosystem credit species; Species = Species credit species; V = Vulnerable; E = Endangered; M = Migratory.



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Date: 4/8/2019

Project Number: 3365

Project Manager: LB

Drawn by: GT

Niche Survey Records (2016-2018)

- Eastern Bentwing-bat
- Eastern False Pipistrelle
- Eastern Freetail-bat
- Golden-tipped Bat
- Greater Broad-nosed Bat
- Greater Glider
- Koala
- Little Bentwing-bat
- Littlejohn's Tree Frog
- Rosenberg's Goanna
- Scarlet Robin
- Varied Sittella
- White-bellied Sea-Eagle
- Yellow-bellied Sheathtail-bat

Wildlife Atlas Records (OEH 2016)

- Barking Owl
- Broad-headed Snake
- Eastern Bentwing-bat
- Eastern False Pipistrelle
- Eastern Freetail-bat
- Eastern Pygmy-possum
- Gang-gang Cockatoo
- Giant Burrowing Frog
- Giant Dragonfly
- Glossy Black-Cockatoo
- Greater Broad-nosed Bat
- Grey-headed Flying-fox
- Koala
- Large-eared Pied Bat
- Little Bentwing-bat
- Little Lorikeet
- Littlejohn's Tree Frog
- Masked Owl
- Powerful Owl
- Red-crowned Toadlet
- Rosenberg's Goanna
- Scarlet Robin
- Sooty Owl
- Southern Brown Bandicoot (eastern)
- Southern Myotis
- Squirrel Glider
- Turquoise Parrot
- Varied Sittella
- Yellow-bellied Glider
- Perennial watercourse
- Non-perennial watercourse
- Study Area
- Ventilation Shaft Sites

km
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GDA 1994 MGA Zone 56

N

Threatened fauna recorded

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FIGURE 11

Imagery: (c) S32 2015

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7. Impact Assessment

The impact assessment forms Stage 2 of the BAR as detailed in the FBA. Further Assessments of Significance have been carried out for those species listed under the EPBC Act that may potentially be impacted by the Project. The impact assessment has incorporated the findings from the specialist studies in order to determine the severity and potential for impacts on biodiversity.

7.1 Avoidance of Impacts

In accordance with the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014) and the FBA, proponents must demonstrate the measures employed to avoid, mitigate and offset impacts of a Project on biodiversity values. This section of the report outlines the avoidance, management and mitigation measures that South32 has incorporated into the Project design or would employ during construction, operation and completion of the Project to reduce impacts on biodiversity values. Section 11 of this report describes the offset strategy for the Project to account for residual impacts that cannot be avoided or mitigated. Section 11.4.2 also describes an additional avoidance measure, being the relinquishment of currently approved (and offset) impacts to Coastal Upland Swamps in Dendrobium Area 3.

7.1.1 Site Selection and Design Considerations

A number of key constraints and longwall setbacks have been considered in the development of the Project surface infrastructure, and underground mining layout, based on previous mining experience at the Dendrobium Mine and stakeholder feedback. The constraints and justification for project site selection has been provided by South32 and summarised in Table 19.

Primary constraints dictated that the Project underground mining areas were located within the following:

- Existing extent of CCL 768; and
- Mineable areas of the coal seams as determined by geological constraints (e.g. igneous intrusions, thickness of the coal seams etc.).

In addition, a number of longwall setbacks from both built and natural features were developed and incorporated within the design to minimise the potential for impacts to surface infrastructure and the environment, including:

- No direct undermining of the existing Avon and Cordeaux Dam waterbodies.
- Longwall setbacks from both the Avon and Cordeaux Dam walls (minimum setback distance of 1 km).
- Longwall setbacks from the Full Supply Levels (FSLs) of both the Avon and Cordeaux Dams (minimum setback distance of 300 m from the FSLs).
- Setbacks from named watercourses (i.e. Cordeaux River, Avon River and Donalds Castle Creek) to achieve 200 millimetres (mm) or less additional predicted closure.

Table 19: Justification of Project Site Location as Provided by South32

Constraint/Setback	Summary of Setback	Criteria
CCL	Area 5 is constrained by the extent of CCL 768 to the west and north and the extent of Area 3 consent to the east. Area 6 is constrained by the extent of CCL 768 to the north.	
Geology and resource	Area 5 is constrained by igneous intrusions to the east, and high-ash zone to the north-east and a thinning Bulli Seam to the south and south-east. Area 6 is constrained by a fault zone to the east.	
Restriction on Extraction Height	Extraction height restricted to a maximum of 3.9 m.	
No mining below existing Avon/Cordeaux Dams (Waterbodies)	Avoidance of longwall mining under existing Avon Dam and Cordeaux Dam has been adopted for the Approved Dendrobium Mine.	Dam Safety Committee (DSC) must endorse any extraction under stored water for existing storages, including first workings and secondary workings. The DSC has endorsed several instances of first workings under Lake Cordeaux at the Approved Dendrobium Mine.
1 km setback from existing Avon/Cordeaux Dam walls	1 km minimum distance from Avon/Cordeaux Dam walls to longwalls (secondary extraction).	DSC must endorse any mining within the DSC Notification Zones. The DSC has published Guidance notes, including: No uncontrolled extraction (e.g. full-sized longwalls) within 1.7x depth of cover of existing dam structures. No mining (any) within 1.2x depth of cover of existing dam structures.
300 m setback from existing Dam Full Supply Level (FSL)	> 300 m minimum distance from existing Avon Dam FSL. > 300 m minimum distance from existing Cordeaux Dam FSL, however, distance is determined by 1 km setback from existing dam wall.	DSC endorsement for mining to date in the Approved Area 3B has included the following: *that extraction is not endorsed within a minimum horizontal distance to the FSL equal to 300 m.* *extractions through geological structures projected to intersect the Reservoir that could result in more than negligible leakage from the Reservoir are avoided.*
Setbacks from named watercourses (as defined by the NSW Department of Lands) to achieve 200 mm or less closure	Relevant to Cordeaux River, Avon River and Donalds Castle Creek.	Achieve 200 mm or less additional predicted closure along named streams.
Setbacks from "key stream features": Pools (>100 m^3 and permanent) Waterfalls/Steps (>5 m and with permanent pool at base)	Applies to features along streams within the Study Area.	Setback of 50 m when mining will occur on one side of the key stream feature. Setback of 100 m when mining will occur on more than one side of the key stream feature.

In addition to the above, the Project longwall layout was further refined to include a number of setbacks (e.g. shortening of longwalls, inclusion of longwall coal blocks) to avoid the direct undermining of 'key stream features' (i.e. pools greater than 100 cubic metres and permanent; waterfalls greater than 5 m and with permanent pool at base) as identified by South32.

The proposed longwall set-backs from the watercourses minimises the potential for subsidence related impacts on biodiversity known to occur, in particular threatened amphibians.

The proposed location of the ventilation shaft sites was subject to an initial preliminary biodiversity constraints assessment to avoid areas of TECs (including Coastal Upland Swamps) and watercourses. The proposed sites were then inspected and modified where such features occurred. A larger footprint was inspected for each ventilation shaft site to inform the site layout. Each of the sites were positioned adjacent to existing fire roads to minimise access disturbance within native vegetation areas.

7.2 Impacts to Vegetation and Habitat from Vegetation Clearing

The Project would result in direct impact to approximately 28.5 ha of native vegetation associated with the clearing for surface infrastructure, including (Figure 12):

- 18.8 ha for ventilation shaft sites;
- 0.2 ha for the proposed carpark;
- 5.0 ha for the exploration boreholes. This impact would be a relatively short-term and actively rehabilitated after decommissioning; and
- 4.5 ha for the transmission lines. This impact would involve the clearing and maintenance of vegetation above a height of approximately 2 metres.

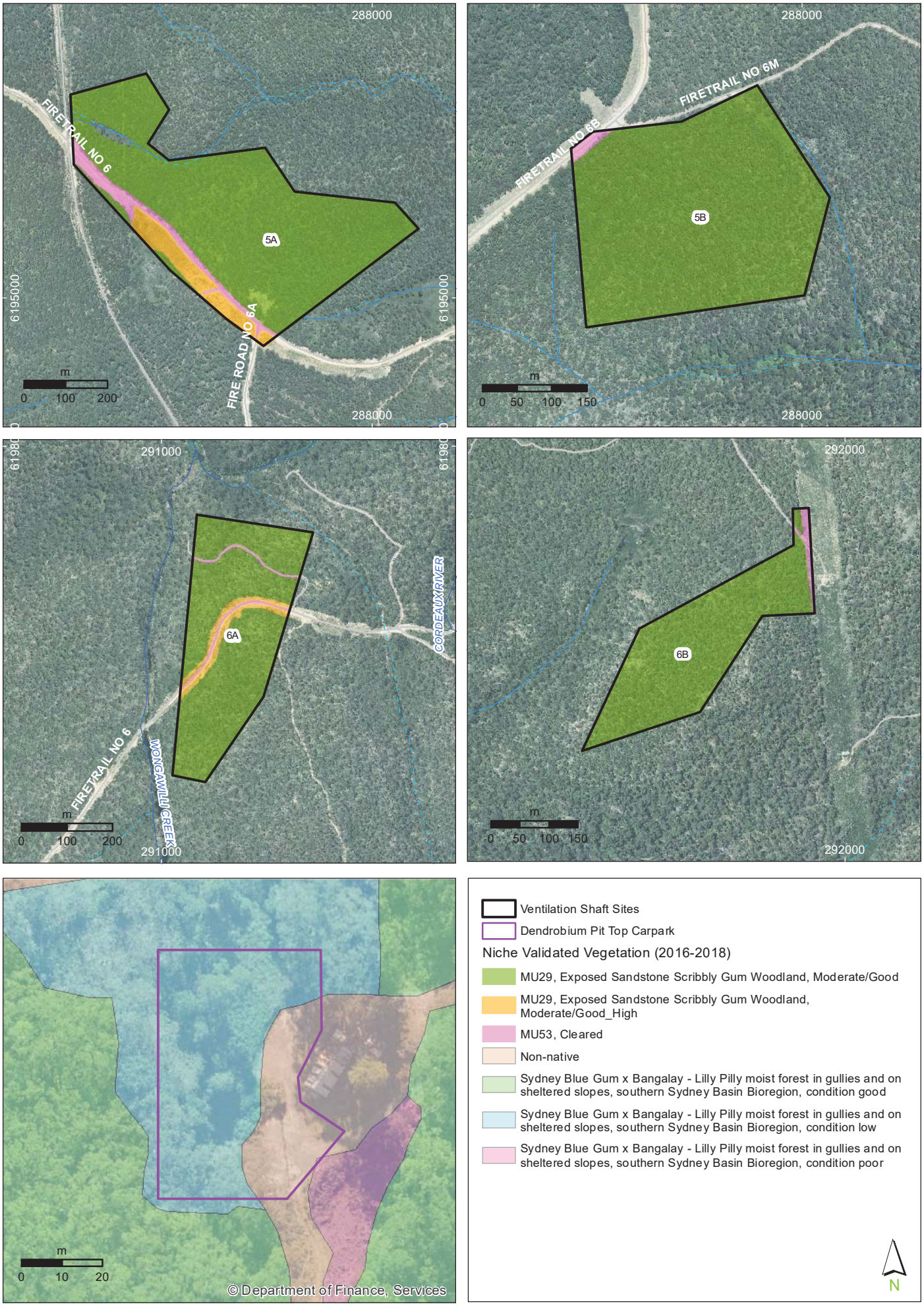
All native vegetation areas would be rehabilitated following decommissioning as per South32's company-wide closure standards and rehabilitation strategy (see section 9.2.4), and all potential indirect impacts minimised through implementation of the mitigation measures detailed in section 9.

7.3 Subsidence and its Potential to Impact Terrestrial Ecology Values

Predictions regarding the likelihood and potential impact of subsidence for the Project were investigated and reported by MSEC (2019). Natural surface features within the Study Area sensitive to subsidence movements identified by MSEC (2019) include the following:

- Avon River;
- Cordeaux River;
- Donalds Castle Creek;
- Wongawilli Creek;
- Drainage lines;
- Cliffs;
- Rocky outcrops steep slopes; and
- Swamps, wetlands and water related ecosystems.

These features provide habitat for a range of biodiversity, therefore consideration of the potential effects of subsidence on these features and threatened biodiversity is addressed in this report.



Vegetation and habitat clearing impacts

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FIGURE 12

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The potential effects of subsidence include:

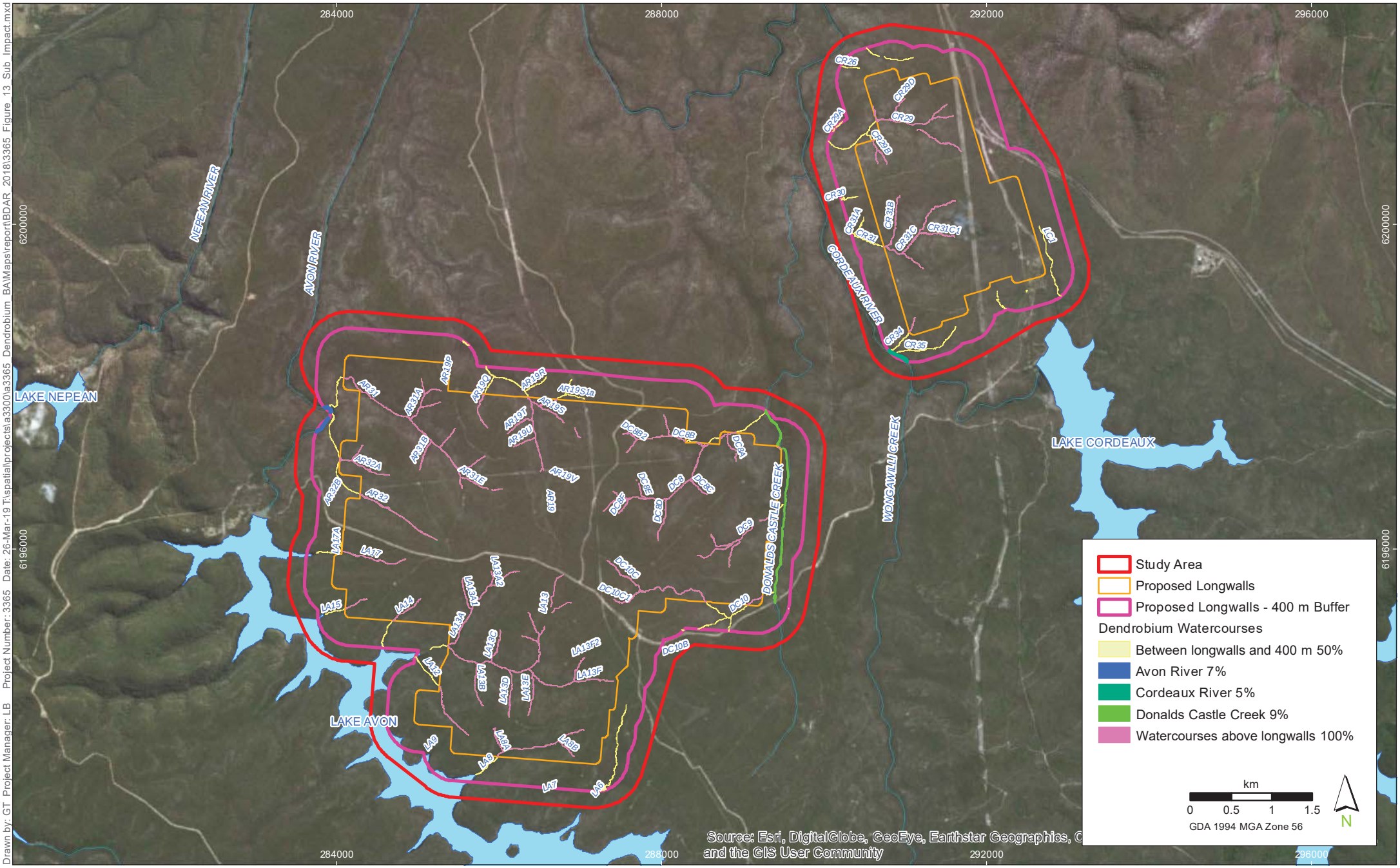
- Fracturing of river and creek beds, which may result in:
  - surface water flow diversion in the streams;
  - reduced flows and pool water levels;
- Changes in levels of ponding, scouring or desiccation due to mining induced tilt;
- Instability and rock falls along cliff-faces; and
- Slippages, erosion and rock falls on steep slopes and rock ledges.

A summary of the predicted impacts that the Project may have on natural surface features sensitive to subsidence (as described by MSEC 2019), and the associated potential impacts to ecology, are described in Table 20 below and shown on Figure 13. An assessment of the potential subsidence related impacts on native vegetation and species credits are discussed in the following sections.

7.3.1 Cumulative impacts

The Project would expand longwall coal mining within the Dendrobium Areas following on from mining of Dendrobium Area 3 to the south, which was approved in 2008. Generally, the Project will add to cumulative impacts from longwall mining via additional clearing and subsidence. Future applications for longwall coal mining with the Southern Coalfield are likely to occur, within existing constraints to mining, including extent of the coal resource and environmental considerations.

Detailed and ongoing monitoring of previous impacts (within areas such as Dendrobium Mine Area 3) from longwall mining has allowed for a better understanding of likely impacts on terrestrial ecology and more accurate subsidence predictions. In turn, this has contributed to more sensitive mine-planning and development of targeted avoidance and mitigation measures as presented within this report.



Subsidence impacts to watercourses

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FIGURE 13

Imagery: (c) DigitalGlobe 2017-11-01

Table 20: Subsidence Related Impacts to Biodiversity (MSEC 2019)

Type	Description of Natural Feature	Subsidence Impact (MSEC 2019)	Potential Biodiversity Impact
Avon River	The Avon River commences near Calderwood, within the Wollongong LGA and flows generally north reaching its confluence with the Cordeaux River, south of the Wilton township. The Avon River is located west of the proposed longwall Area 5. The total length of river within the Study Area based on the 600 m boundary is 0.8 km. The section of the Avon River within the Study Area is a fifth order perennial stream. The upper reaches of the river has been impounded by Lake Avon. The surface water flows, therefore, are controlled by the release of water from the dam. The bed of the river comprises exposed bedrock containing rockbars with standing pools. There are also other controlling features including boulderfields, riffle zones and debris accumulations.	**Impact Assessments for the Avon River** … *"Fracturing in bedrock has been observed due to previous longwall mining where the tensile strains are greater than 0.5 mm/m or where the compressive strains are greater than 2 mm/m. It is possible, therefore, that fracturing could occur along the Avon River due to the valley related compressive strains. Fracturing has been observed up to approximately 400 m outside of previously extracted longwalls in the Southern Coalfield ..."* *"The length of the Avon River located within 400 m of the proposed longwalls is approximately 0.4 km. It is possible that minor and isolated fracturing could occur along the section of the river located closest to the proposed longwalls.* *The Avon River is located at a minimum distance of 360 m from proposed longwalls in Area 5. There have been five areas of Type 3 impacts reported outside the previously extracted LW9 to LW13 in Area 3B, at distances of 115 m to 290 m from the mining area (refer to Section 3.8). However, there have been no Type 3 impacts observed at distances of 360 m or greater from the previously extracted longwalls at the Mine or elsewhere in the Southern Coalfield."* *"… The maximum predicted total closure for the Avon River due to the extraction of the proposed longwalls is 200 mm. The predicted rate of impact for the pools and channels along this river due to the extraction of the proposed longwalls, therefore, is in the order of 7 %.* *It has been assessed that the likelihood of significant fracturing resulting in surface water flow diversions along the Avon River is very low, i.e. affecting approximately 7 % of the pools and channels along the 0.4 km section of river located within approximately 400 m of the proposed longwalls."*	Subsidence within the Avon River has the potential to impact on the range of aquatic, riparian and terrestrial flora and fauna dependant on the riverine habitat and its water. It is predicted that about 7 % of pools and channels along the 0.4 km section of the Avon River located within approximately 400 m of the proposed longwalls may have surface water flow diversions as a result of the Project.
Cordeaux River	The Cordeaux River commences below Mount Keira, within the Wollongong LGA and flows generally north and northwest joined by the Avon River before its confluence with the Nepean River, south of the Wilton township. The Cordeaux River is located to the west and to the south of the proposed longwalls in Area 6. The total length of river that is located within the Study Area based on the 600 m boundary is 1.4 km. The section of the Cordeaux River within the Study Area is a third order perennial stream. The upper reaches of the river have been impounded by Lake Cordeaux. The surface water flows, therefore, are controlled by the release of water from the dam. The bed of the river comprises exposed bedrock containing rockbars with standing pools. There are also other controlling features including boulderfields, riffle zones and debris accumulations.	**Impact Assessments for the Cordeaux River** … *"Fracturing in bedrock has been observed due to previous longwall mining where the tensile strains are greater than 0.5 mm/m or where the compressive strains are greater than 2 mm/m. It is possible, therefore, that fracturing could occur along the Cordeaux River due to the valley related compressive strains. Fracturing has been observed up to approximately 400 m outside of previously extracted longwalls in the Southern Coalfield ..."* *"The length of the Cordeaux River located within 400 m of the proposed longwalls is approximately 0.25 km. It is possible that minor and isolated fracturing could occur along the section of the river located closest to the proposed longwalls.* *The Cordeaux River is located at a minimum distance of 370 m from proposed longwalls in Area 6. There have been no Type 3 impacts observed at distances of 370 m or greater from the previously extracted longwalls at the Mine or elsewhere in the Southern Coalfield.* *The maximum predicted total closure for the Cordeaux River due to the extraction of the proposed longwalls is 80 mm. There have been five areas of Type 3 impacts reported outside the previously extracted LW9 to LW13 in Area 3B, at distances of 115 m to 290 m from the mining area (refer to Section 3.8). However, there have been no Type 3 impacts outside of previous longwall mining at a predicted total closure of 80 mm.* *It has been assessed that the likelihood of significant fracturing resulting in surface water flow diversions along the Cordeaux River is very low, i.e. affecting less than 5 % of the channels located within the Study Area. Minor fracturing could occur elsewhere along the river for distances up to approximately 400 m from the proposed longwalls."*	Subsidence within the Cordeaux River has the potential to impact on the range of aquatic, riparian and terrestrial flora and fauna dependant on the riverine habitat and its water. It is predicted that about 5 % of pools and channels along Cordeaux River located within 400 m of the proposed longwalls may have surface water flow diversions as a result of the Project.

Type	Description of Natural Feature	Subsidence Impact (MSEC 2019)	Potential Biodiversity Impact
Donalds Castle Creek	Donalds Castle Creek is situated on the eastern side of the proposed longwalls in Area 5. The total length of creek that is located within the Study Area based on the 600 m boundary is approximately 3.3 km. The total length of creek that has been previously mined beneath is approximately 1.5 km. The section of Donalds Castle Creek located within the Study Area is a third and fourth order perennial stream with a small base flow and increased flows for short periods of time after each significant rain event. The creek generally flows in a northerly direction and drains into the Cordeaux River to the west of the proposed longwalls in Area 6. The bed of the creek comprises exposed bedrock containing rockbars with standing pools. There are also other controlling features including boulderfields, riffle zones and debris accumulations.	**Impact Assessments for Donalds Castle Creek** ***Potential for increased levels of ponding, scouring or desiccation due to mining tilt*** … *"… The predicted changes in grade due to the extraction of the proposed longwalls are considerably less than the average natural grade. It is unlikely, therefore, that there would be adverse changes in the potential for ponding, flooding or scouring of the banks along the creek due to the mining-induced tilts.* *It is possible, however, that there could be some localised changes in the levels of ponding or flooding, due to the mining-induced tilts, where the maximum changes in grade coincide with existing pools, steps or cascades along the creek. It is predicted that these changes would not result in adverse impacts on the creek since the predicted changes in grade are less than 0.05 %."*	Adverse changes in the potential for ponding, flooding or scouring are unlikely. Some localised change to microhabitats (debris, riffles, etc.) may impact upon existing amphibian habitat along Donalds Castle Creek. However, MSEC predicts that such changes are unlikely to adversely impact the creek.
		Potential for fracturing and surface water flow diversion in the streams … *"The maximum predicted compressive strain for Donalds Castle Creek due to the valley closure effects is 7 mm/m based on the 95 % confidence level. Fracturing in bedrock has been observed due to previous longwall mining where the tensile strains are greater than 0.5 mm/m or where the compressive strains are greater than 2 mm/m. Fracturing therefore could occur along Donalds Castle Creek due to the valley related compressive strains. Fracturing has been observed up to approximately 400 m outside of previously extracted longwalls in the Southern Coalfield ..."* *"The length of Donalds Castle Creek located within 400 m of the proposed longwalls is approximately 2.9 km. It is possible that fracturing could occur along the section of the creek located closest to the proposed longwalls."* *"… The maximum predicted total closure for Donalds Castle Creek due to the extraction of the proposed longwalls is 210 mm. The predicted rate of impact for the pools along this creek due to the extraction of the proposed longwalls, therefore, is in the order of 9 %.* *It has been assessed that the likelihood of significant fracturing resulting in surface water flow diversions along Donalds Castle Creek is very low, i.e. affecting approximately 9 % of the pools located within the Study Area."*	It is predicted that about 9 % of pools along Donalds Castle Creek within 400 m of the proposed longwalls may have fracturing resulting in surface water flow diversions as a result of the Project within the Study Area. This may impact upon pools which amphibians rely on for breeding and lifecycle development. Whilst, not all pools are predicted to be impacted and impacts are likely to be relatively minor and localised, during times of low rainfall may see breeding amphibian pools dry limiting habitat.
Wongawilli Creek	Wongawilli Creek is a third order perennial stream with a small base flow and increased flows for short periods of time after each significant rain event. Pools in the creek are permanent (based on monitoring to date) and naturally develop behind the rockbars and at the sediment and debris accumulations. Wongawilli Creek is situated to the east of the proposed longwalls in Area 5 and to the south of the proposed longwalls in Area 6. The upper reaches of Wongawilli Creek are located between the completed longwalls in Areas 3A and 3B and between the two series of approved longwalls in Area 3C. The completed longwalls have been mined up to distances from the creek of 110 m in Area 3A and 260 m in Area 3B.	**Impact Assessments for Wongawilli Creek** … *"Wongawilli Creek is situated to the east of the proposed longwalls in Area 5 and to the south of the proposed longwalls in Area 6. The creek is located outside the Study Area based both on the 35° angle of draw and the 600 m boundary. The minimum distances of the creek from the proposed longwalls in each of the proposed mining areas are 0.7 km from LW601B and 1.4 km from LW512."* … *"Fracturing has occurred in one pool along Wongawilli Creek due to the previous mining in Areas 3A and 3B. The impact site is located 200 m west of LW6 and 410 m east of LW9. Pool water levels below baseline conditions have been observed in this pool at low flow conditions during the mining of LW13. This site has therefore been considered a Type 3 impact.* *The predicted additional vertical subsidence, upsidence and closure along Wongawilli Creek, due to the extraction of the proposed longwalls in Areas 5 and 6, are all less than 20 mm. Very low-levels of closure could develop at the northern end of the creek, at the confluence with the Cordeaux River, but it is unlikely to result in measurable strains due to its distance from the proposed longwalls.*	As stated by MSEC (2019) Wongawilli Creek is unlikely to be adversely impacted from the proposed longwalls.

Type	Description of Natural Feature	Subsidence Impact (MSEC 2019)	Potential Biodiversity Impact
		It is unlikely, therefore, that Wongawilli Creek would experience adverse impacts due to the extraction of the proposed longwalls in Areas 5 and 6. This is supported by the observation that there have been no adverse impacts on streams at the Mine, or elsewhere in the Southern Coalfield, that have been located at distances similar to that of Wongawilli Creek from the proposed longwalls."	
Drainage lines	There are a number of unnamed drainage lines located within the Study Area. The drainage lines in Area 5 are tributaries to the Avon Reservoir and the Avon River in the western part of the mining area and are tributaries to Donalds Castle Creek in the eastern part of the mining area. The drainage lines in Area 6 are tributaries to the Cordeaux River. The drainage lines located directly above the proposed longwalls are generally first and second order streams, with a 0.7 km section that is third order. The drainage lines overlying the proposed mining areas are ephemeral (HEC, 2019). The beds of the drainage lines generally comprise exposed bedrock containing rockbars with some standing pools. There are also other controlling features including boulderfields, riffle zones and debris accumulations.	**Impact Assessments for the Drainage Lines** ***Potential for increased levels of ponding, flooding and scouring due to the mining-induced tilt*** … *"The maximum predicted changes in grade are similar orders of magnitude as the natural gradients along the drainage lines …"* … *"It is unlikely that large-scale adverse changes in the levels of ponding or scouring of the banks along these drainage lines due to the predicted mining-induced tilt. It is possible that localised increased ponding could develop in some locations, where the natural grades are smallest and the predicted mining-induced tilts are the greatest. It is also possible, that there could be localised areas that experience increased scouring of the banks, in the locations of the predicted maximum increasing tilts, such as downstream of the longwall chain pillars.* *The potential impacts of increased ponding and scouring of the drainage lines, therefore, are expected to be minor and localised.* *The tributaries to the drainage lines have high natural gradients as they are located on the sides of the ridgelines. It is unlikely, therefore, that increased ponding or scouring would develop along these tributaries due to the mining-induced tilt."* ***Potential for cracking in the creek bed and fracturing of bedrock*** … *"… The predicted subsidence parameters for the proposed longwalls are less than the maxima predicted for the existing and approved longwalls due to their smaller extraction heights. The likelihood and extents of the assessed impacts on the drainage lines due to the extraction of the proposed longwalls in Areas 5 and 6, therefore, are expected to be less than that observed above the previously extracted longwalls in Area 3B.* *It is expected that fracturing of the bedrock would occur along the sections of the drainage lines that are located directly above the proposed longwalls. Fracturing can also occur outside the extents of the proposed longwalls, with fracturing occurring at distances up to approximately 400 m."* … *"Surface water flow diversions are likely to occur along the sections of drainage lines that are located directly above the proposed longwalls. In times of heavy rainfall, the majority of the runoff would flow over the fractured bedrock and soil beds and would not be diverted into the dilated strata below. In times of low flow, however, surface water flows can be diverted into the dilated strata below the beds.* *The tributaries to the drainage lines may also experience fracturing due to the conventional ground movements. These tributaries are ephemeral and, therefore, surface water flows only occur during and for short periods after rain events. The diversion of surface water flows in these tributaries is unlikely to affect water availability due to their high natural gradients and the free draining nature of the ridgelines."*	Potential impacts of ponding and scouring are predicted to be minor and localised. The divergence of surface water during periods of low rainfall may impact upon amphibian habitat. However, given the extensive habitat available and the minor and localised impacts, it is unlikely to significantly impact amphibian populations.

Type	Description of Natural Feature	Subsidence Impact (MSEC 2019)	Potential Biodiversity Impact
Cliffs[1]	The cliffs and minor cliffs are predominantly located along the lower reaches of the streams including: AR31, AR32, DC8, DC10, LA6, LA7, LA8, LA10, LA13, LA14, LA15, LA17 and their associated tributaries in Area 5; and the Cordeaux River, CR29, CR31, CR35, LC1 and their associated tributaries in Area 6. There are 40 cliffs that have been identified directly or partially above the proposed longwalls in Area 5. No cliffs have been identified directly above the proposed longwalls in Area 6. The lengths of each of the cliffs located directly or partially above the proposed longwalls in Area 5 range between 20 m and 200 m. The total length of cliffs located directly or partially above the proposed longwalls is approximately 2.2 km. The lengths of each of the cliffs located outside the proposed longwalls in Area 5 and within the 35° angles of draw range between 20 m and 165 m. The total length of these cliffs is approximately 1.7 km. The maximum heights of each of the cliffs located directly or partially above the proposed longwalls vary between 10 m and 25 m. The cliffs have formed predominantly from Hawkesbury Sandstone, with the faces being at various stages of weathering and erosion. The cliffs have many overhangs and undercuts that are generally less than 6 m.	**Impact Assessments for the Cliffs** … *"It is difficult to assess the likelihood of cliff instabilities based upon predicted ground movements. The likelihood of a cliff becoming unstable is dependent on many factors that are difficult to quantify … It is therefore possible that cliff instabilities may occur during mining that may be attributable to either natural causes, mine subsidence, or both.* *The likelihood of instabilities for the cliffs located directly or partially above the proposed longwalls in Area 5 has been assessed using the previous experience of mining beneath cliffs at the Mine. The cliffs located above the previously extracted longwalls in Area 1 are the most relevant case study."* … *"Based on the experience in Area 1 at the Mine, it has been estimated that between 7 % and 10 % of the total length, or between 3 % and 5 % of the total face area of the cliffs located directly or partially above the proposed longwalls in Area 5 would be impacted. This represents a total length of impact of approximately 150 m to 220 m, or a total face area of impact of approximately 800 m^2 to 1400 m^2.* *The remaining cliffs located outside the extents of the proposed longwalls and within the 35° angle of draw are predicted to experience vertical subsidence of less than 100 mm. These cliffs are predicted to experience only low-levels of tilt, curvature and strain. Rock falls could occur at some of the cliffs located outside the extents of the proposed longwalls, which would represent less than 1 % of the affected cliffs. It is estimated that these impacts would affect a total length of less than 20 m or a face area of less than 100 m^2.* *It is unlikely that the cliffs located outside the 35° angle of draw would experience adverse impacts due to their distances outside of the mining areas. This is based on the extensive experience of mining near to but not directly beneath cliffs in the NSW coalfields, where no large cliff falls have occurred when the cliffs are located completely outside the angle of draw from mining. It is still possible, but unlikely, that rock falls could occur due to mining, natural processes, or both."*	It has been estimated that between 7 % and 10 % of the total length, or between 3 % and 5 % of the total face area of the cliffs located directly or partially above the proposed longwalls in Area 5 would be impacted. This represents a total length of impact of approximately 150 m to 220 m, or a total face area of impact of approximately 800 m^2 to 1400 m^2. Some fauna species are dependent on the specialised habitat of the cliff faces/ rock ledges and overhangs for survival. Cliff faces and rock ledges have the potential to support habitat for threatened species.

Type	Description of Natural Feature	Subsidence Impact (MSEC 2019)	Potential Biodiversity Impact
Rocky outcrops steep slopes and	A steep slope has been defined as an area of land having a gradient between 1 in 3 (33% or 18.3°) and 2 in 1 (200% or 63.4°). The steep slopes within the Study Area have been identified within the alignments of the streams. The slopes are steepest along the lower reaches of the streams, outside the extents of the proposed longwalls. Rock outcrops are defined as exposed rockfaces with heights of less than 10 m or slopes of less than 2 in 1. There are rock outcrops located across the Study Area, primarily within the valleys of the streams and along the steep slopes.	**Impact Assessments for the Rock Outcrops and Steep Slopes** *"The maximum predicted tilt for the rock outcrops and steep slopes within the Study Area is 25 mm/m (i.e. 2.5 %, or 1 in 40). The predicted changes in grade are very small when compared to the natural surface grades, which are greater than 1 in 3. It is unlikely, therefore, that the mining-induced tilts would result in an adverse impact on the stability of the rock outcrops or steep slopes.* *The rock outcrops and steep slopes are more likely to be affected by curvature and strain, rather than tilt. The potential impacts would generally occur from the increased horizontal movements in the downslope direction, resulting in tension cracks appearing at the tops and on the sides of the rock outcrops and steep slopes, buckling of the bedrock at the bottoms of the rock outcrops, and compression ridges forming at the bottoms of the steep slopes.* *The maximum predicted total curvatures for the rock outcrops and steep slopes within the Study Area are 0.50 km-1 hogging and 0.60 km-1 sagging. The maximum predicted curvatures and strains for these features are similar to those predicted to have occurred for LW1 and LW2, which mined directly beneath a ridgeline comprising cliffs, rock outcrops and steep slopes. The impacts observed from this case study, therefore, can be used to provide an indication of the potential impacts on the rock outcrops and steep slopes located within the Study Area."* *…* *"LW1 and LW2 mined directly beneath a ridgeline where steep slopes had natural surface gradients of up to 1 in 1 (i.e. 100 %, or an angle to the horizontal of 45 °). A number of surface cracks were observed along the steep slopes located directly above LW1 and LW2 ..."* *…* *"It is expected, therefore, that the downslope movement of the ground would also occur along rock outcrops and steep slopes within the Study Area. The steep slopes are heavily vegetated and natural erosion due to soil instability (i.e. natural downslope movements) was not readily apparent from the site investigations undertaken. If tension cracks were to develop, due to the extraction of the proposed longwalls, it is possible that soil erosion could occur if these cracks were left untreated."* *…*	Slippage of earth and rocks down steep slopes and rock falls has the potential to directly impact (destroy/smother) vegetation, flora and fauna habitat as well as directly injure or kill native fauna.

Type	Description of Natural Feature	Subsidence Impact (MSEC 2019)	Potential Biodiversity Impact
Swamps, wetlands and water related ecosystems	A description of Coastal Upland Swamps can be found in Section 4.5.2.	**Impact Assessments for the Swamps** ***Potential for changes in surface water flows due to mining-induced tilts*** *"Mining can potentially affect surface water flows through swamps, if the mining-induced tilts are much greater than the natural gradients, potentially resulting in increased levels of ponding or scouring, or affecting the distribution of the water within the swamps.* *The maximum predicted tilt for the swamps within the Study Area is 19 mm/m (i.e. 1.9 %, or 1 in 53). The mining-induced tilts are small when compared with the natural gradients within the swamps …"* *…* *"It is unlikely, therefore, that there would be large-scale adverse changes in the levels of ponding or scouring of the swamps based on the predicted vertical subsidence and tilt."* ***Potential for cracking in the swamps and fracturing of bedrock*** *"Fracturing of the uppermost bedrock has been observed in the past, as a result of longwall mining, where the tensile strains have been greater than 0.5 mm/m or where the compressive strains have been greater than 2 mm/m.* *The swamps that are located outside the extents of the proposed longwalls (eight in Area 5 and 13 in Area 6) are predicted to generally experience tensile strains less than 0.5 mm/m and compressive strains less than 2 mm/m due to the proposed mining. It is unlikely, therefore, that the bedrock beneath these swamps would experience significant fracturing.* *Fracturing has been observed in streams located outside the extents of previously extracted longwalls in the NSW coalfields. Fracturing has been observed up to 400 m from longwalls; however, these have occurred within large valleys and have not resulted in adverse impacts. Hence, it is possible that minor and isolated fracturing could occur in the bedrock beneath the swamps located outside the extents of the proposed longwalls; however, it is unlikely to result in adverse surface impacts on these swamps.* *The swamps that are located directly above the proposed longwalls are predicted to experience tensile strains greater than 0.5 mm/m and compressive strains greater than 2 mm/m. It is expected, therefore, that fracturing would occur in the bedrock beneath these swamps."* *"The valley related upsidence movements could result in the dilation of the strata beneath the valley infill swamps …"* *"The dilated strata beneath the drainage lines, upstream of the swamps, could result in the diversion of some surface water flows beneath parts of the valley infill swamps. It is noted, however, that the drainage lines upstream of the swamps are generally ephemeral and, therefore, surface water flows occur during and shortly after rainfall events."* *…*	Potential fracturing of bedrock within Coastal Upland Swamps partially or entirely above th proposed longwalls. Potential changes to the hydrology of Coastal Upland Swamps due to mining induced tilt. Potential for changes in floristic composition of vegetation communities in response to changes in hydrology.

[1] "Cliff Continuous rock face, including overhangs, having a minimum length of 20 m, a minimum height of 10 m and a minimum slope of 2 to 1 (>63.4º). Minor Cliff A continuous rock face, including overhangs, having a minimum length of 20 m, heights between 5 m and 10 m and a minimum slope of 2 to 1 (>63.4º); or a rock face having a maximum length of 20 m and a minimum height of 10 m"

7.4 Native Vegetation

7.4.1 Impact from Surface Infrastructure

The Project would result in the direct impact to approximately 28.5 ha of native vegetation associated with the clearing for surface infrastructure.

The vegetation to be cleared for the ventilation shaft sites and Dendrobium Pit Top Carpark includes:

- 18.8 ha of PCT1083 Red Bloodwood - scribbly gum heathy woodland (HN566)
- 0.2 ha of PCT1245 Sydney Blue Gum x Bangalay - Lilly Pilly moist forest (ME044).

Vegetation that may be cleared for the additional service boreholes includes:

- Up to 4 ha of native vegetation that does not align to a TEC or Coastal Upland Swamp, anticipated to be PCT1083 Red Bloodwood - scribbly gum heathy woodland (HN566).
- Up to 1 ha of PCT1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest (HN556), which aligns to the Shale Sandstone Transition Forest TEC under both NSW and Commonwealth legislation.

Vegetation that may be cleared for the transmission lines includes:

- Up to 4 ha of native vegetation that does not align to a TEC or Coastal Upland Swamp, anticipated to be 3 ha of PCT1083 Red Bloodwood - scribbly gum heathy woodland (HN566) and 1 ha of PCT1250 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest (HN651).
- Up to 0.5 ha of PCT1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest (HN556), which aligns to the Shale Sandstone Transition Forest TEC under both NSW and Commonwealth legislation.

7.4.2 Impact from Subsidence – Non-Swamp Vegetation

Subsidence from the Project may result in the following impacts to non-swamp native vegetation:

- Vegetation die-back around strata gas emission/drainage sites within creeks.
- Changes to the floristic composition of vegetation communities immediately adjacent to creeks/ponds where fracturing may result in changes to water flow and water retention periods.
- Destruction/smothering of vegetation/tree fall by rock falls and/or slippage of earth and rocks down steep slopes.

Each of these subsidence related impacts are discussed below.

Vegetation Die-Back Around Strata Gas Emission/Drainage Sites within Creeks

The release of gas emissions from fracturing of sandstone strata may occur as a result of subsidence. Gas may be released into rivers and streams as these areas form topographical low points in the landscape.

The Project has the potential to result in enhanced strata gas emissions overlying watercourses. While not affecting water quality per se, the gas expression associated with release of strata gas has the potential to cause vegetation dieback in the vicinity of the gas release point.

Vegetation dieback as result of gas emissions is a rare event and has only occurred previously on one occasion at Tower Mine, over small areas in the base of the Cataract Gorge that had been directly mined beneath by Longwalls 10 and 14 (Eco Logical Australia, 2004 in TEC 2007), and small localised changes to riparian vegetation along a section of the Waratah Rivulet (HC 2007). These impacts were short term impacts, and limited to small areas of vegetation, local to the points of emission, and when the gas emissions declined, the affected areas were successfully restored. No similar impacts have been reported during the mining of Dendrobium Area 3.

PCTs that occur along the riparian zones of the Study Area includes PCT1083 Red Bloodwood - Scribbly Gum heathy woodland (HN566) and PCT1250 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest (HN651). It is possible that some localised die back from gas emissions may occur to these PCTs where plants occur immediately above or adjacent to the point of gas emission.

Given MSEC (2019) reports that gas releases resulting in observable vegetation die back are not common, and in the instance where it has occurred at Tower Colliery the impacts were limited to small areas that were successfully revegetated, it is expected that any impacts to the PCTs as a result of gas emissions from the Project would be limited in extent and temporal in nature, and that, as for the sites previously affected by gas emissions, if it was to occur, the vegetation would regenerate once the gas emissions ceased. As such, it is considered unlikely that gas emissions from subsidence would result in a decrease in the extent of the PCTs and habitat within the Study Area.

Changes to Riparian Floristic Composition due to Increased Levels of Ponding, Scouring or Desiccation

Changes in the grade of a stream as a result of subsidence has the potential to lead to increased ponding, scouring and/or desiccation. MSEC (2019) states 'It is possible that there could be very localised areas along the streams which could experience small increases in the levels of ponding, where the predicted maximum tilts occur in the locations where the natural gradients are low. However, as the predicted changes in grade are typically less than 1%, any localised changes in ponding are expected to be minor and not result in adverse impacts on these streams. Predicted maximum increases in grade (which may lead to scouring) are relatively small compared with natural grades and the potential increase for scouring is not expected to be significant'.

Vegetation communities which are independent of ground-water and not closely associated with the water levels and hydrology of the creeks are unlikely to be impacted by subsidence due to underground mining.

The localised changes to ponding are predicted by MSEC (2019) to be relatively minor and not result in adverse impacts on the streams. It is similarly expected that any potential impacts to riparian vegetation that may affect the floristic composition of the community would be minor, and highly localised being limited to the area immediately adjacent to the water source. In the Southern Coalfield, previous impacts to riparian vegetation as a result of subsidence have been minor in occurrence, and mostly attributed from gas release causing relatively short term damage to the vegetation, rather than changes to hydrological regimes (as mentioned above).

To date, regular, long-term monitoring of vegetation potentially subject to the impacts of subsidence (undertaken by South32), has not reported any significant areas of vegetation die back as a result of subsidence. Small areas of vegetation die back have been reported in Biosis (2015; 2016), however as discussed in the assessments it is unclear if the events are related to subsidence or a natural event. Regardless, from the monitoring to date, based on only a small number of gas emissions events being reported at Tower Mine and Waratah Rivulet (Eco Logical Australia, 2004 in TEC 2007; HC 2007) such events seem to be relatively minor, temporary in nature and relatively rare.

Unlike the Coastal Upland Swamps, the vegetation adjacent to the creeks is not solely reliant upon ground-water for survival. The presence of water within these watercourses is subject to weather conditions and rainfall events: many areas of the watercourses experience extended dry periods. The vegetation within these areas is therefore already adapted somewhat to temporal changes in the availability of water and periods of dryness. As such, impacts, should they occur, are likely to be highly localised with only minor changes to species composition likely depending on the interaction of that species with changes in water availability. As such, should water diversion occur as a result of subsidence, it is unlikely to result in significant alterations to the composition of the communities or vegetation die back. As such, it is considered unlikely that subsidence would result in any extensive or significant impact to native riparian vegetation within the Study Area. It is highly unlikely that potential impacts as a result of a predicted change to stream hydrology, would decrease the area of PCTs or vegetative habitat that currently occurs along the creeklines of the Study Area.

Destruction of Vegetation/Tree Fall by Rock Falls and Earth Slippages

The steep slopes on the sides of valleys are predominantly found in Hawkesbury Sandstone and consist of a mixture of cliffs and rock outcrops, which are stable at vertical to overhanging, and screed slopes with rocky soils and loose rock fragments. Much of these areas occur along the watercourses within the Study Area.

Slippage of earth and rocks down steep slopes and rock falls have the potential to directly impact (destroy/smother) vegetation, flora and fauna habitat as well as directly injure or kill native fauna.

Subsidence may result in the downslope movement of soils, causing tension cracks to appear at the tops of the slopes, and compression ridges to form at the bottoms of the slopes, which in turn has the potential to cause erosion (MSEC 2019). However, as indicated by MSEC (2019), the total length of impact of cliffs that may be impacted above the longwalls amounts to approximately 25 to 35 m, and only 1% of cliffs located outside the extent of the longwalls may exhibit isolated rock falls. As such, it is considered unlikely that any large-scale impacts to native vegetation due to earth and rock-face instability would occur. If such an event was to occur, the impacts would be localised.

7.4.3 Impact from Subsidence – Coastal Upland Swamps

In determining the potential for impacts associated the Project, MSEC (2019) predicted a number of potential subsidence issues that may be experienced in Coastal Upland Swamps within the Study Area. In order to assess how subsidence may impact upon the extent, floristic composition and habitat with the Coastal Upland Swamps, the results of the existing monitoring campaigns, relevant studies and documentation on historic erosion events have been reviewed. Of particular relevance are the findings from the Dendrobium Mine Area 3A and 3B Coastal Upland Swamp monitoring program, that begun in 2003 across approximately 15 Coastal Upland Swamps, with findings reported annually.

The impact predictions provided in MSEC (2019) (Table 20) indicate that Coastal Upland Swamps partially or entirely located above the proposed longwalls are expected to experience the full range of predicted subsidence movements, compared to Coastal Upland Swamps located outside the extent of the proposed longwalls which will experience reduced levels of subsidence. It is not expected that there would be adverse changes in the levels of ponding or scouring of the Coastal Upland Swamps based on the predicted mining induced tilt, or significant changes in the distribution of surface waters due to mining induced tilt or vertical subsidence.

Based on assessments of water levels and recession rates around past mining in Areas 2, 3A and 3B, it was concluded by Watershed (2019) that hydrographs from swamp piezometers directly above or within 60 m of longwalls exhibit a mining effect, be that through a reduction in the water table to below pre-mining levels and/or increased recession (drainage) rate. Effects on swamp water tables were not reported at distances greater than 60 m from a longwall panel.

Of the 46 Coastal Upland Swamps recorded within the Study Area, 25 are located above longwalls or occur wholly or partially within 60 m from the proposed longwalls.

The predicted subsidence movements have the potential to result in hydrological changes, which have the potential to result in the following key changes to Coastal Upland Swamps in the Study Area:

- Reduction in groundwater levels or desaturation of the upland swamp sediments; and/or
- Transition of the upland swamp to a drier vegetation type; and/or
- Desaturation of soil particles exposing the swamp to peat desiccation; and/or
- Exposure to greater bushfire intensity due to loss of inundation; and/or
- Increased scour and erosion events.

Each of these potential impacts in relation to the Study Area has been discussed in an impact assessment provided in Appendix 8 for the potential impacts to Coastal Upland Swamps. The impact assessment discussion has incorporated the results from the South32, Metropolitan Coal and Wollongong Coal Coastal Upland Swamp monitoring where available.

As discussed in Appendix 8, key conclusions provided in the Biosis 2016/2017 Dendrobium Swamp Monitoring Report, have been summarised in Table 21 below.

Table 21. Dendrobium monitoring 2016/2017 results (Biosis 2017)

Monitoring	Biosis (2017) results summary
LiDAR mapping of total upland swamp area	- The area of upland swamps decreased relative to the 2014 baseline in 2017 across all impact and control swamps assessed, with the exception of Swamp 08 (impact swamp) which recorded a marginal increase. - The changes observed in "impacted" upland swamp extent between 2016 to 2017 are comparable to those observed at the control swamps. - No significant change in the extent of individual upland swamps across both the control and impact treatments was observed in 2017. - Both "impact" and control swamps recorded a decrease in extent, which reflects a change that is observed on a regional scale and is not attributable to localised mining impacts. - While all upland swamps within the study area have decreased from the baseline minimal change was identified between 2016 and 2017.
LiDAR mapping of individual groundwater dependent communities within swamps	- No significant change in the extent of individual upland swamps across both the control and impact treatments was observed in 2017. Both "impact" and control swamps recorded a decrease in extent, which reflects a change that is observed on a regional scale and is not attributable to localised mining impacts. - The change in extent of vegetation communities within upland swamps from the baseline is most notable at impact sites, with declines in extent identified for all vegetation communities. The declines were most noticeable within the Tea-tree Thicket community, indicating that this community is the most sensitive community, however Tea-tree Thicket only comprises 5% of all Coastal Upland Swamp vegetation in the Study Area, its overall extent is small and is disproportionately influenced by change at transitional zones between communities. - The decline of Tea-tree Thicket Community from its baseline extent is not statistically significant.

Monitoring	Biosis (2017) results summary
Total Species Richness (TSR)	- An overall decline in TSR has been observed at all sites and is likely indicative of landscape scale factors, such as changes in climatic conditions, natural succession of swamp vegetation and/or changes on upland swamp vegetation following bushfire. - Whilst vegetation dynamics associated with fire may explain observed declines in richness and diversity at all sites, it is unlikely to have been the only factor contributing to the changes observed at post-mining sites.
Flora composition	- All data for each monitoring site was combined to analyse changes in flora species composition over time using a multivariate presence-absence model. - Statistically significant yearly, and occasionally seasonal, trends in species composition were detected at most sites, regardless of mining area (Dendrobium Area 3A or 3B) or treatment (control or impact sites) when applying a conservative 0.1 alpha significance threshold. - In addition to the yearly and seasonal trends across all sites, a significant change in species composition pre-mining to post-mining was found at two of the six sites; Swamp 15B and Swamp 15A(2) (impact swamps). At the remaining sites there is no statistical significance in floristic composition when compared to before and after mining and between control and impact sites. - Statistically significant yearly and, occasionally, seasonal trends in species composition were detected at most sites, regardless of mining area or treatment. Such global trends are indicative of natural turnover of species within upland swamps in response to seasonal and annual variability in climate, competition, disturbance and edaphic factors including nutrient availability.

As discussed in Appendix 8, key conclusions from the impact assessment include the following:

- Detecting changes in Coastal Upland Swamp vegetation and habitat change as a result of subsidence is confronted with many limitations and variables, and as such, results from the monitoring programs have not been conclusive to date. This is largely attributed to the time over which change may be observed in vegetation as a result of subsidence, influences of the surrounding landscape, current limitations of monitoring, in particular current LiDAR and aerial photograph interpretation models, and the unique nature of each swamp and its subsidence impacts.
- No large scale study has been completed to compile and analyse trends in the pre and post mining data from the Coastal Upland Swamps piezometer results from the Illawarra Coal, Metropolitan Coal and Wollongong Coal monitoring programs. However, the results available indicate that when a longwall passes beneath or within 60 m of an upland swamp, subsidence may result in a change in groundwater recession levels. It is therefore likely that swamps located above or within 60 m of the proposed longwalls (25 are located above longwalls), would experience some degree of impact from changes to groundwater levels.
- The Coastal Upland Swamps within the Study Area comprise predominately drier vegetation types including: approximately 49% of Eucalypt Fringing Woodland (not part of the threatened community listing), 32% of Restioid Heath, and 5% of Banksia Thicket. Wetter swamp communities consisted of 10% of Tea-tree Thicket, 0.4% Sedgeland Complex and 3.5% Cyperoid Heath. It is reasonable to conclude that a decrease in species distribution or abundance, or extent of sub-communities, that are reliant on semi-permanent to permanent waterlogging (such as Tea-tree Thicket and Cyperoid Heath) within a swamp that has experienced lower water levels following mining, may indicate an impact from mining. Similarly, an increase in drier vegetation types within swamps that have experienced lower water levels following mining, such as Banksia Thicket or Eucalypt Fringing Woodland, may also serve as an indicator of mining impacts.
- Despite detected changes in groundwater in swamps located above longwalls, there have been no strong links detailed in the monitoring reports to date that indicate that a significant vegetation response has occurred in Coastal Upland Swamps due to hydrological changes associated with mining.

- Given the Coastal Upland Swamps of the Study Area are made of up of 86% of drier subvegetation communities (Eucalypt Fringing Woodland, Banksia Thicket and Restriod Heath), it is also possible that these communities are more resilient to hydrological changes, given they are not as dependent on waterlogged peat compared to wetter subvegetation communities (Teatree Thicket, and Cyperoid Heath). However to date, no studies have been completed to support this.
- A reduction in the water table from subsidence may result in changes to the cohesion of the soils within Coastal Upland Swamps. The organic matter within the soil may undergo a hydrophobic reaction, which in turn results in the organic matter, which binds the sand grains, becoming loose and resulting in sediments that are highly erodible (Young 2017, DPE 2015). As described above, Coastal Upland Swamps directly above and within 60 m of proposed longwalls are expected to exhibit a change in groundwater as a response to mining. However, it is possible that should a decrease in waterlogging occur, it may result in peat desiccation which would expose the Coastal Upland Swamp to greater intensity burns . In relation to the Project, MSEC (2019) states that for the Coastal Upland Swamps in the Study Area it is not expected there will 'be adverse changes in the levels of ponding or scouring within the swamps due to mining induced tilt'. Over 500 swamps have been directly mined beneath in the Southern Coalfield using varying methods (Richardson and Ryan 2007), with only three (0.6%) exhibiting scour and erosion events. It is therefore considered that the likelihood of such events occurring within the Study Area is low.

Based on the results of Watershed (2019) and the impact assessment provided in Appendix 8, subsidence related impacts such as hydrological changes are likely to occur in Coastal Upland Swamps above and within 60m of the longwalls, with some potential for impacts elsewhere within the Study Area. This has some potential to impact upon the Coastal Upland Swamp system in the long-term, however, the evidence collected to date does not support that a significant impact to the Coastal Upland Swamp system is likely (Appendix 8).

7.4.4 Impacts to EPBC Act Listed Threatened Ecological Communities

The Project would result in an impact to the following TECs listed under the EPBC Act:

- Potential for subsidence related impacts on the TEC portions of Coastal Upland Swamps, in the form of bedrock fracturing, hydrological changes and ecosystem function.
- Maximum of 1.5 ha of Shale Sandstone Transition Forest TEC (PCT1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin (HN556)), which is listed as Critically Endangered under the EPBC Act. This TEC would potentially be impacted by the additional service borehole sites and transmission lines.

An Assessment of Significance has also been completed in Appendix 7 for the impacts to Shale Sandstone Transition Forest TEC and Coastal Upland Swamps under the EPBC Act.

The assessment concluded that a significant impact to Shale Sandstone Transition Forest TEC is unlikely due to the following:

- The clearing of Shale Sandstone Transition Forest TEC will be conducted in a way leaving the root-ball of the plants intact, to assist in natural regeneration following the clearing.
- The clearing would avoid mature and hollow-bearing trees where possible.
- Active restoration including brush-matting would be undertaken immediately upon decommissioning.
- The impact would not result in the extinction of Shale Sandstone Transition Forest TEC as 173.5 ha occurs in Area 5 and Area 6.

- The Project is unlikely to result in long-term fragmentation of a patch of Shale Sandstone Transition Forest TEC.
- The Project will not adversely affect habitat critical to the survival of the ecological community.

The Assessment concluded that a significant impact to the TEC portions of Coastal Upland Swamps is possible due to the following:

- There is the possibility that the TEC portions of Coastal Upland Swamps, in particular those directly mined beneath, may transition to a drier woodland vegetation type and thus reduce the extent and composition of the TEC.
- As discussed above, the TEC portions of Coastal Upland Swamps directly above the longwalls, or which occur within 60 of the proposed longwalls are likely to experience hydrological changes. Indirect impacts associated with this include:
  - change in groundwater recession and flow
  - change in surface water flow
  - transition to a drier woodland vegetation type
  - soil cohesion changed to erodible particles.
- The Project may potentially modify or impact abiotic (non-living) factors (such as water, nutrients, or soil) necessary for survival and persistence of the TEC.

A biodiversity offset has been provided for the TEC portions of the Coastal Upland Swamps in section 10.1.2.

7.5 Threatened Flora

7.5.1 Clearing of Habitat for Surface Infrastructure

As discussed in section 5.5, no threatened flora was recorded within the area to be directly disturbed for the ventilation shaft sites or carpark. Furthermore, biodiversity due diligence assessments would be completed during the additional service borehole establishment to ensure that no threatened flora would be impacted by the works. The Project would therefore not result in the clearing of any threatened flora.

7.5.2 Subsidence Related Impacts to Threatened Flora

Subsidence impacts toward threatened flora may occur as a result of the following:

- Die-back of threatened flora that occurs immediately adjacent to a strata gas emission/drainage event.
- Loss of threatened flora and its habitat as a result of a change in hydrological regime.
- Damage or loss of threatened flora from rock falls and/or slippage of earth and rocks down steep slopes.

These impacts are generally centred on habitat types along riparian areas, Coastal Upland Swamps, and habitat immediately above and below cliff lines and steep slopes. Vegetation and habitat that occurs on the flat terrain of the Study Area are located away from areas that may be prone to subsidence related impacts.

As indicated in section 5.5, only two threatened flora with a high likelihood of occurrence, and one attributed to a moderate likelihood of occurrence, may occur within habitat types sensitive to subsidence:

- *Epacris purpuracens* var. *purpurescens* is known to occur within Coastal Upland Swamps and within ephemeral drainage channels within the Southern Coalfield. This species was not recorded within the Study Area during the field survey, however a record from Bionet (2016) occurs adjacent to an access track in Area 6. It is also likely that given the size of the Study Area targeted searches of the entire area were not undertaken and its presence is not possible to rule out.

- *Pultenaea aristata* is known to occur within Coastal Upland Swamps in the Southern Coalfield. Large populations have been recorded by Niche within Coastal Upland Swamps in Dendrobium Area 3B (Niche 2012). The species was not recorded during the survey within the Coastal Upland Swamps within the Study Area, however, given the size of the swamps, the inability to cover the entire extent due to inaccessibility, the species occurrence within the Study Area cannot be ruled out.
- *Pomaderris brunnea* has been previously mapped by Bionet (2016) as occurring within the Study Area (Figure 9). Records of this species occur adjacent to an existing access track setback from a creekline within PCT1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus (HN566) within Area 6. The record is from the 1950s, and it is unclear if the identification is correct, given *Pomaderris brunnea* is generally found 'in a very limited area around the Colo, Nepean and Hawkesbury Rivers, including the Bargo area and near Camden' (DEC 2015). The record also seems to be an outlier when compared to the other records for the species which are centred around the Picton area, approximately 12 km from the record within the Study Area. Regardless, a precautionary approach has been taken given the previous record and it has been assumed that some potential habitat may occur within the gullies of the Study Area to which this species is known to have similar habitat preferences. The location of the record and vicinity surrounding it was surveyed, however the plant(s) were not found during the field survey.

Epacris purpuracens var. *purpurescens*, *Pultenaea aristata* and *Pomaderris brunnea* have been discussed below in relation to subsidence related impacts, and through consideration of the potential impacts in MSEC (2019) are considered unlikely to be impacted by subsidence.

It should be noted that *Leucopogon exolasius* is unlikely to occur within subsidence sensitive environments, however it has been discussed below given it was recorded within the Study Area.

Die-Back of Threatened Flora that Occurs Immediately Adjacent to a Strata Gas Emission/Drainage Event

As discussed in relation to native vegetation, die-back of plants from gas emissions is a rare event. If such an event was to happen, it would be very localised, and unlikely to result in large scale die back of native flora. The likelihood for threatened flora to be located immediately adjacent to the edge of a watercourse, that may have foliage exposed to a gas emission event is considered low. Furthermore, *Pultenaea aristata* generally occurs on the high elevations in woodland or swamp habitats that are positioned away from the watercourse bed. And similarly, *Pomaderris brunnea* and the known population *Leucopogon exolasius* that occurs along Donalds Castle Creek, for the most part, are typically likely to occur on the mid-bank to higher banks and gullies, away from the creek bed. Furthermore, the population of *Leucopogon exolasius* that was recorded by Niche (2019) within Area 5, occurs away from riparian areas. As such, the chances of a gas emission event affecting any potential population is considered low.

Loss of Threatened Flora and its Habitat as a Result of a Changed Hydrological Regime

Both *Epacris purpurscens* var. *purpurescens* and *Pultenaea aristata* have potential habitat with Coastal Upland Swamps. As discussed in section 7.4.3 and Appendix 8, Coastal Upland Swamps may be subject to changes in hydrology through bedrock fracturing and mining induced tilt which could result in changes to vegetative response and ecosystem function. However, to date, no significant changes to vegetation/habitat as a result of subsidence has been detected within Coastal Upland Swamps currently being monitored as part of the Dendrobium Mine, Metropolitan Mine and Wollongong Coal monitoring programs (Appendix 8). Furthermore, catastrophic events such as erosion and scour have only been observed at three Coastal Upland Swamps, despite over 500 Coastal Upland Swamps being historically mined under since the early and mid-1900s. Such catastrophic events have also been attributed by parties to a number of man-made and natural events independent of possible subsidence impacts (Appendix 8).

It should be noted that both species can also inhabit Eucalypt Fringing Woodland or Exposed Sandstone Scribbly Gum vegetation communities which Coastal Upland Swamp could, in the event of an unforeseen and previously unobserved impact, eventually transition to over time in response to hydrological change.

Based on the lack of detection within Coastal Upland Swamps, the low likelihood for catastrophic events, and habitat within drier vegetation communities, it is considered that the likelihood of impacts to potential habitat within Coastal Upland Swamps for *Epacris purpurscens* var. *purpurescens* and *Pultenaea aristata* are relatively low.

In relation to changes to water flow and standing pools, this is unlikely to affect *Epacris purpurscens* var. *purpurescens, Pomaderris brunnea, Pultenaea aristata* and *Leucopogon exolasius.* All four of these species do not occur submerged, immersed or directly connected via roots to the water within pools. The drying of pools, or predicted changes to the hydrological regime to watercourses within the Study Area are therefore unlikely to result in impacts to these threatened flora species.

Damage or Loss of Threatened Flora from Rock Falls and/or Slippage of Earth and Rocks Down Steep Slopes

As discussed in relation to native vegetation, the likelihood for any large-scale impacts associated with potential rock falls/slipping of rock are low. The chances of threatened flora to be present directly in the locality of such events is considered low. As indicated by MSEC (2019), the total length of impact of cliffs that may be impacted above longwalls amounts to approximately 150 m to 220 m, whilst 1 % of cliffs located outside the extent of longwalls may exhibit isolated rock falls (Table 20). As such, it is unlikely that any large-scale impacts to threatened flora due to earth and rock-face instability would occur.

7.5.3 Impacts to EPBC Act Listed Threatened Flora

As discussed in section 5.5, EPBC Act listed threatened flora that are known to occur within the Study Area or have potential to occur in proposed infrastructure sites and/or subsidence sensitive habitat include: *Leucopogon exalasius* (known to occur within the Study Area), *Pomaderris brunnea* (recorded by Bionet though unclear if species identified correctly) and *Pultenaea aristata* (potential to occur). As such, Assessments of Significance have been completed for *Leucopogon exalasius, Pomaderris brunnea* and *Pultenaea aristata* (Appendix 7).

The Assessments of Significance concluded that a significant impact to *Leucopogon exalasius, Pomaderris brunnea* and *Pultenaea aristata* is unlikely based on the following:

- The species were not detected in the surface disturbance footprint areas, and as such are unlikely to be directly or indirectly impacted by the surface infrastructure works.
- Mitigation measures would be employed to minimise impacts to threatened flora and habitat throughout the area (section 9).
- The species are unlikely to be impacted by subsidence given the population of the species does not occur within the riparian inundation area of the creek within the Study Area. Thus any potential hydrological change as a result of subsidence within such environments are unlikely to impact upon *Leucopogon exolasius, Pomaderris brunnea* and *Pultenaea aristata.*
- Gas emissions as a result of subsidence are predicted to be rare, and given the species is known to occur on rocky hill slopes die back from gas emission would largely be avoided.
- It is highly unlikely that falling cliffs/rocks as a result of subsidence would impact the species.
- The species is therefore considered unlikely to be significantly impacted by the Project.

7.6 Threatened Fauna

The Project may result in impacts to threatened fauna as a result of clearing of habitat for the surface infrastructure, or via subsidence which is predicted to have impacts on swamps, watercourses and other natural features within the Study Area. Avoidance measures attempting to limit these impacts are described in section 7.1.

Field survey for threatened species concentrated on detection of species prone to impacts from the Project, particularly subsidence impacts. Under the NSW FBA, threatened species are classed as species credit species (those that use specialised habitat features and are difficult to predict based on attributes such as associated vegetation types) or ecosystem credit species.

The likelihood of occurrence, habitat requirements and potential for impacts for all subject threatened fauna species is considered in Appendix 2. Additional detailed impact assessment for particular threatened fauna such as species credit species has been conducted depending on the severity of potential impacts, sensitivity of the species to impacts or due to legislative requirements.

7.7 Ecosystem Credit Species

Since ecosystem credit threatened species are linked to vegetation types, assessment and offsetting considerations for these species is largely done via consideration of impacts to vegetation types (see section 7.4). The list of 13 species in Table 22 constitutes those ecosystem credit species recorded or considered to have a high likelihood of occurring within the Study Area. Expected impacts for these species are discussed in Table 22. Generally, the ecosystem credit species discussed below are all mobile species that are expected to occur throughout the majority of habitat types within the Study Area. Impacts for these species are primarily related to clearing for surface infrastructure, which comprises clearing of a maximum of 28.5 ha as described in section 7.4.

The Grey-headed Flying Fox is listed as a dual credit species and is listed as Vulnerable under the EPBC Act. An assessment of significance for this species pursuant to the EPBC Act is provided in section 7.

Table 22: Ecosystem Credit Species Likely to Occur within the Study Area and Potential for Impacts from the Proposal

Common Name	EPBC Act	BC Act	Credit Status	Likelihood of Occurrence	Impact and Assessment
Eastern Bentwing-bat	-	V	Species/ Ecosystem. Not generated by BBCC (since added).	Known. Single record from both Area 5 and Vent Shaft 3 during present 2016/17 fauna baseline study. Previously recorded nearby in Area 3B and DA5. 23 records within 5 km (OEH 2018). Possibility of roosting in crevices and small caves within rocky outcrops. Not likely to contain maternity roosting habitat, therefore it is an Ecosystem Credit species only.	Maternity caves would not occur within the Study Area. If roosting occurs within the Study Area, it is unlikely to be widespread or significant and minimal impacts from subsidence of features such as cliffs are expected to occur given the limited propensity of roosting within the Study Area. No further assessment or offsetting is considered required.
Eastern False Pipistrelle	-	V	Ecosystem	Known – recorded at single site within Vent Shaft 3 during present 2016/17 fauna baseline study. Potential to occur within a variety of woodland. 10 records within 5 km (OEH 2018).	Roosts in hollow trees. Impacts to foraging habitat and possible roosting habitat from clearing for surface infrastructure. No special significance of areas to be cleared in comparison to other extensive areas of habitat within the Study Area and surrounds. Offsets required via ecosystem credits.
Eastern Freetail-bat	-	V	Ecosystem	Known. Recorded at Vent shaft site 3. Potential in all woodland types.	Roosts in hollow trees. Impacts to foraging habitat and possible roosting habitat from clearing for surface infrastructure. No special significance of areas to be cleared in comparison to other extensive areas of habitat within the Study Area and surrounds. Offsets required via ecosystem credits.
Gang-gang Cockatoo	-	V	Species/Ecosystem	Known. Previously recorded in both Area 5 and Area 6 (OEH 2018). Recorded near Area 6 during present 2016/17 fauna baseline study but not from Study Area. Likely to fly over the Study Area from time to time and forage in response to flowering/fruiting pulses – no roost sites are known from the area, therefore it is an Ecosystem Credit species only.	Impacts from clearing. No special significance of habitat to be cleared and species was not encountered using these habitats. Offsets required via ecosystem credits.
Glossy Black-Cockatoo	-	V	Species/Ecosystem	High. Previously recorded nearby in Area 3B (OEH 2018). Not recorded during present 2016/17 fauna baseline study. Likely to fly over the Study Area from time to time and forage in response to flowering/fruiting pulses – no roost sites are known from the area, therefore it is an Ecosystem Credit species only.	Impacts from clearing. No special significance of habitat to be cleared and species was not encountered using these habitats. Offsets required via ecosystem credits.
Greater Broad-nosed Bat	-	V	Ecosystem	Known. Recorded three times within Area 5 and Vent Shaft 3 during present 2016/17 fauna baseline study.	Roosts in hollow trees. Impacts to foraging habitat and possible roosting habitat from clearing for surface infrastructure. No special significance of areas to be cleared in comparison to other extensive areas of habitat within the Study Area and surrounds. Offsets required via ecosystem credits.
Grey-headed Flying-fox	V	V	Species/ Ecosystem. Not generated by BBCC (since added).	High. Likely to fly over the Study Area from time to time and forage in response to flowering/fruiting pulses – no roost sites are known from the area, therefore it is an Ecosystem Credit species only.	Common and widespread species throughout the region. Impacts from clearing but confined to marginal foraging habitat which is widespread throughout the Study Area and surrounds and has low productivity. Offsets required via ecosystem credits.

Common Name	EPBC Act	BC Act	Credit Status	Likelihood of Occurrence	Impact and Assessment
Little Bentwing-bat	-	V	Species/ Ecosystem. Not generated by BBCC (since added).	Known. Single record from Ventilation Shaft 3 during present 2016/17 fauna baseline study. Possible to occur in crevassed/cave rocky outcrops. Not likely to contain maternity roosting habitat. One other record within 5km (OEH 2018), therefore it is an Ecosystem Credit species only.	Maternity caves would not occur within the Study Area. If roosting occurs within the Study Area, it is unlikely to be widespread or significant and minimal impacts from subsidence of features such as cliffs are expected to occur given the limited propensity of roosting within the Study Area. No further assessment or offsetting is considered required.
Powerful Owl	-	V	Species/Ecosystem	High. Not recorded during present 2016/17 fauna baseline study. 5 records from within 5 km (OEH 2018). Possible habitat in all woodland vegetation types. Likely to fly over the Study Area from time to time and forage in response to flowering/fruiting pulses – no roost sites are known from the area, therefore it is an Ecosystem Credit species only.	Impacts via clearing of marginal foraging habitat. Very low density of prey throughout all areas to be cleared except 1.5 ha of clearing within Sandstone Transition Forest. Highly unlikely to nest within vent shaft sites. Offsets via ecosystem credits.
Rosenberg's Goanna	-	V	Recently changed in NSW to ecosystem credit	Known. Seven records during present 2016/17 fauna baseline study. Area 5 and Area 6 and Vent Shaft 3.	Species recorded within moderate frequency throughout Study Area. Considered unlikely to be impacted via subsidence. Clearing impacts to foraging and potential nesting habitat (termite mounds). Offset via ecosystem credits.
Scarlet Robin	-	V	Ecosystem	Known. Previously recorded nearby in Dendrobium Area 3B. Recorded twice during present 2016/17 fauna baseline study in Area 5.	Impacts via clearing of marginal foraging habitat. Offsets via ecosystem credits.
Varied Sittella	-	V	Ecosystem	Known record from Area 5. Recorded during present 2016/17 fauna baseline study in Area 6. Could occur throughout the Study Area in multiple habitats.	Impacts related to clearing. Offsets via ecosystem credits.
White-bellied Sea-Eagle	M	V	Species/Ecosystem	Known. Observed flying over site. However, no breeding habitat, therefore it is an Ecosystem Credit species only.	Unlikely to be impacted. Breeding habitat would not be impacted. Offsets via ecosystem credits.

7.8 Species Credit Species

The list of species in Table 23 constitutes those species credit species recorded, assumed present or considered to have a high likelihood of occurring within the Study Area. In addition, dual credit species (ecosystem/species credit species) have been included in the list where potential impacts are likely to occur to the species credit component of their habitat. Expected impacts for these species are also discussed in Table 23. Six of the nine species are considered to be impacted by the Project, therefore species polygons have been prepared to demonstrate and quantify the maximum expected level of impact to the species from the Project.

Table 23: Species credit species likely to occur within the Study Area and potential for impacts from the proposal

Common Name	EPBC Act	BC Act	Species Credit Feature/Habitat	Likelihood of occurrence	Impact and Assessment	Size of maximum impact species polygon (ha)
Broad-headed Snake	V	E	Land within 500 m of sandstone escarpments with hollow-bearing trees, rock crevices or flat sandstone rocks on exposed cliff edges and sandstone outcropping.	Known. Previously recorded from Area 5 with other records nearby (14 within 5 km). Not recorded during present 2016/17 fauna baseline study, however survey was partly outside of preferred timing. Limited prey items observed during present study.	Limited impacts likely for this species confined to subsidence impacts consisting of any cracking of potential sheltering habitat. Preferred sheltering habitat does not occur within areas where clearing will occur.	0.28
Eastern Bentwing-bat	-	V	Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding including species records with microhabitat code "IC - in cave;" observation type code "E nest-roost;" with numbers of individuals >500.	Known. Single record from both Area 5 and Vent Shaft 3 during present 2016/17 fauna baseline study. Previously recorded nearby in Area 3B and DA5. 23 records within 5km. Possible to occur in crevassed/cave rocky outcrops. Not likely to contain maternity roosting habitat or any breeding habitat since preferred caves do not develop in sandstone geology of area. One other record within 5 km.	Maternity caves would not occur within the Study area. If roosting occurs within the Study area it is unlikely to be widespread or significant and minimal impacts from subsidence of features such as cliffs are expected to occur. No further assessment of offsetting is considered required.	N/A
Eastern Pygmy-possum	-	V	None specified.	Known from Area 5 – Atlas Record. Could occur in parts of the Study Area including swamps and various other communities. Not recorded during present 2016/17 fauna baseline study.	Not recorded. Occurs in parts of the study area, however was not detected in vent shaft sites where clearing impacts would occur. Subsidence impacts are not expected for this species or are considered to be minor-negligible as the species is not limited to swamps and the potential impacts to swamps would not restrict this species using the swamp and other surrounding communities. No further assessment required.	N/A
Giant Burrowing Frog	V	V	None specified.	Known record from Area 5 (NSW Wildlife Atlas). Likely in creeks and swamps with potential breeding pools. No additional records from present 2016/17 fauna baseline study although assumed present as difficult to detect and access restricted in ideal survey conditions.	Impacts associated primarily with subsidence. Species considered further in section 7.9 and Appendix 7.	32.74
Giant Dragonfly	-	E	Swamps; Within 500 m of swamps.	See Aquatic Ecology Assessment for survey details. Recorded from recent survey within the study area (Cardno 2019).	Impacts associated primarily with subsidence. Species considered further in section 7.9.	13.93
Koala	V	V	Other; Areas identified via survey as important habitat (see comments).	Known. Recorded during present 2016/17 fauna baseline study within Area 5 and Area 6. See Koala habitat mapping.	Clearing impacts only. Vegetation within vent shafts does not offer preferred feed trees/habitat, however a Koala was heard around vent shaft site 4 and the species is known to move throughout the study area. One hectare of clearing of preferred habitat would likely be impacted by the proposal. Impacts and offsetting considered in section 7.9 and Appendix 7.	1.50

Common Name	EPBC Act	BC Act	Species Credit Feature/Habitat	Likelihood of occurrence	Impact and Assessment	Size of maximum impact species polygon (ha)
Little Bentwing-bat	-	V	Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding including species records with microhabitat code "IC - in cave;" observation type code "E nest-roost;" with numbers of individuals >500.	Known. Single record from Ventilation Shaft 3 during present 2016/17 fauna baseline study. Possible to occur in crevassed/cave rocky outcrops. Not likely to contain maternity roosting habitat or any breeding habitat since preferred caves do not develop in sandstone geology of area. One other record within 5km.	Maternity caves would not occur within the study area. If roosting occurs within the study area it is unlikely to be widespread or significant and minimal impacts from subsidence of features such as cliffs are expected to occur. No further assessment of offsetting is considered required.	N/A
Littlejohn's Tree Frog	V	V	None specified.	Known. Creeks and swamps with potential breeding pools. Found via tadpole surveys during the present 2016/17 fauna baseline study at three locations within Area 5 and three locations within Area 6.	Impacts associated primarily with subsidence. Species considered further in section 7.9 and Appendix 7.	32.74
Red-crowned Toadlet	-	V	None specified.	High. Recorded adjacent to Area 5 in recent years though not recorded in the present 2016/17 fauna baseline study. Possibly difficult to detect in recent surveys due to limited rainfall.	Impacts associated primarily with subsidence. Species considered further in section 7.9.	7.21

7.9 Fauna Species Polygons

7.9.1 Broad-headed Snake

Habitat and Survey Findings

The Broad-headed Snake has a limited potential occurrence across the study area as habitat required for sheltering is very specific to the species needs. The species requires shelter under rocks with a west to north-west aspect and is usually found in rocky outcrops and sandstone ridgetops (DoE 2018b). Survey for Broad-headed Snake did not detect the species, however it has been recorded within the north eastern boundary of Area 5 previously and in adjacent areas. Survey was not conducted during the optimal season for the species according to the BBCC (August-September), however was conducted during months where the species can be detected, late spring through to mid-summer, November to January (DoEE 2011).

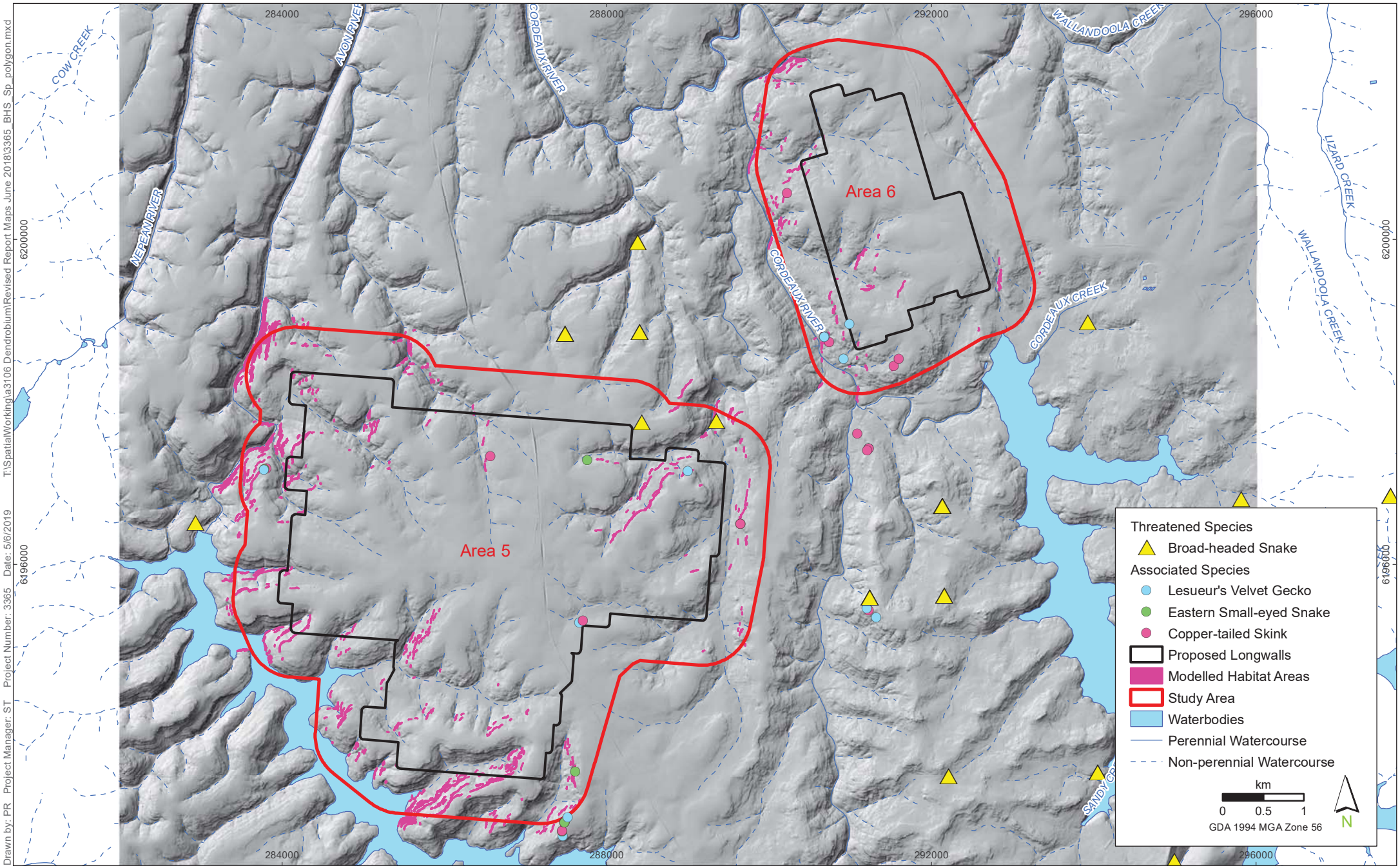
Potential habitat for this species was modelled by mapping areas with a westerly to north-easterly aspect with slopes of 30 degrees or greater (this is a conservative model given the aforementioned west to northwest habitat prescription) and applying a 30 m buffer (Figure 14). Habitat modelling allowed for detection of approximately 30 ha of cliffs and steep slopes with a favourable aspect for the species above or partially above the proposed longwall layout (where the vast majority of subsidence impacts are expected to occur). Habitat modelling assisted in identifying areas in which to conduct field survey, however it was observed that much of the modelled area did not support preferred habitat for the species.

Impact Considerations

Impacts to any potential habitat for this species is likely to be limited, based on previous observations of subsidence within adjacent mined areas and MSEC predictions of subsidence for the current proposal. That is, predictions of subsidence impacts such as rockfalls are limited in their extent (MSEC 2019; section 7.3). This factor, coupled with the requirement that subsidence would need to be coincident with sheltering habitat for the Broad-headed Snake which is quite limited, and that deleterious impacts would need to then result leads to a prediction of minimal impacts for this species.

No specific polygon for this species is presented, as the location of actual habitat is constrained in total area but potentially spread across a large area.

An offset amount of 0.28 ha (2,800 metres squared (m^2)) has been applied for this species which considers the maximum predicted area of cliff face impacts (1,400 m^2) and adds a similar area of habitat for steep slopes and outcropping areas. Further mapping of habitat may be undertaken to refine the extent of potential habitat for this species and also measure actual impacts following mining. Any changes in actual impact to these considered above (i.e. 0.28 ha) would subsequently alter the required offset (see also section 10.1).



Broad-headed Snake habitat modelling and records

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 14

niche Environment and Heritage

Source: Geoscience Australia and Niche

7.9.2 Littlejohn's Tree Frog

Habitat and Survey Findings

Littlejohn's Tree Frog has been recorded in preferred habitats across the Project area and surrounds. Detectability of the species varies with rainfall, with call surveys for adult frogs being optimal after heavy rain (DEWHA 2010a), when the most prolific breeding occurs. Timing of breeding throughout the year is highly variable (DECC 2009). Several authors have suggested that larval (tadpole) survey is a more effective method to survey for the species (e.g. Hero et al. 2002). While a range of methods to detect the species were employed in the present survey, tadpole surveys were a focus due to limitations in access to the site during and after heavy rain. In addition, it was recognised that tadpole survey is likely to aid in identifying limiting habitat for tadpole development. Tadpoles of this species are relatively conspicuous and present for months after breeding events.

Within the Project area, the species relies upon semi-permanent to permanent pools for tadpole development (Biosis 2016, Daly and Craven 2007), with maturation times for tadpoles of the species having been observed to take around 4 months (Anstis 2002), although this is variable in the field depending on factors such as weather. Pools of sufficient depth and hydroperiod within the catchment area were almost exclusively located along second order or higher streams or else first order streams where headwater swamps are positioned upstream.

Impact Considerations

Swamps act as a buffer allowing for more continuous and even water flows along streams after rain events (Young 2017, NSW Scientific Committee 2012) and thus greater hydroperiods (or permanency) within pools along smaller streams. This may influence tadpole development for species with lengthy periods of metamorphosis. Therefore, while swamps are not considered required for tadpole development, they may aid in providing suitable conditions downstream for tadpole development to occur, particularly along 1st and 2nd order streams.

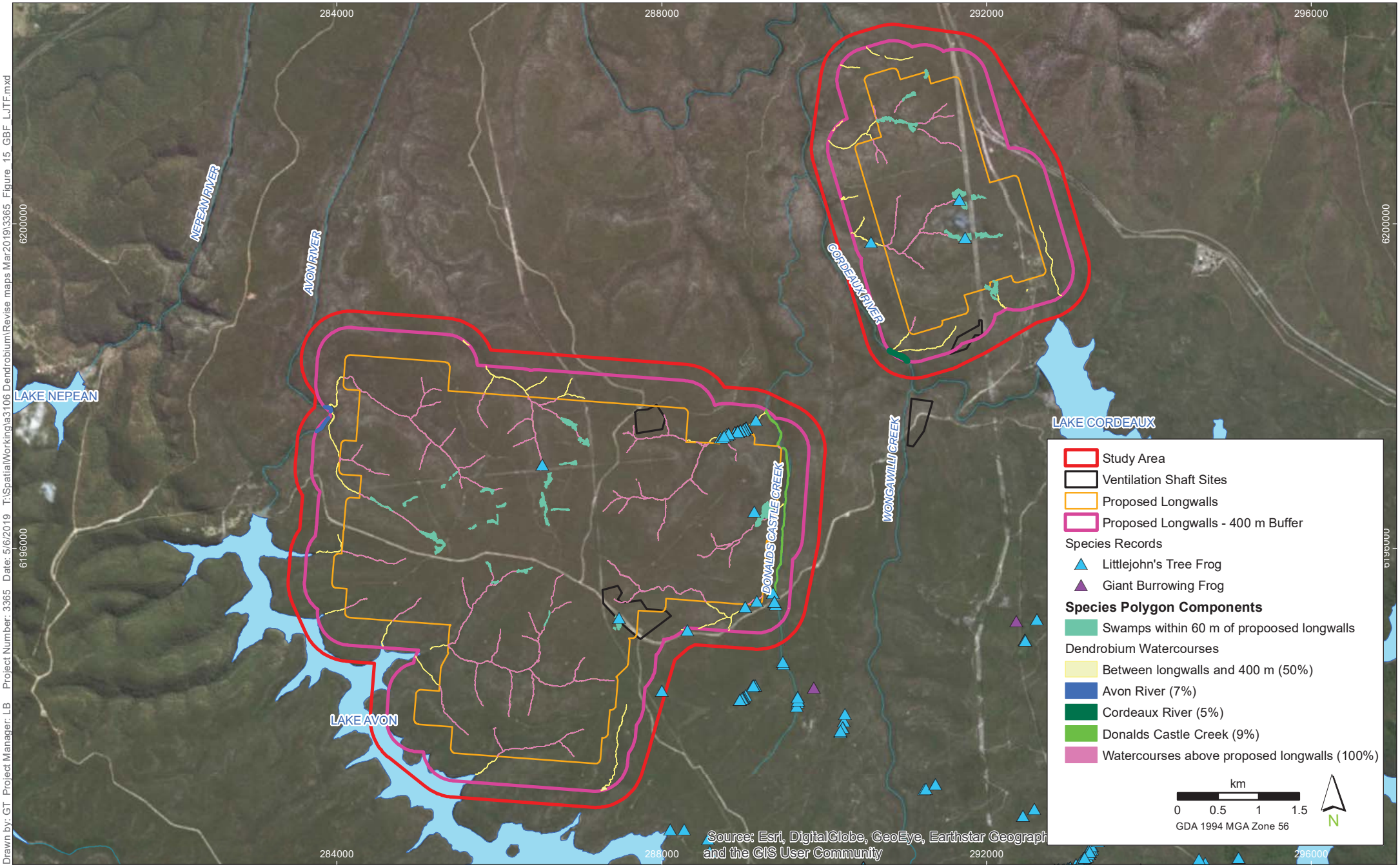
Many locations where the species is found do not have upland swamps present (e.g. Watagan Mountains) and there is no known associated vegetation type that the species relies on specifically. The species has been recorded in coastal woodland, heaths and also in disturbed and undisturbed woodlands from Watagans National Park NSW to Buchan Victoria (DoE 2018c).

Swamps and heath may aid in providing suitable conditions to forage and shelter, facilitated through moisture availability and abundance of debris. However, the species is known to shelter in a range of habitats. The extent to which drying of swamps might impact the capacity of swamp sites to provide ideal sheltering conditions is unknown, however it seems likely that swamps are more important in regard to enhancing opportunities for tadpole development downstream rather than providing ideal sheltering habitat given the variety of sheltering habitats reportedly used. Also, expected changes in swamp composition due to subsidence is unlikely to prevent their capacity to be used as a sheltering environment although may add some increased risk of desiccation for some swamps.

The approach to a species polygon (or area of maximum offset liability) for this species is tabled below (Table 24) and illustrated in Figure 15. The species polygon comprises potentially impacted foraging, sheltering and breeding habitat totalling 32.74 ha. It is intended that these offsetting calculations be refined during monitoring for the species post-approval (but prior to mining) to confirm the area of habitat occupied by the species within the Study Area. Confirmation of changes to groundwater (within swamps) or pool water (within creeks) would also be required to determine impacts for the species, consistent with confirmation of impacts to swamp habitat outlined within the NSW Swamps Offset Policy (OEH 2016a).

Table 24: Determination of Species Polygons for Littlejohn's Tree Frog and Giant Burrowing Frog

Feature	Explanation of Area Determination	Area (ha)
First order streams directly above proposed longwalls	For first order streams, all watercourse sections downstream of where pooling commences and the stream section immediately upstream have been included within the polygon. Some pools in the upper sections of 1st order streams may not be suitable for breeding/habitat development due to insufficient water retention (particularly those streams without significant swamps above), however these stream sections have been retained to be conservative.	8.94
Second order and above streams directly above proposed longwalls	All watercourse sections.	
Streams between extent of proposed longwalls 400 m from proposed longwalls	Severity of subsidence impacts (such as limited retention of water within pools) have been demonstrated to decrease significantly where longwalls have not been mined directly below the stream. For example, previous monitoring of breeding pools close to longwall mining has demonstrated pool levels consistent within pre-mining levels, particularly when pools are upstream of longwalls (e.g. Biosis 2016, Biosis 2017). No quantitative subsidence predictions regarding subsidence have been provided by MSEC for smaller streams between the extent of the proposed longwalls and 400 m from the proposed longwalls. However, given that major streams within this distance of longwalls are predicted to experience impacts over <10% of their length, the overall area of streams between the extent of the proposed longwalls and 400 m from the proposed longwalls has been discounted by 50% to determine the maximum possible impact area. All streams are shown within Figure 15.	1.97
Major streams (Avon River, Cordeaux River, Donalds Castle Creek)	Quantitative subsidence predictions regarding subsidence have been provided by MSEC for major creeks and rivers within 400 m of proposed longwall mining. Major streams within this distance of longwalls are predicted to experience impacts over <10% of their length. Therefore, whilst the entire length of the streams have been included within the polygon mapping, the overall area has been discounted by the relevant amount to calculate the maximum offset liability area. It is considered unlikely that the Avon River and Cordeaux River will be used by Littlejohn's Tree Frog for breeding given they are relatively fast flowing high order watercourses. This will be confirmed during future surveys.	0.16
Swamps within 60 m of proposed longwalls	For the purpose of an offset strategy, all swamps either wholly or partially within 60 m of longwalls have been retained within species polygons, since there is potential for impacts to swamps to impact foraging and sheltering habitat and therefore the occurrence of Littlejohn's Tree Frog within these environments. Based on a review of records and literature, it is expected that not all swamps or swamp areas would provide important habitat to Littlejohn's Tree Frog (i.e. habitat used on a regular basis). Records for Littlejohn's Tree Frogs within swamps appear to be concentrated within larger 'wetter' swamps with pools immediately downstream or within the swamp. Therefore, the overall offset requirement for this species is expected to reduce once additional surveys and monitoring of actual impacts occurs.	21.66
Fringing riparian vegetation	Fringing riparian vegetation has not been included within any offset calculations as no subsidence impacts to these habitats have been demonstrated via monitoring (e.g. Biosis 2016, Biosis 2017c).	0
Total Area		32.74



Species polygon – Giant Burrowing Frog and Littlejohn's Tree Frog

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 15

Imagery: (c) DigitalGlobe 2017-11-01

7.9.3 Giant Burrowing Frog

Habitat and Survey Findings

The Giant Burrowing Frog has been recorded in preferred habitats once in the east of the Study Area along a 3rd order tributary to Donalds Castle Creek as well as south and east of the Study Area approximately 1 km away (Figure 14).

Detectability of adults of the species typically requires significant rainfall (DECC 2009) prior to or during survey, which is when most breeding occurs (e.g. DoE 2018d; Penman et. al 2008). Activity is described as occurring through September to May, but reliant on heavy rain (DECC 2009). Tadpole surveys and nocturnal searches in suitable habitat and weather conditions are more effective than call surveys (DEWHA 2010a). While a range of methods to detect the species were employed in the present survey, tadpole surveys were a focus due to limitations in access to the site during and after heavy rain. In addition, it was recognised that tadpole survey is likely to aid in identifying limiting habitat for tadpole development. Tadpoles are present for months after breeding events, however adult frogs do not breed in all years (DEWHA 2010a) and recent monitoring as part of Dendrobium Area 3B subsidence monitoring have highlighted absence of tadpoles in some years versus abundant tadpoles in limited areas in others (Biosis 2016). Given, these factors, it is assumed that the Giant Burrowing Frog is present throughout the preferred habitats of the Study Area despite its lack of detection in the present survey.

Within the Project Area, the species relies upon semi-permanent pools for tadpole development, with maturation times for tadpoles having been observed to take 3-11 months (Watson and Martin 1973). Pools of sufficient depth and hydroperiod within the catchment area were almost exclusively located along 2nd order or higher streams or else 1st order streams where headwater swamps are positioned upstream.

Impact Considerations

Swamps act as a buffer allowing for more continuous and even water flows along streams after rain events (e.g. Young 2017) and thus greater hydroperiods (or permanency) within pools along smaller streams. This may influence tadpole development for species with lengthy periods of metamorphosis. Therefore, while swamps are not considered required for tadpole development, they may aid in providing suitable conditions downstream for tadpole development to occur, particularly along 1st and 2nd order streams.

Swamps and heath may aid in providing suitable conditions to forage and shelter, facilitated through moisture availability and abundance of debris. However, the species is known to shelter in a range of habitats. The extent to which drying of swamps might impact the capacity of swamp sites to provide ideal sheltering conditions is unknown, however it seems likely that swamps are more important in regard to enhancing opportunities for tadpole development downstream rather than providing ideal sheltering habitat given the variety of sheltering habitats reportedly used. Also, expected changes in swamp composition due to subsidence is unlikely to prevent their capacity to be used as a sheltering environment although may add some increased risk of desiccation for some swamps.

The approach to a species polygon for offsetting for this species is the same for Littlejohn's Tree Frog which is tabled above (Table 23) and illustrated in Figure 14. The species polygon comprises potential impacted foraging, sheltering and breeding habitat totalling 32.74 ha. It is intended that these offsetting calculations be refined during monitoring for the species post-approval (but prior to mining) to confirm the area of habitat occupied by the species within the Study Area. Confirmation of changes to groundwater (within swamps) or pool water (within creeks) would also be required to determine impacts for the species, consistent with confirmation of impacts to swamp habitat outlined within the NSW Swamps Offset Policy (OEH 2016a).

7.9.4 Red-crowned Toadlet

Habitat and Survey Findings

The Red-crowned Toadlet has been recorded in preferred habitat once in the eastern part of the Study Area beside Fire Trail 6 in 2014 (OEH 2018), and there are numerous records of the species south of the Study Area (Figure 16). The species has typically been found in table drains, soaks and along 1st order watercourses. Habitat for the species has been described as temporary creeks, gutters and soaks and under rocks and logs (NPWS 2001).

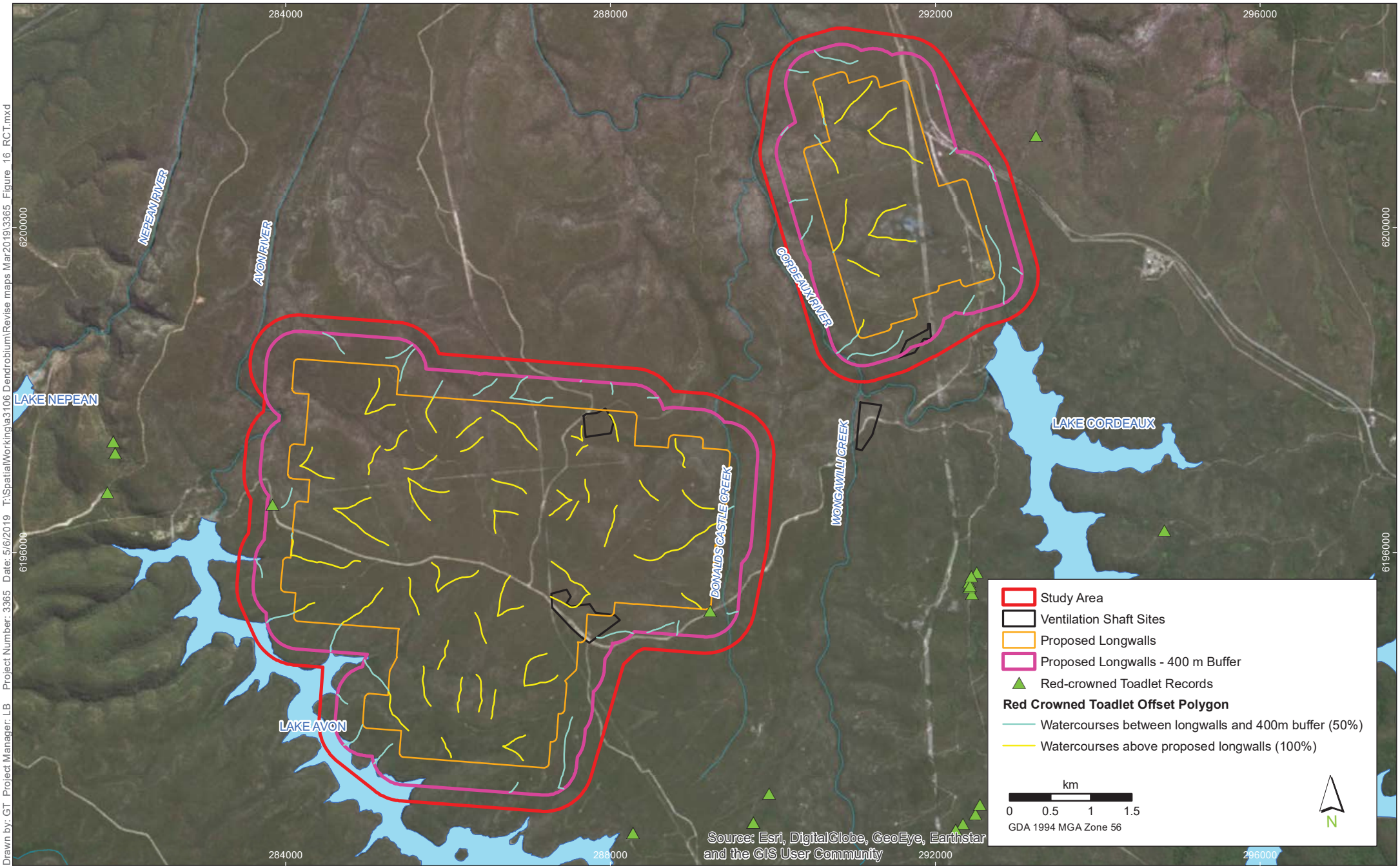
While some records of the species in the local area are adjacent to swamps, it is not considered that swamps play an important role in providing appropriate breeding or sheltering habitat, since the species is found from a wide range of habitats without swamps and there is no emphasis on swamp communities within habitat prescriptions for this species (e.g. OEH 2018, Thumm and Mahoney 1999).

The species may have gone undetected during some of the current survey due to lack of significant rain prior to the survey period (the species has recently been detected during survey to the north after 2018 spring/summer rains ended a period of relative drought). However, much of the survey timing was appropriate for detection of the species according to relevant guidelines (DECC 2009), which would suggest that the species is restricted to pockets of the study area, consistent with other occurrences within the catchment area.

Impact Considerations

Given its habitat preferences appear to be largely dependent upon surface water runoff and seepage rather than ground water and requirements for semi-permanent pools, it is considered that this species is less sensitive to impacts from subsidence in comparison with other species such as Littlejohn's Tree Frog. Nonetheless, changes in hydrology related to cracking of bedrock underlying streams providing habitat for the Red-crowned Toadlet have the potential to influence moisture levels and retention of moisture within small pools, soaks and leaf litter environments on which Red-crowned Toadlet's rely to complete their lifecycle.

While Red-crowned Toadlet were not observed during the present study, it is expected that the species would be present in some areas, particularly along 1st order streams. Directly above the proposed longwalls, these environments would experience the full range of predicted subsidence impacts (MSEC 2019). As described in Table 24, based on subsidence predictions for larger watercourses, streams between the extent of the proposed longwalls and 400 m from the proposed longwalls have been discounted by 50% to determine the maximum possible impact area (MSEC 2019). The approach to a species polygon for offsetting for this species (Figure 16) was therefore to calculate the area of all 1st order streams directly above the proposed longwalls by using the available linear stream mapping and applying a 2 m width to account for the area of impact (totalling 5.93 ha). The same approach was applied to 1st order streams between the extent of the proposed longwalls and 400 m from proposed longwalls, however a 50% discount was applied based on predicted modelling of subsidence impacts for larger streams (total area of 1.28 ha). The combined area of the species polygon (representing potential area of impact to identified habitat) constitutes 7.21 ha.



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niche Environment and Heritage

Species Polygon - Red-crowned Toadlet

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 16

Imagery: (c) DigitalGlobe 2017-11-01

7.9.5 Giant Dragonfly

Habitat and Survey Findings

Giant Dragonfly survey and impact assessment has been documented by Cardno (2019). Giant Dragonfly is found typically in permanent swamps and bogs containing some free water and open vegetation. It is considered an obligate groundwater dependent mire (peat-forming wetland) dwelling species (Cardno 2019). Its breeding success is dependent on sites with a groundwater regime that provides enough surface moisture to minimise desiccation of eggs and early larval instars, peatland soils suitable for burrowing by larvae, and that have a water table height that allows larvae to access or extend their burrows (Cardno 2019; Baird 2012).

Swamp habitat was assessed by Cardno (2019) for its potential to provide suitable breeding habitat using the following indicators:

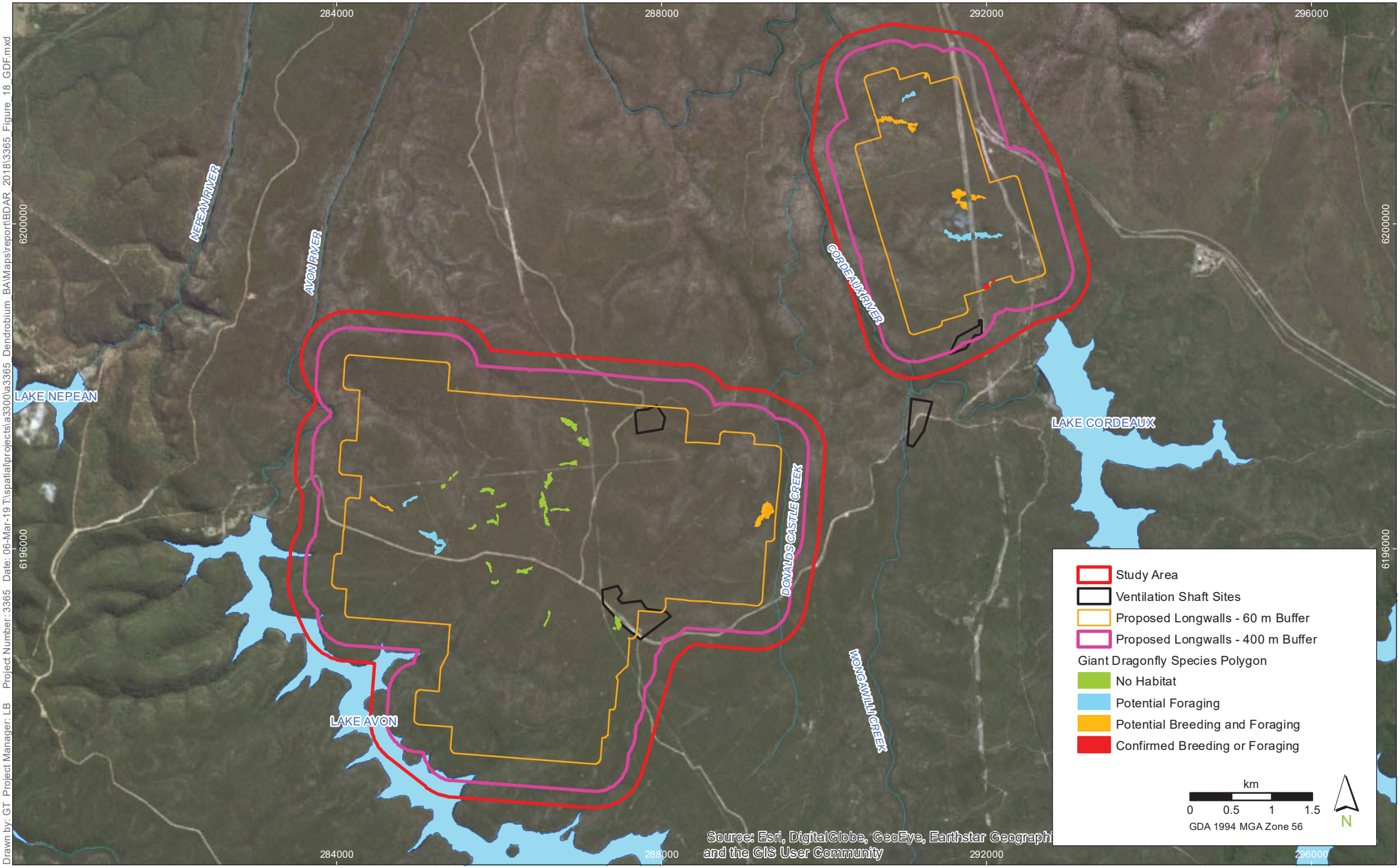
- Presence of emergent groundwater seepage or obvious substrata surface moisture that indicates localised waterlogging or surface moistness due to capillary action;
- Relatively soft organic-rich or peaty substrata identified initially by some sponginess of the substrate when walking; and
- Presence of moist swamp vegetation sub-communities of cyperoid (Family: Cyperaceae) heath, Swamp Banksia (Banksia robur), Pouched Coral Fern (Gleichenia dicarpa) or tea-tree thicket.

One or two adult Giant Dragonflies were observed in each of three swamps in Area 6. An additional 13 swamps were identified as potential breeding habitat based on the presence of potential Giant Dragonfly burrows (not easily distinguishable from juvenile crayfish burrows) and/or favourable habitat or hydrological regime. Swamps within 500 m of potential or known breeding swamps were considered to be potential foraging habitat (Cardno 2019).

Impact Considerations

In order to quantify potential impacts for Giant Dragonfly and inform the species polygons for the species, impacted swamps have been considered as those swamps constituting potential foraging or breeding habitat within 60 m of proposed longwalls (Figure 17). These environments have been considered to experience the full range of expected subsidence impacts.

The species polygon therefore comprises swamps with known breeding habitat (1.48 ha), potential breeding and foraging habitat (7.10 ha) and identified potential foraging habitat (5.35 ha). This resulted in a combined species polygon of 13.93 ha (Figure 17).



Species Polygon - Giant Dragonfly

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 17

Imagery: (c) DigitalGlobe 2017-11-01

7.9.6 Koala

Habitat and Survey Findings

Habitat for the Koala is described in Appendices 2 and 11 and shown in Figure 18.

Impact Considerations

The Koala is not considered to be impacted via subsidence impacts from the Project. Potential impacts for the Koala are related to clearing for surface infrastructure, primarily vent shaft sites. Vent shaft sites have been positioned to avoid clearing of potential Koala habitat as determined by the presence of known feed trees and mapped in Figure 18.

A Koala was heard calling from the vicinity of vent shaft site 5A in response to call playback survey, however the recorded Koala was likely to have been a male moving through the vent shaft site area (possibly along the cleared track) rather than resident within it. No preferred feed trees are present within any of the vent shaft sites, with vent shaft site 5A dominated by *Corymbia gummifera, Eucalyptus haemastoma* and *Eucalyptus racemosa.* Koala SAT surveys and spotlighting did not detect Koalas at vent shaft site 5A further demonstrating the low likelihood of Koalas using this area on a regular basis. A known area of resident Koalas occurs within Sandstone Transition Forest areas approximately 300 m north of vent shaft site 5A (Figure 18) with potential habitat extending to within 200 m north of the vent shaft site. Koalas were observed within areas mapped as core habitat 300 m north regularly during spotlighting and call playback and Koala scats were relatively dense throughout these areas where searches were done sporadically.

Koala records occur along most of the fire roads within the vicinity since the species (specifically males) are known to disperse widely. It is therefore concluded that the Koala recorded at the northern end of vent shaft site 5A was a dispersing rather than a resident Koala. The vent shaft site is unlikely to significantly impede Koala movement and offsetting for clearing impacts within the site is considered unnecessary, as the Koala habitat on site is not considered important (i.e. land identified as core or potential habitat). Indirect impacts to the Koala will be managed according to the Koala Plan of Management in Appendix 11.

The proposal includes a requirement for clearing of up to 1.5 ha of Shale Sandstone Transition Forest TEC. This area has been accounted for as the species polygon for the species, although not mapped since the exact area of clearing has not yet been determined.

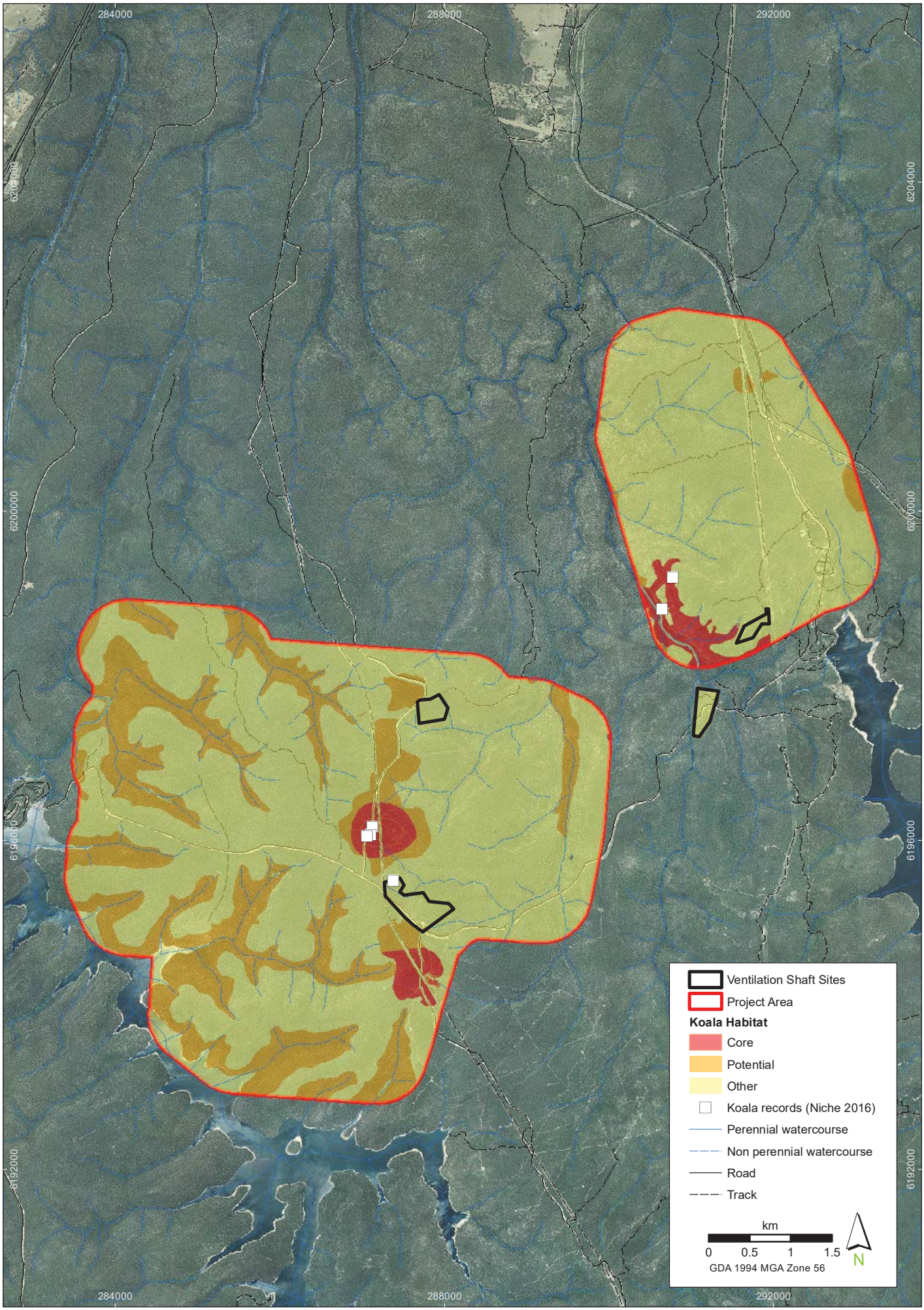
7.9.7 Impact to EPBC Act Listed Fauna

Assessments of Significance have been completed for those listed threatened fauna under the EPBC Act that have a moderate to high likelihood of occurrence within the Study Area (Appendix 8) including:

- Koala;
- Giant Burrowing Frog;
- Greater Glider;
- Grey-headed Flying-fox; and
- Littlejohn's Tree Frog.

The Assessments of Significance have concluded significant impacts for:

- Giant Burrowing Frog; and
- Littlejohn's Tree Frog.



Koala habitat mapping

Dendrobium Mine – Plan for the Future: Coal for Steelmaking - Koala Plan of Management

FIGURE 18

Imagery: (c) S32 2015

8. Impacts Requiring Further Consideration

Under section 9.2 of the FBA, the assessor is required to identify impacts on biodiversity values that require further consideration.

Impacts on biodiversity values that require further consideration are:

(a) impacts on landscape features, being:

(i) impacts that will reduce the width of vegetation in the riparian buffer zone bordering significant streams and rivers, important wetlands or estuarine areas in accordance with Subsection 9.2.3, or

(ii) impacts that will prevent species movement along corridors that have been identified as providing significant biodiversity linkages across the state in accordance with Subsection 9.2.3, and

(b) impacts on native vegetation that are likely to cause the extinction of an EEC/CEEC from an IBRA subregion or significantly reduce its viability in accordance with Subsection 9.2.4, and

(c) impacts on critical habitat or on threatened species or populations that are likely to cause the extinction of a species or population from an IBRA subregion or significantly reduce its viability in accordance with Subsection 9.2.5.

Biodiversity values identified in the SEARs as requiring further consideration include:

- Shale Sandstone Transition Forest in the Sydney Basin Bioregion CEEC;
- River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin & South East Corner Bioregions EEC; and
- Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin & South East Corner Bioregions EEC.

However, as detailed in section 4.5, River-flat Eucalypt Forest on Coastal Floodplains and Swamp Oak Floodplain Forest TECs do not occur within the Study Area. As such, no further consideration into these communities is required.

In regards to Shale Sandstone Transition Forest TEC, it occurs within the Study Area, and therefore discussed below in relation to the requirements of the FBA.

8.1 Shale Sandstone Transition Forest

(a) the area and condition of the CEEC or EEC to be impacted directly and indirectly by the proposed development

A total of 1.5 ha of Shale Sandstone Transition Forest TEC (PCT1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin (HN556)) may be directly impacted by the Project for the additional service boreholes and transmission lines. Each additional service borehole would be approximately 50 m by 50 m (0.25 ha), and would be actively rehabilitated following decommissioning of the borehole activity (typically 7 weeks from clearing commencement).

The condition of Shale Sandstone Transition Forest TEC to be impacted is of benchmark condition – with stratum layers intact, no weeds and high resilience.

In relation to the borehole locations, to minimise impacts on Shale Sandstone Transition Forest TEC, a biodiversity due diligence assessment would be completed prior to clearing to position the borehole locations in areas that do not contain large trees, hollow bearing trees, threatened flora or important habitat (e.g. termite mounds, extensive hollow logs etc.). The clearing would also be undertaken in a manner whereby the rootball of the vegetation is left intact to aid in the rehabilitation of the site. Brushmatting would also be undertaken following decommissioning, along with regular monitoring and follow up actions if required to ensure the Shale Sandstone Transition Forest TEC is regenerating towards a benchmark condition.

In relation to the transmission line corridors, only vegetation above an approximately height of 2 m would be cleared and maintained via slashing.

Further mitigation measures to be employed at the site are discussed in section 9.

(b) the extent and overall condition of the CEEC or EEC within an area of 1000 ha and then 10,000 ha surrounding the proposed development footprint.

The mapped occurrence of Shale Sandstone Transition Forest TEC based on NPWS (2003) surrounding the development footprint is as follows (Figure 19):

- 1,000 ha = does not cover the entire site, and as such Area 5 includes 158 ha and Area 6 includes 15.5 ha; and
- 10,000 ha = 641 ha.

The condition of Shale Sandstone Transition Forest TEC within both the 1,000 ha and 10,000 ha circles would be in benchmark condition given the patches mainly occur within WaterNSW Catchment Landholdings typically located away from urban pressures.

(c) an estimate of the extant area and overall condition of the CEEC or EEC remaining in the IBRA subregion after the impact of the proposed development has been taken into consideration

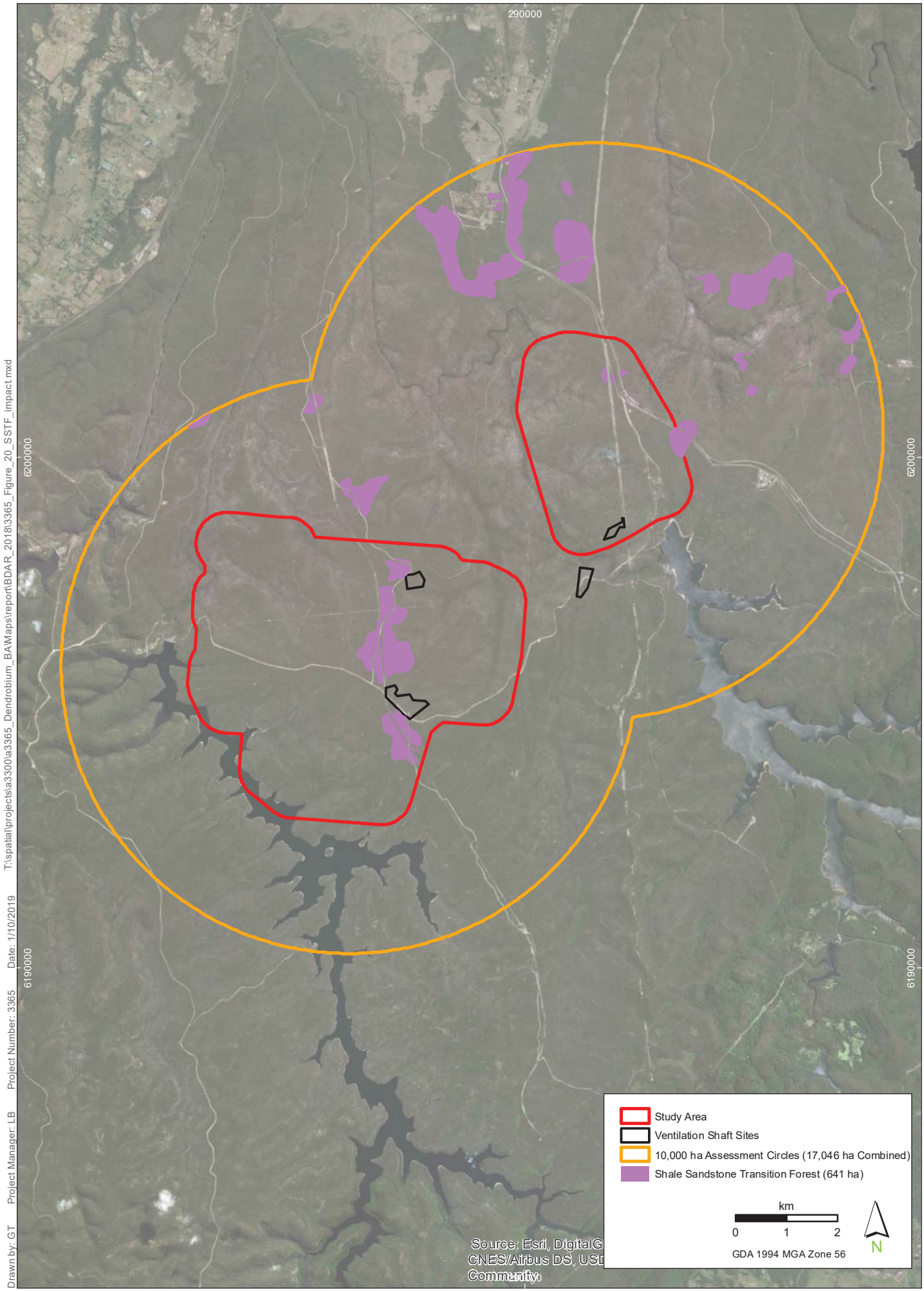
The Project occurs in the Sydney Cataract IBRA subregion. Approximately 9,600 ha of Shale Sandstone Transition Forest TEC has been mapped within its distribution mainly occurring with the Cumberland IBRA subregion region and Sydney Cataract IBRA subregion based on OEH (2013). It is highly likely that given the urban and rural pressures within the region, that the condition of Shale Sandstone Transition Forest TEC on average is likely to be degraded, with patches of the mapped occurrence within rural lands to be dominated by weeds.

The Project will result in a short-term impact to Shale Sandstone Transition Forest TEC, which would reduce the extent in the short term by 1.5 ha. This equates to approximately 0.01% of the mapped occurrence of Shale Sandstone Transition Forest TEC within the Sydney Cataract IBRA region.

(d) the development proposal's impact on:

(i) abiotic factors critical to the long-term survival of the CEEC or EEC. For example, will the impact lead to a reduction of groundwater levels or substantial alteration of surface water patterns?

The Project will result in a short term impact to 1 ha of Shale Sandstone Transition Forest TECassociated with the clearing for the borehole locations, and a long-term impact to approximately 0.5 ha associated with slashing for the transmission line easement installation and maintenance.



Impacts for further consideration - Shale Sandstone Transition Forest

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 19

Imagery: (c) Digitalglobe 2108/01/11

As discussed previously, in relation to the service boreholes, a biodiversity due diligence assessment would be completed prior to clearing to position the borehole locations in areas that do not contain large trees, hollow bearing trees, threatened flora or important habitat (e.g. termite mounds, extensive hollow logs etc.). The clearing would also be undertaken in a manner whereby the rootball of the vegetation is left intact to aid in the rehabilitation of the site. Brushmatting would also be undertaken following decommissioning, along with regular monitoring and follow up actions if required to ensure the Shale Sandstone Transition Forest is regenerating towards a benchmark condition.

As discussed in section 7.4.2, Shale Sandstone Transition Forest TEC is unlikely to be impacted by subsidence as a result of the Project.

(ii) characteristic and functionally important species through impacts such as, but not limited to, inappropriate fire/flooding regimes, removal of understorey species or harvesting of plants

The Project will not result in inappropriate fire and flooding regimes that would impact upon surrounding patches of Shale Sandstone Transition Forest TEC. A Fire Management Plan would be developed as part of the Project to minimise any potential fire ignition from the site, and to ensure that appropriate fire management is carried out. Flooding as a result of the Project is unlikely to result in an impact to Shale Sandstone Transition Forest. The community is typically located away from the lower lying areas of the landscape. As discussed previously, subsidence will not result in an impact to the community.

(iii) the quality and integrity of an occurrence of the CEEC or EEC through threats and indirect impacts including, but not limited to, assisting invasive flora and fauna species to become established or causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants which may harm or inhibit growth of species in the CEEC or EEC.

The removal of 1.5 ha of Shale Sandstone Transition Forest TEC opens the surrounding patches to edge effects. Edge effects include the invasion of weeds, erosion and sedimentation. Mitigation measures to be undertaken as part of the project include: weed control, demarcating 'no go' areas, and contractor education (section 9).

(e) direct or indirect fragmentation and isolation of an important area of the CEEC or EEC

Given Shale Sandstone Transition Forest is listed as Critically Endangered under the BC Act and the EPBC Act, all areas containing this community are important, particularly larger patches.

The removal of Shale Sandstone Transition Forest for the service boreholes will result in short-term fragmentation of the community surrounding the borehole location however connectivity would still be intact surrounding the borehole location.

In relation to the transmission line corridors, only vegetation above an approximate height of 2 m would be cleared and maintained via slashing. Therefore the vegetation communities would remain largely intact.

The Project would not result in isolation of a patch of Shale Sandstone Transition Forest TEC.

(f) the measures proposed to contribute to the recovery of the CEEC or EEC in the IBRA subregion.

The Project will require a like-for-like offset to address the requirements of the FBA. As such, this will result in the establishment of a conservation area that will protect and enhance Shale Sandstone Transition Forest. Given Shale Sandstone Transition Forest TEC is quite limited in its range, much of the land the community occupies is in the Sydney Cataract IBRA subregion, and as such, there is a level of confidence that the conservation area would be established there, and thus contribute to the recovery of the TEC within the IBRA subregion.

9. Managing Indirect Impacts

9.1 Indirect Impacts

Indirect impacts associated with the Project will largely occur as a result of subsidence related impacts, or during the construction of the surface infrastructure. All impacts will be minimised where possible through management procedures. A range of indirect impacts are likely to, or could, occur as a result of the Project including:

- Increased noise and dust.
- Erosion or sedimentation around the surface infrastructure during construction and operation.
- Increased spreading of weed propagules.
- Increased edge-effects on the adjacent woodlands.
- Water diversion from subsidence cracking.

The indirect impacts described above are variable in terms of the distance they may extend from the area of impact, and in many cases, due to mitigation measures, indirect impacts will be completely contained within the direct disturbance area.

Indirect impacts on the biodiversity values of areas surrounding the proposed disturbance footprint, along with recommended mitigation measures to minimise identified impacts, are discussed in Table 25.

The cost of environmental mitigation measures for the Project has been included in the economic analysis for the Project by Cadence Economics (2019). These costs are incorporated into the Project operating costs.

Table 25: Indicated Impacts and Proposed Mitigation Measures

Likely Impact from the Project	Potential Extent of the Indirect Impact Prior to Mitigation	Mitigation Measure	Expected Success of Mitigation Measure
Edge Effects			
The establishment of surface infrastructure would result in the creation of new edges adjacent to areas of existing native vegetation. The new edges of the surface infrastructure could facilitate the establishment and spread of introduced plant species. In the context of the ventilation shaft site, the sites occur within a relatively intact natural landscape with minimal weeds, the spread of introduce weeds would typically be limited to machinery/vehicles/personnel carrying weed seed. As such, weed spread is not likely to contribute to significant management effort for the ventilation shaft sites compared to if the site was in a highly weed infested area. The carpark is predominately located in a disturbed area which contains a large portion of introduced species. The carpark would result in removing a core area of introduced species, however may result in additional weed spread throughout the life of operation. Appropriate monitoring and control measures would be implemented at the surface infrastructure sites during and after construction, to assist in preventing weed invasion. The surface infrastructure would be progressively rehabilitated and will eventually be entirely revegetated to a native PCT, which will recreate fauna habitat.	Varying distance from subject site. Potentially occurring within 20 m of disturbance area throughout the active life of the Project. However, as previously discussed, given the intact condition of vegetation at the ventilation shaft sites, control of any potential weeds would not result in significant management efforts.	Demarcation for the boundary of vegetation clearing at the edge of the Study Area where it occurs immediately adjacent to native vegetation. Signposting will be used to inform Project personnel and site visitors of areas of conservation value to restrict entry or inform behaviour that will reduce incidental interactions with fauna. Weed management and pest management and monitoring to be implemented in the relevant Management Plans for the Project. Sedimentation management to be applied in areas that may result in runoff during construction and operation.	Active weed, and pest management are anticipated to be successful at managing edge effects from the Project.
Erosion and Sedimentation			
Erosion of soils during construction and operation of the Project may involve the following: • Alteration of soil structure beneath infrastructure items, and roads (these have been taken into consideration within the Study Area calculations). • The increase of surface water flow from the Study Area during rain events into the woodland areas around the surface infrastructure. Mitigation measures will be put in place during the construction and operation to limit the erosion and sedimentation and deposition of soil particulates in drainage lines and vegetation surrounding the surface infrastructure. With the mitigation measures in place, it is likely that the potential for erosion and sedimentation would be contained within the subject site.	Variable depending on topography and operation however all surface infrastructure be located on relatively flat terrain.	An Erosion and Sediment Control Plan has been developed and approved as part of the Water Management Plan for the Dendrobium Mine.	Sedimentation control is known to reduce sedimentation spills. Surface water flows have been designed to follow natural drainage.
Air Quality/Dust Emissions			
The majority of potential air quality related impacts due to the Project are related to the development/expansion of the Project surface facilities rather than the extension of the underground mining of coal. As such, dust and odour emissions associated with the upcast ventilation shafts, including pollutants from pre- and post-drainage flaring as well as air quality emissions at the Cordeaux Pit Top are most relevant as these locations are the most isolated and proximal to bushland settings. background nitrogen dioxide concentrations proximal to the ventilations shaft sites and Cordeaux Pit Top are expected to be low to negligible and therefore cumulative impacts due to flaring are not expected. The impact of dust emissions at the ventilation shaft sites are predicted to be minor, with short terms minor dust during construction. Such short term impacts are likely to have negligible impacts to biodiversity.	Variable depending on wind conditions.	Existing air quality mitigation and management measures would be implemented for the Project where applicable, and the existing Dendrobium Mine Air Quality Management Plan (South32 2018a) would be reviewed and revised accordingly for the Project.	Successful implementation of dust control would minimise dust. Current dust suppression mitigation works are on-going at the Mine.

Likely Impact from the Project	Potential Extent of the Indirect Impact Prior to Mitigation	Mitigation Measure	Expected Success of Mitigation Measure
Noise			
The majority of noise sources at the surface facilities for the Project would effectively be unchanged from the existing operations of the approved Dendrobium Mine, with the exception of the proposed Ventilation Shaft Sites and the use of the Cordeaux Pit Top for potential future access to underground mining operations. These sites are surrounded by bushland and are isolated from residential receivers. <u>Construction Noise Impacts</u> Surface construction activities would occur during the day-time at all surface facilities. Night-time construction activities would not occur at any of the existing or proposed surface facilities, with the exception the proposed ventilation shaft sites. Construction at the ventilation shaft sites would occur 24 hours per day, seven days per week (i.e. during the night-time period). All construction activities would only be temporary in nature and would be managed to minimise construction noise impacts. Given the short-term during, impacts to native fauna are likely to be negligible. <u>Operational Noise Impacts</u> The proposed ventilation shaft sites and Cordeaux Pit Top are the surface facilities most isolated from urbanised areas. Only the ventilation shaft sites that would operate as upcast ventilation shafts would have potential to generate operational noise, of which there would be one in each of the Area 5 (i.e. either Shaft Nos 5A or 5B) and Area 6 (i.e. either Shaft Nos 6A or 6B) ventilation shafts. Predicted operational noise levels at other Project facilities (e.g. Dendrobium Pit Top, Kemira Valley Coal Loading Facility etc.) would be similar to existing noise levels for the Dendrobium Mine. It is highly unlikely that the noise generated from the ventilation shafts would be such that local population of fauna would move out of the immediate vicinity resulting in impacts to fauna populations and lifecycles.	Variable depending on wind conditions. Potential for noise impacts likely throughout life of Mine.	Existing noise mitigation and management measures would be implemented for the Project where applicable at the existing and proposed surface facilities, and the existing Dendrobium Mine Noise Management Plan (South32 2018b) would be reviewed and revised accordingly.	Expected – currently a mitigation and monitoring plan in place.
Air Quality			
The majority of potential air quality related impacts due to the Project are related to the development/expansion of the Project surface facilities rather than the extension of the underground mining of coal. As such, dust and odour emissions associated with the upcast ventilation shafts, including pollutants from pre- and post-drainage flaring as well as air quality emissions at the Cordeaux Pit Top are most relevant as these locations are the most isolated and proximal to bushland settings. The impact of dust emissions at the ventilation shaft sites are predicted to be minor. Background nitrogen dioxide concentrations proximal to the ventilations shaft sites and Cordeaux Pit Top are expected to be low to negligible and therefore cumulative impacts due to flaring are not expected. The Cordeaux Pit Top is remote from residential areas and would be a minor source of emissions. Existing air quality mitigation and management measures would be implemented for the Project where applicable, and the existing Dendrobium Mine Air Quality Management Plan (South32 2018a) would be reviewed and revised accordingly for the Project.	Variable, though localised around areas of impact.	Existing dust mitigation and management measures would be implemented for the Project.	Expected – currently a mitigation and monitoring plan in place.
Fire			
During construction there is potential for equipment to trigger a fire ignition event e.g. welding. The potential for this to occur is higher during the hotter months. Mitigation measures include Catchment Closures during Fire Ban Days, fire extinguishers in vehicles, spill kits etc. To date, no bushfires have started from contractors/employees at Dendrobium Mine during construction activities.	Potential to be widespread in locality, though unlikely.	The Dendrobium Mine Bushfire Management Plan (South32 2018c) will incorporate bushfire management protocols to prevent and deal with the potential for bushfire.	Given the existing Mine operations have not resulted in any significant fires, the implementation of the Bushfire Management Plan would likely assist in fire prevention.

Likely Impact from the Project	Potential Extent of the Indirect Impact Prior to Mitigation	Mitigation Measure	Expected Success of Mitigation Measure
Light			
Lighting associated with surface operations is mostly fixed lighting for safety, security and operational purposes. Potential lighting impacts from visual stray light are associated with flood lighting of key operational areas such as Dendrobium Pit Top and the Kemira Valley Coal Loading Facility (e.g. yards, carparks etc.). The Project is not likely to increase the artificial lighting impacts at existing surface facilities. Additional lighting impacts associated with the Project would be related to the proposed ventilation shaft sites (during construction phase – which would occur 24 hours, 7 days per week) and at the Cordeaux Pit Top, when used for operational access. These sites are located most proximal to bushland setting and hence most likely to impact on biodiversity. Night lighting impacts at the proposed ventilation shaft sites due to construction would be localised and temporary. Standard lighting management measures and controls consistent with those specified in the existing Dendrobium Mine Lighting Management Plan (South32 2018d) would be implemented during Project ventilation shaft construction activities to reduce potential lighting impacts. Given the relatively short during construction, no long-term impacts associated with lighting are predicted to occur. No other night lighting for construction activities is required (all other construction during the day) nor are there further changes to current operational night lighting arrangements proposed for the Project.	Variable – however generally within the immediate facility.	Existing mitigation and management measures would continue for the Dendrobium Mine, and would be implemented for the Project where applicable (e.g. standard lighting mitigation measures at the existing Dendrobium Pit Top carpark would be implemented at the proposed Dendrobium Pit Top Carpark Extension). The existing Dendrobium Mine Lighting Management Plan would be reviewed and revised accordingly for the Project.	Minor/negligible impacts are predicted to be relatively short-term.
Subsidence Related Bedrock Cracking			
Throughout the life of longwall mining, there is potential for subsidence induced cracking to occur throughout the landscape, the results of which ultimately change the hydrology of an area. This has been detailed in MSEC (2019). As detailed throughout this BAR, this has impacts on a range of natural features and biodiversity.	Variable, though more likely above longwalls.	As described in Section 7.3, mine subsidence has the potential to cause surface cracking, including surface tension cracking near the top of slopes. If tension cracks are left untreated, there is potential for soil erosion to increase. Where significant cracks are detected and the potential for soil erosion (or other environmental consequences) is considered to be material, they would be repaired/filled as soon as practicable (Section 7.3).	The repair of subsidence cracks is relatively common in the mining industry, particularly in the NSW Hunter Valley. Similar success is expected at Dendrobium albeit allowing that access to some cracks may be impeded or unsafe or cause greater environmental harm that the crack itself.
Vehicle strikes			
	Potential interaction whilst driving to and from Catchment Lands, particularly at night. Speed limits are already in place.	Maintain existing traffic rules and speed limits. Monitoring of vehicle strikes would be undertaken, which may inform further protocols to reduce potential impacts (e.g. slower speed limits).	Expected.

9.2 Plans and Procedures for Reducing Impacts

South32 currently has a number of existing approved Dendrobium Area 3 management plans, which detail the mitigation and management associated with the Dendrobium mine and associated workings. Key Management Plans include:

- Swamp Impact Monitoring Management and Contingency Plan (South32 2017a);
- Watercourse Impact Monitoring Management and Contingency Plan (South32 2017b);
- Pollution Incident Response Management Plan EPL3241 (South32 2018e);
- Dendrobium Mine Air Quality Management Plan (South32 2018a);
- Dendrobium Mine Bushfire Management Plan (South32 2018c);
- Dendrobium Mine Landscape Management Plan (South32 2018f);
- Dendrobium Mine Noise Management Plan (South32 2018b);
- Dendrobium Mine Waste Management Plan (South32 2018g);
- Dendrobium Mine Lighting Management Plan (South32 2018d) and
- Dendrobium Mine Traffic Management Plan (South32 2018h).

Operations for the Project will continue to be managed in accordance with the existing plans, which will be revised and updated to incorporate the additional environmental management requirements as outlined in the EIS for the Project. The Landscape Management Plan would be updated to include biodiversity management measures associated with the construction and operation of the Project in order to protect and manage important biodiversity values.

All management plans will be submitted/updated to the satisfaction of relevant State and Commonwealth agencies. The plans will also be prepared/updated in consultation with the relevant NSW government agency, which will be outlined in the conditions of Project Approval, should the project be approved.

Key components to be updated and incorporated into the existing Plans include:

Vegetation clearing protocol for surface infrastructure sites

A vegetation clearing protocol would be incorporated in a Landscape Management Plan and would include the following:

- Prior to clearing of native vegetation, ecologists are to survey for ground-dwelling fauna and to remove any fauna/fauna habitat (nests or hollow logs) to adjacent habitat that would not be further disturbed.
- Prior to clearing all hollow-bearing trees are to be marked. Underscrubbing would then take place within the vegetation surrounding the hollow-bearing trees.
- After a 24 hour period, in the presence of an ecologist, the hollow-bearing trees would be gently felled.
- Any fauna displaced during clearing are to be captured where possible and relocated to previously identified, safe areas (fauna to be captured and handled only by personnel trained to do so), or otherwise promoted to move into adjoining areas outside the disturbance area.
- In an event that fauna are injured during clearing, the NSW Wildlife Information, Rescue and Education Service (WIRES) will be contacted to handle and collect for appropriate care and rehabilitation.

Employee Education and General Environmental Controls

Employees and contractors would be educated on, and required to implement the following controls, to avoid or at least minimise potential environmental impacts associated with the construction of the surface infrastructure.

- Minimise dust generation by minimising the extent and time that bare soil is exposed and by appropriate dust suppression.
- Procedures for the management of hydrocarbon and/or chemical spills throughout the Study Area including the requirements for vehicles to carry spill kits.
- Ensuring vehicles remain on designated roads and tracks and abide by site speed limits, through use of signposting and driver education during the induction process and in on-going Project discussions.
- Management and removal of all rubbish from the Study Area.

Pest and Weed Management

Pest and weed management activities during the Project will include:

- Management protocols for feral animals such as foxes, rabbits and cats.
- Management protocols for the identification of noxious or significant environmental weeds within areas to be cleared (in order to avoid transporting the weeds to rehabilitation areas or other parts of the site).

9.2.1 Fire management

South32 currently has a Dendrobium Mine Bushfire Management Plan (South32 2018c). Fire prevention and suppression are detailed within the Plan including emergency protocols should a fire occur. This Plan would be updated where required to reflect the Project.

9.2.2 Koala Plan of Management

A Koala Plan of Management has been prepared for the Project to provide further safeguards to minimise impacts to the Koala. This plan has been attached to Appendix 11. Key recommendation from the Koala Plan of Management include:

- Minimising clearing in areas of core or potential Koala habitat;
- Rehabilitation of the additional service borehole sites;
- Reducing the risk of Koala injury and death (including pre-clearing surveys, establishment of speed limits on all tracks and roads and Koala-specific inductions for all personnel); and
- Koala injury monitoring.

9.2.3 Landscape Management Plan

To reduce the impact on threatened biodiversity, a due diligence assessment would be completed at the proposed location of the service borehole sites and transmission line corridors by a suitable ecologist. The assessment would be in accordance with Landscape Management Plan which would be updated prior to the commencement of clearing. The updated Landscape Management Plan would include a Vegetation Management Protocol that minimises any potential disturbance of natural vegetation. Surveys would be conducted for threatened flora species and TECs. If any threatened flora species are identified, the proposed site would be relocated to avoid any associated impacts. Clearing of TECs would be avoided, apart from some minor clearing in Shale Sandstone Transition Forest TEC in which clearing, would be kept to a maximum of 1.5 ha. Clearance of all vegetation would be kept to a maximum of 5 ha outside of delineated areas. To minimise impacts to the Shale Sandstone Transition Forest TEC, the Vegetation Management Protocol would include the following measures:

- On-site validation that the vegetation present represents Shale Sandstone Transition Forest TEC.
- Consideration of re-locating infrastructure to avoid validated Shale Sandstone Transition Forest TEC, where practicable.
- Consideration of locating infrastructure along existing access tracks or existing disturbed portions of validated Shale Sandstone Transition Forest TEC.
- If clearing is required, implement appropriate management measures (e.g. pre-clearance surveys, demarcation of a clearance zone to constrain clearance to a minimum, implementation of erosion and sediment control works, progressive rehabilitation works, etc.).
- Design of erosion and sediment control and site water management measures in accordance with applicable guidelines and in consultation with Water NSW.
- Site-specific Aboriginal heritage inspections and, if required, relocation of the proposed sites to avoid known Aboriginal heritage sites.
- Progressive rehabilitation of the disturbance areas, such that only a practical minimum area is disturbed at any one time.

9.2.4 Rehabilitation

The rehabilitation strategy for the Project would be undertaken in accordance with South32's company-wide closure standards and rehabilitation strategy, which addresses closure criteria and land use. This includes requirements for the rehabilitation of disturbed areas (e.g. ventilation shaft sites), decommissioning of infrastructure (e.g. Dendrobium Pit Top), remediation of contaminated sites, treatment and disposal of wastes, land use options, and post closure monitoring and management. Consideration is also given to economic transitions at mine closure and supporting sustainable communities.

Existing overall rehabilitation objectives for the Dendrobium Mine which would continue for the Project are that the final rehabilitated landforms must be:

- Safe;
- Stable;
- Non-polluting; and
- Consistent with key stakeholder expectations (where practical) and surrounding lands.

For all sites other than the Kemira Valley Rail Line and Dendrobium Coal Production Plant (CPP), additional rehabilitation objectives are that:

- Ecosystem function should be restored with the establishment of local native plant species; and
- The ecosystem must be self-sustaining.

A number of post-mining land uses were considered for the Project. The timeframe of the Project (i.e. until 31 December 2048) limits the certainty with which the post mining land use can be defined. However, for the purposes of rehabilitation and mine closure planning for the Project, an interim post-mining land use of native vegetation has been selected for all domains except the Dendrobium CPP. South32 considers that native vegetation represents the highest standard of rehabilitation likely to be required for all relevant sites.

Proposed ventilation shaft sites for the Project are to be rehabilitated to a post-closure land use of forest, similar to the surrounding vegetation. During decommissioning, all infrastructure would be removed to ensure ventilation shaft sites are safe and free of hazardous materials (subject to heritage and alternative end use considerations). The ventilation shaft sites would be sealed, with any contaminated soils identified remediated by removal, encapsulation or land-farming on-site. The final landform established would be stable and consistent with the surrounding environment and designed to reduce erosion. Once the landform is established, plant growth medium would be established with local native plant species with the rehabilitation objective of restoring self-sustaining ecosystem function to the sites.

Key rehabilitation performance measures and completion criteria have been developed for the Project. Post-closure monitoring of rehabilitation areas at the Project would be conducted to assess the progress of rehabilitation areas and the effectiveness of the rehabilitation techniques being used to determine the need for any maintenance and/or contingency measures. Rehabilitation progress of the Project and rehabilitation techniques and materials would be regularly evaluated.

Existing surface infrastructure with no additional disturbance (i.e. land/vegetation clearance) would be rehabilitated in accordance with existing rehabilitation practices and measures for the approved Dendrobium Mine.

10. Threshold Impact Criteria

The FBA lists threshold impact criteria for landscape features, native vegetation, and threatened species in order to determine when an offset or further consideration by consent authorities is required due to a Project's impacts. The impacts are classed according to the following criteria:

a) impacts that the assessor is required to identify for further consideration by the consent authority.

b) impacts for which the assessor is required to determine an offset.

c) impacts for which the assessor is not required to determine an offset.

d) impacts that do not require further assessment by the assessor.

The impacts associated with biodiversity considered for further consideration has been detailed in section 9.

This offset strategy quantifies the required offsets for the Project in accordance with both the BC Act and EPBC Act, through the use of the FBA methodology and the EPBC Act Policy Calculator.

The Project impacts for which the assessor is required to determine an offset impacts to the following:

- Direct impacts from clearing of approximately 28.5 ha of native vegetation, including 1.5 ha of Shale Sandstone Transition Forest TEC.
- Potential subsidence related impacts to Coastal Upland Swamps (section 10.1.2)
- Potential subsidence or clearing impacts to species credit species including (sections 7.8 and 7.9):
  - Potential subsidence related impacts to up to 0.28 ha of Broad-headed Snake habitat.
  - Potential subsidence related impacts to up to 32.74 ha of Littlejohn's Tree Frog habitat.
  - Potential subsidence related impacts to up to 32.74 ha of Giant Burrowing Frog habitat.
  - Potential subsidence related impacts to up to 7.21 ha of Red-crowned Toadlet habitat.
  - Potential subsidence related impacts to up to 13.93 ha of Giant Dragonfly habitat.
  - Potential clearing related impacts to up to 1.50 ha of Koala habitat.

10.1 Quantifying Offset of Impacts

10.1.1 Vegetation Clearing and Habitat Removal

The FBA identifies the BBCC as the appropriate tool for quantifying the precise nature of the offsets required in both ecosystem species credit terms. The major Project function of the BBCC is used under the FBA to quantify the number of credits required for the development.

A calculation of the nature and extent of offset credits required due to the biodiversity impacts associated with the Project was undertaken using Version 4.0 of the BBCC.

Details of the BBCC inputs have been discussed in sections 3 to 4 and section 7. Appendix 10 includes the full output printout of the BBCC for the Project which defines the ecosystem and species credits required to offset the vegetation clearing and habitat removal impacts of the Project on biodiversity in accordance with the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2016).

10.1.2 Subsidence Impacts

The offset strategy presented herein is primarily based on the NSW *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence* (OEH 2016) and the FBA. The FBA prescribes practices to calculate offsets for clearing impacts, however does not apply to lesser or indirect impacts including:

- downstream impacts on hydrology and environmental flows on surface vegetation and Groundwater Dependent Ecosystems; and
- subsidence and cliff falls associated with mining developments.

The NSW *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence* (OEH 2016) (the Addendum) states:

> *Subsidence impacts on Coastal Upland Swamps are inherently more uncertain than the clearing of native vegetation and it takes time and monitoring to ascertain whether impacts have occurred. This means that this addendum applies beyond the development application stage of a major project and requires an adaptive management approach to environmental consequences throughout the life cycle of a major project that involves longwall mining underneath Coastal Upland Swamps.*

Thus, the policy employs a two-staged approach to confirm eventual offset requirements for a project consisting of:

1. identification of the maximum predicted offset liability based on subsidence predictions; and
2. confirmation of actual subsidence impacts based on analysis of piezometer groundwater monitoring data post mining over a 24 month period.

The proponent must demonstrate a legal ability to secure the maximum predicted offset prior to approval of each Extraction Plan. The offset strategy presented herein presents the maximum predicted offset liability based on knowledge and monitoring of previous subsidence impacts within the locality. It also provides some information on strategies that will be employed to secure required offsets. A final offset strategy with specifics of proposed offset measures will be developed and presented for each Extraction Plan as per the requirements of the policy.

The Addendum requires that the loss of the Coastal Upland Swamp should be assumed, for example, that the total area of the Coastal Upland Swamp has essentially been cleared and is devoid of ecosystem function. This is summarised in the Addendum as follows:

> *It is recognised that the impact of altering the hydrological regime within Coastal Upland Swamps is not equivalent to removing all vegetation. However, this impact is likely to result in total loss of the upland swamp ecological community in the long-term as a result of loss of critical ecosystem function. When predicting the offset liability it is the loss of the upland swamp ecological community, including the threatened species that reply on that community, which must be calculated to determine the offset liability.*

Whilst South32 acknowledges that a groundwater change may be experienced in Coastal Upland Swamps in the Study Area, there is strong evidence that indicates native vegetation and fauna habitat would still persist following mining. In fact, there is little evidence to the contrary, and as such, South32 propose that this be taken into consideration when determining the biodiversity offset liability associated with Coastal Upland Swamps. Furthermore, Watershed's (2019) analysis of historic swamp piezometer data from the Dendrobium Mine, concluded that subsidence induced groundwater impacts have not been observed in Coastal Upland Swamps further than 60 m from longwalls.

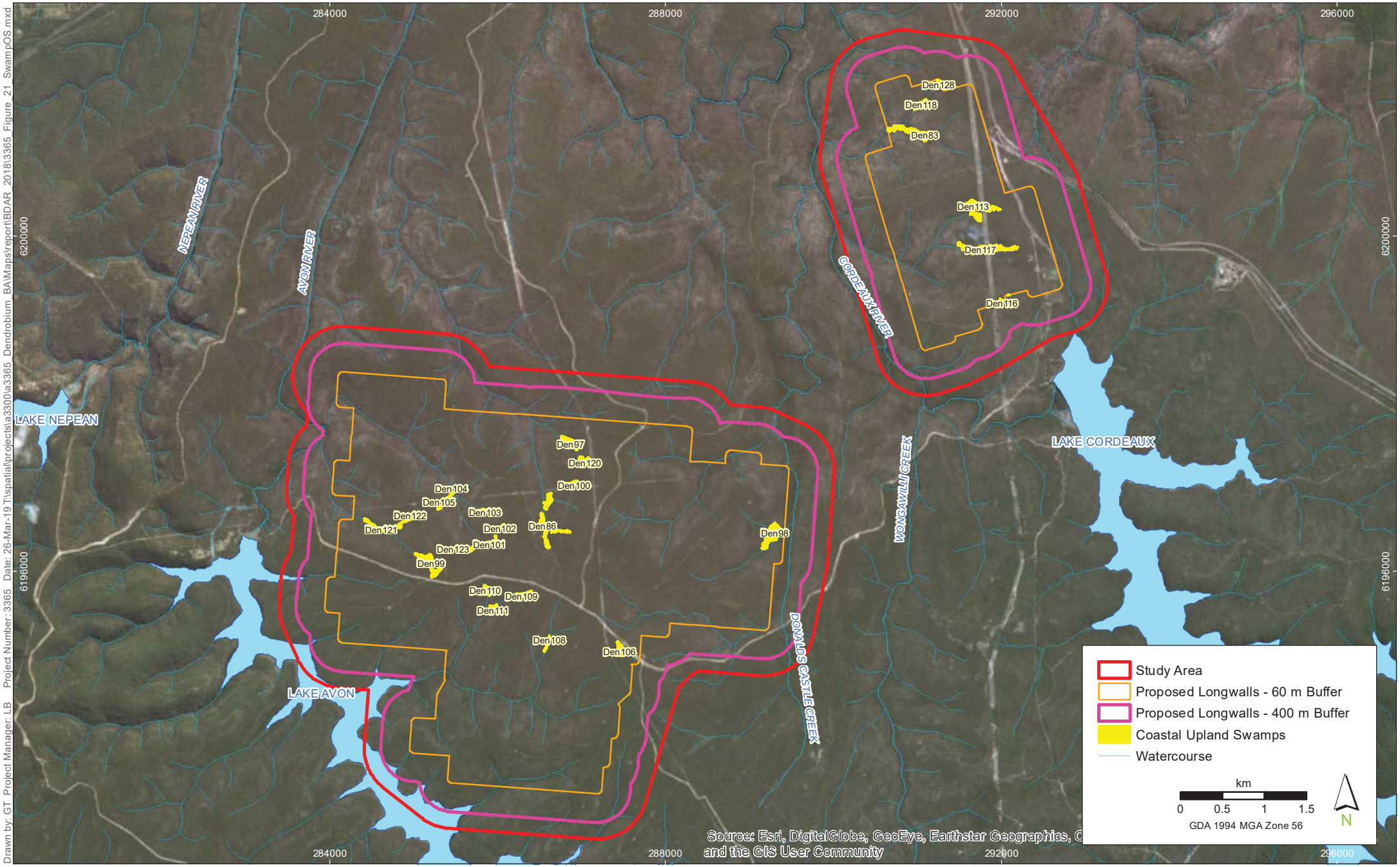
Evidence to support this based on the existing Dendrobium Mine Area 3A and 3B Coastal Upland Swamp monitoring program, and relevant literature has been provided in Appendix 9 of this report, with key summaries justifying the approach taken in applying the Addendum provided in Table 26. The Coastal Upland Swamps which require offsetting are shown in Figure 20.

Table 26. Summary of justification for the approach taken to applying the NSW *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence* (OEH 2016a)

Key justification	Summary
Coastal Upland Swamp vegetation would transition into a drier vegetation community	• To date, monitoring as part of the Dendrobium Mine Area 3A and 3B Coastal Upland Swamp monitoring program has not detected any substantial changes in sub vegetation communities that can be attributed to subsidence (Appendix 8). • Given over 500 swamps have been directly mined beneath using varying methods (Richardson and Ryan 2007) with swamp vegetation still persisting, demonstrates that there is some degree of resilience to subsidence impacts. • At a worst case vegetation transition, Coastal Upland Swamps are likely to take on the appearance and function of a drier swamp community, similar to that of Upland Swamp: Eucalypt Fringing Woodland, which also shares the same PCT as the Coastal Upland Swamp TEC (HN560 Needlebush - banksia wet heath on sandstone plateau); or Exposed Sandstone Scribbly Gum Woodland (HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin). • As such, at a worst case scenario, whilst the ecosystem itself has changed, vegetation is still persistent, and as such site value scores could be amended in the BBCC to reflect a reasonable transition through site scores.
The Predicted threatened species in the BBCC for Coastal Upland Swamps and HN566 are similar	• It is likely that a Coastal Upland Swamp that has been completely changed in hydrological function would resemble that of a drier community, similar to PCT1083 Red Bloodwood - scribbly gum heathy woodland (HN566). • Whilst it is acknowledged that Coastal Upland Swamps are important for a number of threatened flora and fauna, including: Giant Burrowing Frog, Littlejohn's Tree Frog, Giant Dragonfly and *Pultenaea aristata*; the predicted threatened fauna as determined by the BBCC for Coastal Upland Swamps are similar to that of the woodland community (HN566). As such, predicted threatened biodiversity habitat would essentially not be lost if a transition to a drier community takes place and as such, it may be reasonable to attribute the site value score in the BBCC to a more meaningful score than simply a complete loss in habitat.
Candidate threatened species of Coastal Upland Swamps are offset separately	• Threatened biodiversity that are listed on the EPBC Act or are regarded as 'species credit' species are offset accordingly if detected within habitat types impacted by subsidence. • As such, whilst at a worst case scenario, a Coastal Upland Swamp transitions to woodland, through the process of an impact assessment, those threatened biodiversity reliant upon the swamp system are offset separately to the Addendum.
Evidence to support Coastal Upland Swamp impacts directly above and within 60 m from proposed longwalls	• Historical analysis completed by Watershed (2019) of Dendrobium Coastal Upland Swamps and swamp piezometers following longwall mining has indicated that effects on swamps (that could be classified as "greater than negligible environmental consequence") have not been observed at distances greater than 60 m from a longwall panel. • Based on assessments of water levels and recession rates around past mining in Areas 2, 3A and 3B, swamp piezometers directly above and within 60 m of the proposed longwalls are predicted to exhibit a mining effect, be that through a reduction in the water table to below pre-mining levels and/or increased recession (drainage) rate. • Effects on swamp water tables were not reported (i.e. effects were considered nil or negligible) at distances greater than 60 m from a longwall panel. As such, a similar distance could reasonably be expected with the current Project.

Predicted subsidence impacts from the Project are not limited to Coastal Upland Swamps, rather they extend to watercourses and features such as cliffs. Thus, for consistency, the principles of the swamp offset policy have been extended to species credit threatened species and/or significantly impacted species listed under the EPBC Act, which are likely to be impacted by subsidence along swamps and watercourses and require offsetting.

Maximum predicted offset liabilities have been developed for each species based on knowledge of the species, subsidence predictions and previous monitoring of subsidence impacts. The maximum liability for each species has then been applied within the BioBanking calculator according to FBA practices. The maximum offset liability is presented in this report as the Project offset liability. However, as part of calculating the proportion of the offset liability to be applied to successive extraction plans, additional monitoring would be undertaken to confirm species distributions throughout impacted areas. This additional work may reduce the actual offset liability.



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niche Environment and Heritage

Coastal Upland Swamp biodiversity offsetting

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 20

Imagery: (c) DigitalGlobe 2017-11-01

Principles for monitoring for threatened species have been developed here for each species (along swamps and watercourses) to build on principles within the swamp offset policy and provide additional information as to the Project offset strategy at the development approval phase. Monitoring that may be used to refine the maximum offset liability has been provided in Table 27.

Table 27: Monitoring to Refine Maximum Offset Liability

Threatened Species	Suggested Surveys / Monitoring (if reduction in Maximum Liability is to be considered)	Monitoring of Physical Impacts
Broad-headed Snake	Surveys led by appropriately qualified expert within identified areas of potential habitat. Or use of an expert in the species to quantify habitat.	Monitoring of previous longwall areas to record possible subsidence impacts to preferred sheltering habitat.
Littlejohn's Tree Frog	Adult frog and tadpole surveys after sufficient rains, which are known to stimulate breeding events. Survey to be performed within one month of documented breeding events. Once tadpoles/frogs are confirmed as present within a stream reach all sections of that stream with pools supporting sufficient hydro periods should be assumed as habitat. Where no evidence of frogs is recorded at a stream reach or swamp over a two year period and after sufficient survey, the species can be considered absent and no offset is required, regardless of impact monitoring.	Monitoring of pools and piezometer data to confirm if pool retention rates are impacted via subsidence. Where pool retention rates are significantly impacted compared with reference sites, impacts should be confirmed as having occurred.
Giant Burrowing Frog	Unlikely to be able to perform sufficient survey to confidently rule out the species given its infrequent breeding and cryptic nature combined with catchment access restrictions.	Monitoring of pools and piezometer data to confirm if pool retention rates are impacted via subsidence. Where pool retention rates are significantly impacted compared with reference sites, impacts should be confirmed as having occurred.
Red-crowned Toadlet	Adult frog and tadpole surveys after sufficient rains, which are known to stimulate breeding events. Survey to be performed within one week of documented breeding events. Once tadpoles/frogs are confirmed as present within a stream reach all sections of that stream with pools supporting sufficient hydro periods should be assumed as habitat. Where no evidence of frogs is recorded at a stream reach or swamp over a two year period and after sufficient survey, the species can be considered absent and no offset is required, regardless of impact monitoring.	Monitoring of piezometric data to confirm if moisture retention rates are impacted via subsidence.
Giant Dragonfly	Further survey may be able to confirm whether potential swamps are used by the species. Survey as per relevant guidelines.	As per swamp impact monitoring.
Koala	None required – clearing impacts only.	Not applicable – see Koala Plan of Management (Appendix 11).

The final offset liability for all subsidence impacts would be determined post mining based on piezometric data (or other relevant data) as specified within the swamps offset policy (OEH 2016), or alternatively the maximum offset liability as indicated in section 11 would be applied if South32 chooses not to undertake additional surveys to reduce areas of potential habitat.

10.2 Summary of Credits Required for State Offset liability

Offsets required for vegetation disturbance as a result of the Project (ecosystem credits) are shown in Table **28**, and offsets required for species credits are provided in Table 29**.**

It should be noted that the final disturbance footprint associated with the transmission lines has not yet been determined and as such, impacts have been determined based on the assumptions in section 1.2.1. The credit requirements presented in this section, in particular for fauna species, may therefore need to be updated following the final design of the transmission line alignments and associated survey and assessments.

Table 28: Ecosystem Credits Required for the Project

Plant Community Type Name	Area	Ecosystem Credits Required[1]
HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin	25.8	1022
HN556 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	1.5	120
HN651 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest	1.0	80
HN560 Needlebush - banksia wet heath on sandstone plateau of the Sydney Basin Bioregion	17.0	237
HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin	4.6	78
ME044 Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	0.2	6

[1] Note that the ecosystem credits required for the impacts to the transmission lines have taken into consideration a full loss scenario, which presents a conservative estimate of credits given the ground layer and shrub layer may not be cleared. This would be refined once the final footprint has been determined.

Table 29: Species Credits Required for the Project

Threatened Species	Area of Impact (ha)	Credits Required
Broad-headed Snake	0.28	9
Littlejohn's Tree Frog	32.74	851
Giant Burrowing Frog	32.74	426
Red-crowned Toadlet	7.21	94
Giant Dragonfly	13.93	1073
Koala	1.50	39

10.3 Summary of Commonwealth Offset liability

Offsets required for those MNES significantly impacted by the Project include the entities and associated area of potential habitat provided in Table 30 below. As discussed in section 11 Offset Strategy, the offset associated with these species can be determined using the EPBC Act Policy Calculator tool based on area and quality of impact at the development site.

Table 30. Commonwealth offset liability

Commonwealth Offset Liability	Area of impact (ha)
Coastal Upland Swamps of the Sydney Basin Bioregion TEC	21.6
Giant Burrowing Frog	32.74
Littlejohn's Tree Frog	32.74

11. Offset Strategy

The *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014) states that biodiversity offsets provide benefits to biodiversity to compensate for the adverse impacts of an action. Biodiversity offsets assist in achieving long-term conservation outcomes while providing development proponents with the ability to undertake actions that have unavoidable impacts on biodiversity.

Unavoidable impacts to biodiversity are those impacts that are residual (i.e. impacts that remain after impact avoidance, management and mitigation measures are employed to reduce the type or magnitude of biodiversity impacts). Section 7.1 of this report details the design changes that South32 has implemented through the preliminary stages of the Project in order to avoid and reduce impacts to biodiversity values.

Section 9 of this report outlines the management and mitigation actions that South32 will employ to further reduce direct and indirect impacts to biodiversity values as a result of this Project.

This section of the report describes the approach to biodiversity offsetting proposed for the Project in consideration of the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014), *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence*, and Commonwealth EPBC Act Environmental Offsetting Policy.

It should be noted that, as detailed in Section 10.1 for subsidence related impacts to Giant Burrowing Frog, Littlejohn's Tree Frog, Red-crowned Toadlet and Giant Dragonfly, the maximum area of habitat that may be impacted for the threatened fauna has been presented. As provided in the swamp offset policy – 'offsets identified in the Biodiversity Offsets Strategy are only required to be secured or credits retired once the impacts of mining are confirmed through monitoring and reviewed by the independent expert panel. Where it is predicted that a partial impact to an upland swamp is likely, then only the portion of the swamp likely to experience greater than negligible environmental consequences should be included in the offset calculation'. As such, the offset liability provided in this section of the assessment may further be refined if monitoring confirms that impacts are unlikely, or less than predicted.

11.1 Offset Liability

The Project would require a biodiversity offset in accordance with the FBA and associated policy for the following:

- Native vegetation clearing;
- Habitat clearing, potentially impacting Koala habitat;
- Potential subsidence related impacts to the TEC components of Coastal Upland Swamps; and
- Potential subsidence related impacts to habitat associated with Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Broad-headed Snake and Giant Dragonfly.

Under the Commonwealth, only those threatened entities that may be significantly impacted by the Project are required to be offset. Details of the EPBC Act Assessments of Significance are provided in Appendix 7. The Project would therefore require an offset for the following potentially significant impacted entities:

- Coastal Upland Swamps;
- Giant Burrowing Frog; and
- Littlejohn's Tree Frog.

The maximum offset liability for the Project has been provided in Table 28 and Table 29.

11.2 Approach to the Biodiversity Offset

As documented in section 11.2 of the FBA, an offset requirement is represented as a number and type of biodiversity credits determined in accordance with Chapter 10 of the FBA. Subject to provisions in the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014), the conservation measures that may be used to address this offset requirement include:

1. Retirement of biodiversity credits from the biodiversity register established under Part 7A of the NSW *Threatened Species Conservation Act 1995* (TSC Act) (now BC Act).
2. Ecological rehabilitation or remediation of previously disturbed land.
3. Supplementary measures as determined in accordance with the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014).
4. Payment into the Biodiversity Conservation Trust (BCT) Payment Fund (noting not available for Commonwealth offset requirements).
5. A combination of the above.

Whilst, the Project is assessed under the Bilateral Agreement, the Commonwealth Offsetting Policy contains the following key considerations that must be addressed in the offset package:

- Offsets are described as measures that compensate for significant residual adverse impacts on the environment and the policy applies to all matters that are protected under the EPBC Act.
- The 'offsets assessment guide' is a tool that has been developed to help assess the suitability of offset proposals. The offsets assessment guide uses a balance sheet approach to measures impacts and offsets.
- At least 90% of a project's impact should be directly offset (subject to exceptions outlined in the EPBC Act Offsets Policy) and any offsets should be implemented prior to or at the time of the impact occurring.
- Up to 10% (or more if an appropriate exception applies) of a project's impacts may be indirectly offset through compensatory measures such as research, monitoring, education program etc.

DoEE requires biodiversity offset sites to be secured under a legally binding conservation covenant and actively managed under a fully funded plan. There are a variety of mechanisms for achieving this, including (but not limited to) BioBanking, Voluntary Conservation Agreements or dedication of land to the National Parks Estate.

Due to a variety of factors, most notably the approach to offsetting the NSW and Commonwealth Coastal Upland Swamps liability (as detailed further in section 10.1.2), South32 proposes a biodiversity offset package that employs a combination of offsetting opportunities including the following:

1. Retirement of FBA credits through existing South32 BioBank sites.
2. Establishment of Stewardship sites on South32 landholdings.
3. Direct offset actions, such as the rehabilitation of Coastal Upland Swamps subject to diret disturbance impacts.
4. Payment into the BCT Payment Fund.
5. Other supplementary measures

Each component of the biodiversity offset package is detailed in the sections below.

Table 31 outlines the approach that will be taken by South32 to develop a suitable biodiversity offset in accordance with the key offsetting policy principles.

Table 31: Principles for Developing Biodiversity Offsets under NSW and Commonwealth Legislation

Offsetting Principle	How Principle will be addressed in the Offset Package
NSW Biodiversity Offsets Policy for Major Projects (OEH 2014)	
Principle 1: Before offsets are considered, impacts must first be avoided and unavoidable impacts minimised through mitigation measures. Only then should offsets be considered for the remaining impacts.	Impacts have been avoided where possible during the design of the Project. Management and mitigation measures for biodiversity values have been proposed for the Project. Impact avoidance, management and mitigation measures have been detailed in Section 7.1 to Section 9 as well as Section 11.
Principle 2: Offset requirements should be based on a reliable and transparent assessment of losses and gains.	The maximum offset liability has been determined using the FBA and consideration of the swamp offset policy. The latest version of the FBA Credit Calculator has been used to determine the maximum credits required to offset the impacts of the Project on PCTs and species credits. Accredited BioBanking assessors have conducted the field surveys and offset calculations. The proposed offset will be assessed in accordance with the requirements of the FBA, to determine the suitability and quantum of offsets for the Project.
Principle 3: Offsets must be targeted to the biodiversity values being lost or to higher conservation priorities.	The offset proposed will be a like-for-like offset in the first instance. Variation rules are available however not proposed in the first instance.
Principle 4: Offsets must be additional to other legal requirements.	The proposed offset will be additional to other legal obligations that the Project may have.
Principle 5: Offsets must be enduring, enforceable and auditable.	The Biodiversity offset strategy has been developed with specific reference to the FBA.
Principle 6: Supplementary measures can be used in lieu of offsets.	The biodiversity offset site will be formally secured in accordance with the permissible offset mechanisms of the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014).
Commonwealth Offsetting Principles	
Deliver an overall conservation outcome that improves or maintains the viability of the protected matter.	The formalisation of the offset package will manage and fund actions to meet, improve and maintain offset principles for Coastal Upland Swamps, Giant Burrowing Frog and Littlejohn's Tree Frog.
Be built around direct offsets but may include other compensatory measures.	At present, no compensatory measures have been proposed in the offset package, however will consider such options depending on the outcomes of current land acquisition negotiations.
Be in proportion to the level of statutory protection that applies to the protected matter.	The proposed offset package has proposed a like-for-like offset in the first instance. South32 has not proposed a variation to such offsetting at present.
Be of a size and scale proportionate to the residual impacts on the protected matter.	Under the Bilateral Agreement the offset liability for EPBC threatened fauna would meet the credit requirements. Consultation with DoEE would be undertaken to discuss the Coastal Upland Swamp offset liability to ensure the offset is of proportionate to the residual impacts.
Effectively account for and manage the risks of the offset not succeeding.	Offsets would be established in a manner which is secure, auditable with management actions funded.
Be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs.	The offset would be additional to any other requirements specified by Determining Authorities.
Be efficient, effective, timely, transparent, scientifically robust and reasonable.	The offset package would be discussed and negotiated with DoEE.
Have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.	The proposed offset package would be finalised in a manner that provides an auditable and enforced offset in accordance with State and Commonwealth requirements.

11.3 Addressing the Offset Liability for Native Vegetation Impacted by Surface Infrastructure

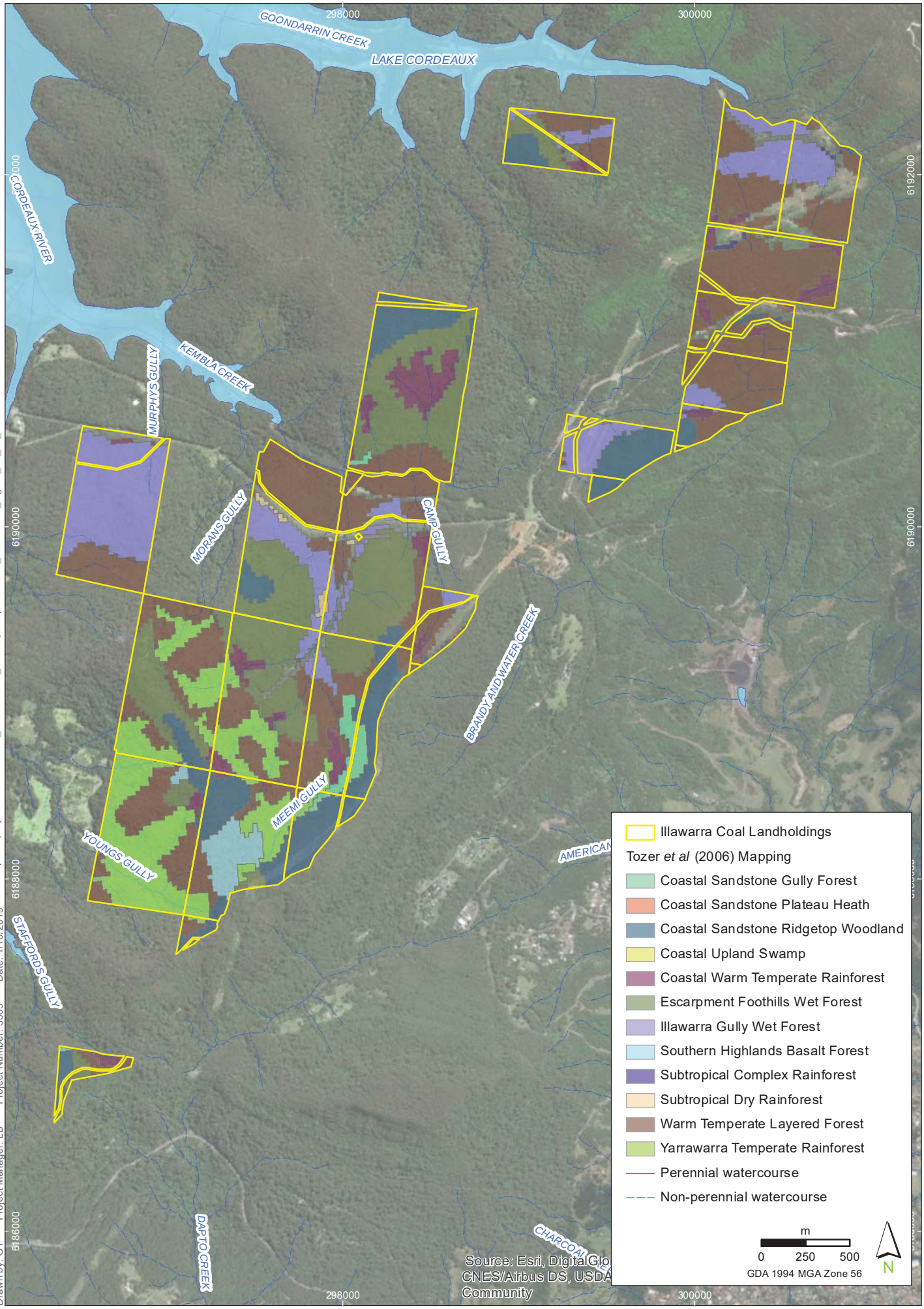
No biodiversity offset is required under the Commonwealth for the removal of native vegetation for the surface infrastructure as vegetation clearing will not lead to a significant impact on any MNES (Appendix 7).

To address the NSW offset requirement, a biodiversity offset is required for the impacts to the following PCTs:

- PCT1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin (HN556);
- PCT1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin Bioregion (HN566);
- PCT1250 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest (HN651);
- PCT1245 Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes (ME044);
- PCT978 Needlebush - banksia wet heath on sandstone plateau of the Sydney Basin Bioregion (HN560); and
- PCT1804 Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin (HN662).

South32 has a number of options available to address the biodiversity offsets associated with the impacts to clearing of native vegetation. The options available include: the retirement of credits on existing South32 BioBank sites, the establishment of new BioBank sites on South32 Landholdings (Figure 21), rehabilitation of previously disturbed Coastal Upland Swamps, funding of supplementary measures and payment in the BCT Fund. The options in relation to the Project are detailed in Table 32.

Given the availability of offsetting options, there is minimal risk for South32 sourcing the native vegetation offset liability.



Illawarra Coal Landholdings potential offsetting

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 21

Imagery: (c) Digitalglobe 2015 - 2017

Table 32: Options to address the Offset Liability for Native Vegetation Clearing

Plant Community Types	Existing Appin West BioBank site and Douglas Park BioBank site (owned by South32)	Establishment of a Stewardship site on IC land	Purchase Credits on the Market[1]	Payment into the BCT Fund
HN556 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Mod/Good	The Appin West BioBank site and Douglas Park BioBank site has sufficient credits available to offset the impacts to HN556.	South32's Cataract River BioBank site would have sufficient credits for HN556.	Not required.	Not required.
HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin Bioregion HN5651 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest	No credits available	South32 has over 1,000 ha of native vegetation on the eastern portion of the Illawarra escarpment (Figure 21). Existing vegetation mapping by NPWS (2003) have mapped over 100 ha of both HN566 and HN651 occurring within the site. It is highly likely that this area is an underestimate given the PCT is relatively common. At an average of 10 credits per ha at a BioBank site, it is therefore likely that the formal establishment of a BioBank site (now Stewardship site) on portions of the landholdings would generate 1,000 BioBanking credits. This would therefore address the offset credit requirement for HN566 and HN651.	This option may be explored should credits become available on the Public market.	Payment in the BCT Fund is an option that is permissible under the FBA.
ME044 Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes	No credits available	The South32 landholdings detailed above have also been mapped by NPWS (2003) to contain over 200 ha of ME044. At an average of 10 credits per ha at a BioBank site, it is therefore likely that the formal establishment of a BioBank site (now Stewardship site) on portions of the landholdings would generate over 2,000 BioBanking credits and therefore address the offset credit requirement for ME044.	This option may be explored should credits become available on the Public market.	Payment in the BCT Fund is an option that is permissible under the FBA.

[1] Credits can be purchased on the public market or payment into the Biodiversity Conservation Trust Fund to satisfy the state offset liability.

11.4 Addressing the Offset Liability for Subsidence Impacts to Coastal Upland Swamps

11.4.1 Addendum to the NSW Biodiversity Offsets Policy for Major Project: Coastal Upland Swamps Impacted by Longwall Mining Subsidence

The approach to determining the Coastal Upland Swamp offset liability is discussed in section 10.1.2. As detailed in the Addendum, the maximum predicted offset liability must be calculated for the total area of Coastal Upland Swamps predicted to be subject to greater than negligible environmental consequences, and this detail provided in the Extraction Plans for the Project.

This Biodiversity Offset Strategy demonstrates the approach South32 will undertake to meet the requirements of its maximum predicted offset liability for Coastal Upland Swamps.

11.4.2 Unused Residual Offsets from South32 Approvals

South32 has previously established a Biodiversity Offset Site at Maddens Plains in order to satisfy the offset requirement for potential impacts to native vegetation, including impacts to Coastal Upland Swamps, as part of the Dendrobium Mine and Bulli Seam Operations. The Maddens Plains site consists of 6 Lots (Lot 1A DP 752054, Lot 1 DP 248386 and Lots 3,4,5 & 6 DP 1 019453) with a combined area of approximately 598 ha. The site is situated to the south of Stanwell Tops and falls partly in the Sydney Metropolitan CMA Sydney Cataract sub-region and the Southern Rivers CMA Illawarra sub-region (Figure 23).

In 2018, South32 transferred Maddens Plains to the NSW Government for incorporation into the National Parks estate. The purpose of the transfer was to offset the predicted biodiversity impacts at both Dendrobium Mine (Area 3) and the Bulli Seam Operations, in particular potential impacts to Coastal Upland Swamp TEC, including those in Table 33. The details of the offset requirement and the biodiversity values included within the Maddens Plains offset sites is provided in the South32 (2016) Strategic Biodiversity Strategy.

Conditions of the transfer made it permissible to utilise the Maddens Plains site for biodiversity offsets for future South32 Projects. This includes where predicted offset requirements are no longer required.

The Maddens Plains site was used to offset the potential impacts to Coastal Upland Swamp TEC that occur within the Dendrobium Area 3 mining domain. As part of this Project South32 is committing to avoid impacts to certain Coastal Upland Swamp TECs currently approved for impact and offset at Maddens Plains. Monitoring data (collected and analysed consistent with the requirements of the NSW Swamps Offset Policy [OEH 2016a]) has shown that subsidence related impacts to these Coastal Upland Swamp TECs have not occurred. The Coastal Upland Swamps for which the existing approval to disturb would be relinquished include Den02, which is 0.7 ha in area (Table 33).

Table 33: Coastal Upland Swamp Revised Biodiversity Offset Liability

Offset Liability	Project		Coastal Upland Swamp TEC no longer Impacted (ha)	Area Reduced by the Area no longer Impacted (ha)	Revised FBA Credits Required
	Area Impacted (ha)	FBA Credits Required	Den02		
Coastal Upland Swamp TEC	21.6	315	0.7	20.9	305

Considering that this swamp has already been offset, the total area of avoided Coastal Upland Swamps (0.7 ha) has been reduced from the additional Coastal Upland Swamps potentially impacted by the Project (total 21.6 ha). The area of Coastal Upland Swamps therefore requiring additional offsetting for the Project is 20.9 ha (Table 33).

Should further analysis identify that additional portions of the existing Area 3 Coastal Upland Swamp offset are also in excess of their previous need, these may also be incorporated in reducing the additional credit requirement for Coastal Upland Swamps.

11.4.3 Addressing the Additional NSW Offset Liability for Coastal Upland Swamps

In order to address the NSW offset liability for Coastal Upland Swamps, South32 proposed to undertake the following:

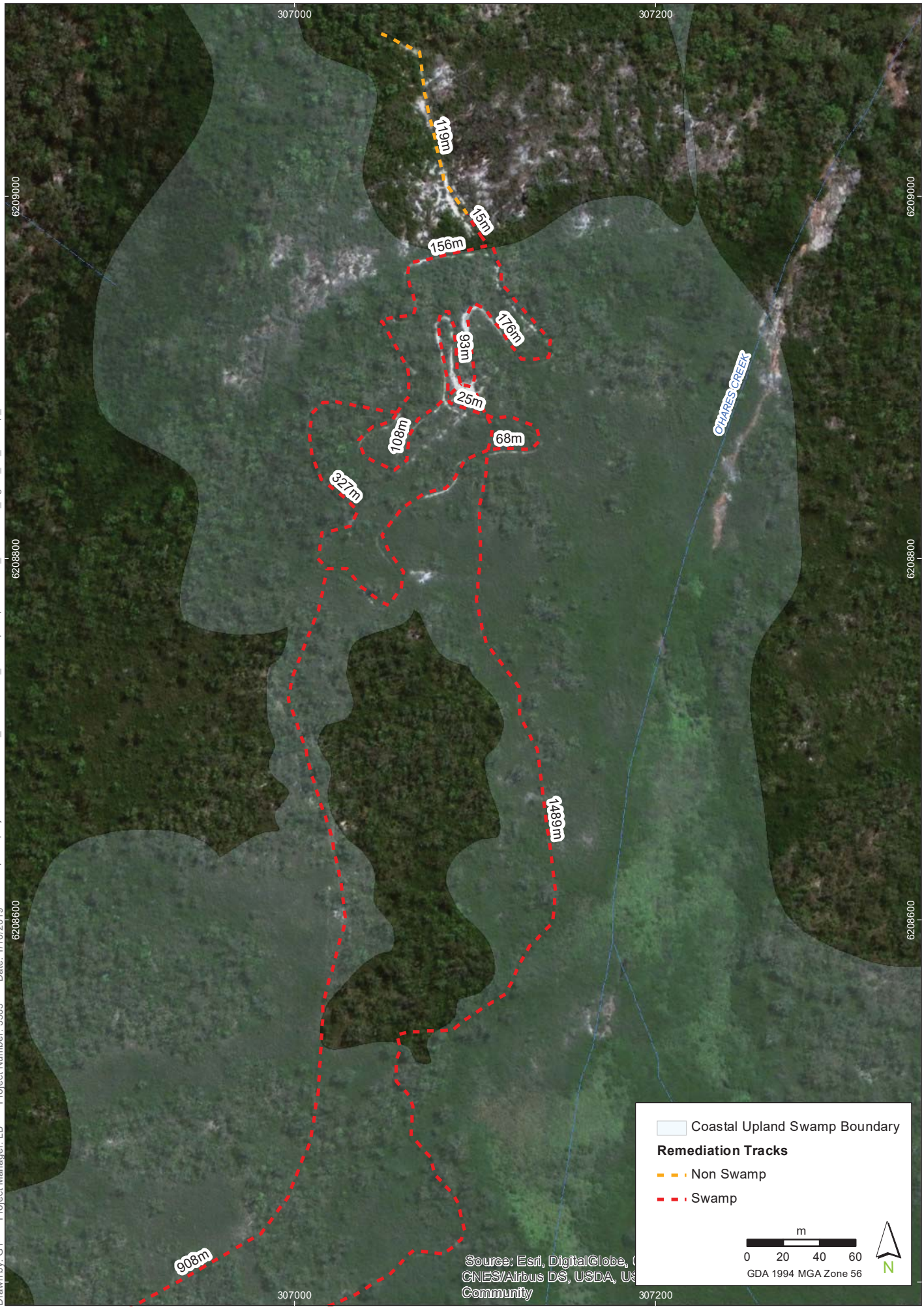
1. **Formal establishment of a Stewardship site within a privately-owned property.**

2. **Apply other supplementary measures to provide a direct offset for Coastal Upland Swamps:** South32 propose to actively rehabilitate impacted swamps largely associated with illegal tracks and decommissioned easements/tracks, with the aim of enhancing and protecting these swamps. Desktop analysis completed by Niche as part of this assessment identified over 123 Coastal Upland Swamps which have had some degree of disturbance, such as illegal tracks (e.g. motorcycles tracks, private landholder access), service easements and access roads, Fire Roads, and public/private roads. Much of these Coastal Upland Swamps occur within land managed by WaterNSW, or within National Parks estate.

South32 propose to work with WaterNSW and NSW National Parks and Wildlife Service (NPWS) to prioritise a number of the impacted Coastal Upland Swamps for rehabilitation works. Upon doing so, direct benefits to the Coastal Upland Swamps would be achieved by:

- Managing the risks discussed in the Scientific Determination (OEH 2012a) for Coastal Upland Swamps in relation to localised disturbance associated with unauthorised use of off-road vehicles, trail bikes and horses, which may cause localised erosion and weed invasion within Coastal Upland Swamps.
- Reducing the potential for localised erosion within damaged Coastal Upland Swamps which may result in development of knick points that may initiate more widespread erosion of swamp sediments, and these effects may be exacerbated by bushfires and/or intense rainfall events.
- Preventing the potential for edge effects (weed spread, erosion etc.) through active rehabilitation of cleared land within Coastal Upland Swamps.
- Through Coastal Upland Swamp rehabilitation projects, enhance habitat for a range of threatened fauna associated with the swamp ecosystem.

An example of a Coastal Upland Swamp rehabilitation project that occurs within WaterNSW landholdings is provided in Figure 22.



Coastal Upland Swamp - Rehabilitation Projects (example)

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

niche Environment and Heritage

FIGURE 22

Imagery: (c) Digitalglobe 2017-01-18

South32 are aware that the rehabilitation of degraded swamps would be regarded as a supplementary measure, as a formal Stewardship site is not being established. However, based on a desktop mapping exercise completed as part of this assessment, the availability of Coastal Upland Swamps that are able to be subject to a Stewardship site arrangement are extremely limited, with the majority (greater than 90%) of Coastal Upland Swamps being located within existing National Parks Estates, Conservation Areas or water catchment land. Those swamps on private landholdings are relatively small (<2 ha) and across multiple landholdings, and therefore available credits are likely to be insignificant compared to the Project offset liability. As such, satisfying the offset liability though Stewardship sites is highly unlikely and South32 propose to apply other supplementary measures as permissible in the FBA. Justification for applying the supplementary measures is provided in Table 34.

Table 34. Supplementary measures applied for Coastal Upland Swamps

Criteria in FBA	How South32 has applied to the Project
FBA section 10.5.4.3 - The consent authority may approve supplementary measures to be proposed as part of the BOS for a PCT impacted at the development site, where in the consent authority's opinion the BOS demonstrates that:	
(a) all reasonable steps have been taken by the proponent to secure a matching ecosystem credit	
Reasonable steps to locate like-for-like offsets include, in addition to consideration of any feasible sites known to the proponent: • checking the biobanking public register and having an expression of interest for credits on it for at least six months • liaising with an OEH office (or Fisheries NSW office for aquatic biodiversity) and relevant local councils to obtain a list of potential sites that meet the requirements for offsetting • considering properties for sale in the required area • providing evidence of why offset sites are not feasible – suitable evidence may include: - the unwillingness of a landowner to sell or establish a biobank site - the cost of an offset site itself should not be a factor unless it can be demonstrated the landowner is charging significantly above market rates.	No credits are available of the public register to date, or historically. Based on desktop mapping undertaken as part of this assessment, the majority (greater than 90%) of Coastal Upland Swamps are located within existing National Parks Estates, Conservation Areas or water catchment land. Remaining Coastal Upland Swamps within private landholdings are generally small (average of around 2.2 ha) and scattered across multiple Lots with different owners. It is therefore not practical (or achievable) for South32 to establish Stewardship sites to the quantity required for the Project due to the constraints above.
(b) the PCT to which a required ecosystem credit relates is associated with a CEEC/EEC or for which the impact of development does not require further consideration according to Subsection 9.2.4, and	Not applicable.
(c) the supplementary measure applies to that CEEC/EEC, and	The proposed rehabilitation projects associated with damaged Coastal Upland Swamps would provide a direct benefit to the TEC through: • Managing the risks discussed in the Scientific Determination (2012) for Coastal Upland Swamps in relation to localised disturbance associated with unauthorised use of off-road vehicles, trail bikes and horses, which may cause localised erosion and weed invasion within Coastal Upland Swamps. • Reducing the potential for localised erosion within damaged Coastal Upland Swamps which may result in development of knick points. • Preventing the potential for edge effects (weed spread, erosion etc.). • Enhance habitat for a range of threatened fauna associated with the swamp ecosystem.
(d) the supplementary measure is carried out in accordance with the rules governing supplementary measures, including calculating the financial contribution of the supplementary measures in accordance with Appendix B of the NSW Biodiversity Offsets Policy for Major Projects.	The cost and scope of the proposed Coastal Upland Swamp rehabilitation projects would be determined in consultation and agreement with OEH, NSW NPWS, WaterNSW and DoEE.

Another potential supplementary measure is the funding of research progress into remediation of Upland Swamp previously impacted by subsidence. Any such program would be developed in consultation with OEH and WaterNSW.

3. **Payment into the BCT fund for any residual credits.**

Given South32 has the option to pay into the BCT Payment Calculator, there is minimal risk that the offset liability would not be met under NSW legislation.

11.4.4 Addressing the Commonwealth Offset Liability for Coastal Upland Swamps

Unlike the NSW offsetting approach, payment into the BCT Payment Fund may not be a primary option to address the Commonwealth offset liability. As such, a direct biodiversity offset is the primary target for 90% of the offset liability. The remaining 10% may be made of indirect offset actions.

As discussed in section 11.4.3 throughout the offsetting investigations, it has become apparent that finding land containing Coastal Upland Swamps not already protected in some form is difficult due to the following:

1. The majority (greater than 90%) of Coastal Upland Swamps are located within existing National Parks Estates, Conservation Areas or water catchment land.

2. Remaining Coastal Upland Swamps within private landholdings are generally small and scattered across multiple lots with different owners.

In order to address the Commonwealth offset liability for Coastal Upland Swamps, South32 proposes to implement a combination of the following:

1. **Subject to discussions with landowners, establish a Stewardship site for privately owned Coastal Upland Swamps.** Land has been identified to meet approximately 75% of the EPBC Act direct offset liability for the Project based on conservative score and quality estimates entered into the EPBC Act Policy Calculator. This preliminary scoring can be provided and discussed with DoEE upon request.

2. **Rehabilitation of Coastal Upland Swamps previously impacted by some degree of disturbance:** Based on the 123 Coastal Upland Swamps identified during the desktop analysis as being impacted by some degree of disturbance, it is proposed that a number of these swamps be actively managed including: access track closure, tubestock plantings, brushmatting, weed control etc. South32 would consult with DoEE, WaterNSW and NPWS to discuss the work plans, costings and Coastal Upland Swamps to be rehabilitated in order to meet both the State and Commonwealth offset liability.

The rehabilitation of Coastal Upland Swamps would contribute to a direct offset to Coastal Upland Swamps given the rehabilitation projects would involve 'actions that provide a measurable conservation gain for an impacted protected matter'[2].

The Coastal Upland Swamp rehabilitation projects would aim at achieving the following priority actions as specified in the SEWPaC (2012) *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy*, by undertaking the following:

- "improving existing habitat for the protected matter creating new habitat for the protected matter;
- reducing threats to the protected matter; and
- averting the loss of a protected matter or its habitat that is under threat".

[2] Direct offsets defined under the DSEWPaC (2012) EPBC Act Policy are defined - "Direct offsets are those actions that provide a measurable conservation gain for an impacted protected matter".

Furthermore, Priority Conservation Action details in the DoE (2014b) would be achieved through the Coastal Upland Swamp rehabilitation projects:

- Manage swamps to prevent the introduction of new, or further spread of, invasive weeds.
- Control invasive pest animals and avoid grazing and/or trampling damage to swamps, and to protect native fauna, through coordinated landscape-scale control programs.

The number and scale of the Coastal Upland Swamp rehabilitation projects would largely be dictated by the establishment of the Stewardship site (estimated to satisfy approximately 75% of the EPBC offset liability), and through consultation with DoEE, OEH, WaterNSW and NPWS. Until such investigations (e.g. field surveys of the potential Stewardship site determining Coastal Upland Swamp extent and quality) and consultation with agencies has been completed, it is not possible to state the total contribution the rehabilitation projects would account for in regards to the Commonwealth EPBC Act Policy Calculator. However, given over 123 Coastal Upland Swamps have some degree of impact, it seems highly likely that there is ample opportunity for South32 to meet 90% of the EPBC Act Policy offset through a number of potential rehabilitation projects. Table 35 includes an example calculation of the aerial extent of the existing Upland Swamps disturbance that could be remediated as part of the Offset Strategy based on 20 Coastal Upland Swamps and Table 36 outlines the offsetting options available to satisfy the Commonwealth offset liability.

Table 35: Access track rehabilitation at 20 Project Swamps

Coastal Upland Swamp Rehabilitation Projects			
Sum of Length (m)	**Area (assuming 3 m width) (ha)**	**Area assuming a 10 m buffer either side of track (ha)**	**Commonwealth offset liability met?**
12,092	3.6 ha	28.5 ha	42%

Table 36: Coastal Upland Swamps offsetting options to address the Commonwealth offset liability

Offset liability	Area of offset liability (ha)	Private property Stewardship site	Project Coastal Upland Swamps	Commonwealth offset liability met?
Coastal Upland Swamp liability	17.9	75%[3]	34-100%[4]	>100%

3. **Funding and/or undertaking research into remediation of Coastal Upland Swamps impacted by subsidence:** As described above, a measurable conservation gain for an impacted potential matter is included in the definition of a direct offset. There are numerous Coastal Upland Swamps across the region that have previously been impacted by subsidence, albeit the impacts have not resulted in a measurable change to the values of the threatened community. Notwithstanding, there has been significant research undertaken into remediating rock bars in streams impacted by subsidence and this knowledge/technology is likely to be applicable to the substrate of Coastal Upland Swamps. Research into this is likely to result in a direct measurable gain to Coastal Upland Swamps.

[3] Based on completing a run of the EPBC Act Policy Calculator using estimated quality scored from aerial interpretation.

[4] Given the number of potential Coastal Upland Swamp Rehabilitation Projects that could be undertaken, through consultation with DoEE, WaterNSW, OEH, and NPWS, meeting EPBC Act Offset liability is possible.

4. **Other direct or supplementary methods:** Should residual offset requirements beyond those described above be required for the Project, these credits could be offset using one or a combination of the following:

    - Funding and/or undertaking research regarding the remediation of upland swamps impacted by subsidence.
    - Funding and/or undertaking actions specifically related to threats to upland swamps. For example, actions to:
        - Address the "Objectives" of the *Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi* (DoEE, 2018).
        - Address the "Priority Conservation Actions" listed in the *Conservation Advice (including listing advice) for Coastal Upland Swamps in the Sydney Basin Bioregion* (DoE, 2014b).
    - Purchasing credits on the market.
    - Other supplementary measures as outlined in the NSW Offset Policy (OEH, 2014).

11.5 Addressing the Offset Liability for Impacts to Threatened Fauna

In order to address both NSW and Commonwealth offset liability for threatened fauna, South32 proposes to retire the credits by the following measures:

1. Residual conservation gains, such as using the Maddens Plains site for residual biodiversity values not offset for the Dendrobium Mine and the Bulli Seam Operations (such as the Giant Burrowing Frog, Littlejohn's Tree Frog and Red-crowned Toadlet).
2. Retire Koala credits from the existing South32 BioBank sites.
3. Payment into the BCT Fund to address the NSW offset liability for Giant Dragonfly and Broad-headed Snake.

These measures have been summarised in Table 37, with further details provided in section 11.5.1 below in regards to the Maddens Plains Offset site.

Based on preliminary investigation, the use of both Maddens Plains and payment into the BCT Fund, would address the NSW and Commonwealth offset liability for Littlejohn's Tree Frog and Giant Burrowing Frog.

Additional offset options that may be explored by South32 include:

1. Complete targeted fauna surveys on South32 landholdings to confirm the presence of the threatened fauna, and establish Stewardship sites with sufficient management funding to enhance and further protect the habitat.
2. Purchase/negotiate the establishment of Stewardship sites within private properties known to contain habitat for the threatened fauna.
3. Purchase credits should they occur on the market.

Given the options presented, there is a low risk for the offset liability not being met.

Table 37: Addressing the offset liability for threatened fauna

Species	Credits required	Offset requirement		Option to pay into BCT Fund	Credits available at existing South32 BioBank sites	Maddens Plains	
		NSW	Commonwealth			Area (ha) (ELA 2011)	Credit estimate (ELA 2011)
Giant Burrowing Frog	426	✓	✓	No – due to Commonwealth offset requirement	×	420.5	2,523
Littlejohn's Tree Frog	851	✓	✓	No – due to Commonwealth offset requirement	×	300	1,800
Red-crowned Toadlet	94	✓	×	Yes	×	263	1,578
Giant Dragonfly	1073	✓	×	Yes	×	-	-
Broad-headed Snake	9	✓	×	Yes	×	-	-
Koala	39	✓	×	Yes	✓		

11.5.1 Maddens Plains Offset Site

The Maddens Plains site consists of 6 Lots (Lot 1A DP 752054, Lot 1 DP 248386 and Lots 3, 4, 5 & 6 DP 1 019453) with a combined area of approximately 598 ha (excluding crown roads reserves). The site is situated to the south of Stanwell Tops and falls partly in the Sydney Metropolitan CMA Sydney Cataract sub-region and the Southern Rivers CMA Illawarra sub-region (Figure 23).

The Maddens Plains site was proposed in 2016 to satisfy the vegetation community offsets for predicted biodiversity impacts at both Dendrobium Mine and the Bulli Seam Operations.

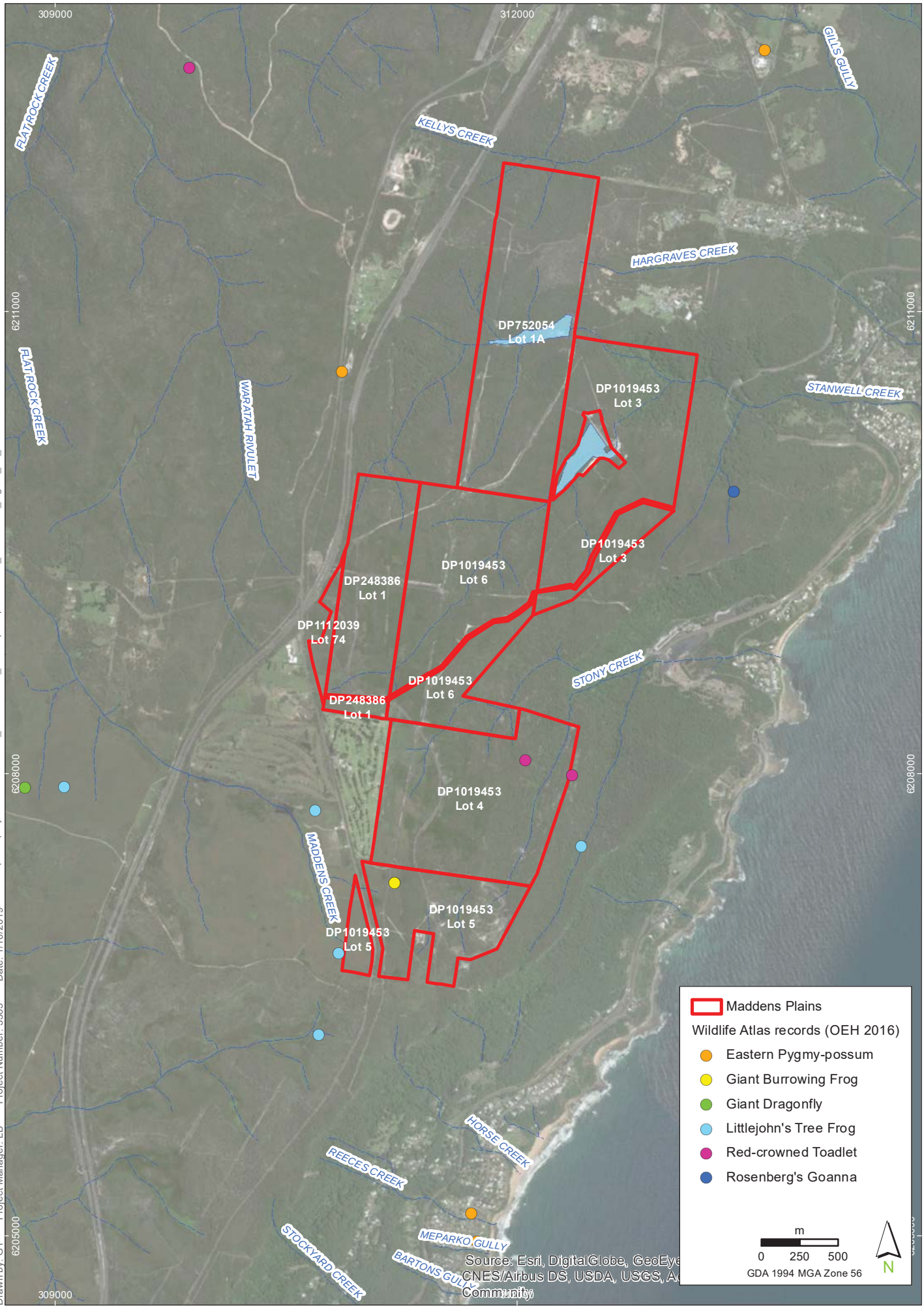
Residual conservation gains, such as using the Maddens Plains site for residual biodiversity values not offset for the Dendrobium Mine and the Bulli Seam Operations (such as the Giant Burrowing Frog, Littlejohn's Tree Frog and Red-crowned Toadlet) is proposed.

A preliminary assessment of the property was completed by ELA (2011) which identified the site contained habitat for the Giant Burrowing Frog, Littlejohn's tree Frog, and Red-crowned Toadlet amongst other threatened species.

The total number of possible Biobank Credits that the Maddens Plains site could generate was estimated by ELA (2011) and this is provided in Table 37. Based on the credit estimate, the site would meet the credit requirement of the Project for the Giant Burrowing Frog, Littlejohn's Tree Frog, and Red-crowned Toadlet, thus addressing both the State and Commonwealth offset liability for these species.

11.6 Finalisation of the Offset Package

The Offset package summarised in Table 39, would be formalised in Extractions Plans should the Project be approved. As previously discussed, the subsidence related offset liability (Coastal Upland Swamps, Littlejohn's Tree Frog, Giant Burrowing Frog and Giant Dragonfly) are only required to be secured or credits retired once the impacts of mining are confirmed through monitoring and reviewed by the Independent Expert Panel (OEH 2016). Where it is predicted that a partial impact to a Coastal Upland Swamp is likely, then only the portion of the swamp likely to experience greater than negligible environmental consequences should be included in the offset calculation. Similarly, it is proposed that where currently conservatively predicated impacts to Littlejohn's Tree Frog, Giant Burrowing Frog and Giant Dragonfly are demonstrated to not have eventuated, that the credit liability for these species be reduced, and detailed accordingly in the Extraction Plans.



Maddens Plains - Fauna offsetting

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 23

Imagery: (c) Digitalglobe 2017-01-17

In summary, the formalisation of the Offset package would include the following core tasks prior to clearing for surface infrastructure, and as per the offset requirements of each Extraction Plan (Table 38):

Table 38: Core tasks to finalise the offset package

Task	Core tasks to be completed
Retirement of credits on South32's existing BioBank sites	Following approval, and prior to vegetation clearing, South32 would retire the ecosystem credits associated with HN566 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin using their existing BioBank site.
Formalisation of Stewardship sites – Coastal Upland Swamps	The formal establishment of a Stewardship site within privately owned property would take place as required.
Consultation with WaterNSW and Commonwealth regarding Swamp rehabilitation and remediation research Projects	Consultation and acceptance of the Swamp rehabilitation projects would take place with WaterNSW and DoEE. Following acceptance, a schedule of works program would be prepared and planned accordingly.
Use of Maddens Plains	Consultation with DoEE and OEH regarding the funding and management proposed at the Maddens Plains site in relation to Littlejohn's Tree Frog, Red-crowned Toadlet, and Giant Burrowing Frog.
Payment into BCT Payment Fund	Payment into the BCT Payment Fund would take place as required to offset the NSW requirement for Coastal Upland Swamps and threatened fauna (including Broad-headed Snake and Giant Dragonfly).

Table 39: Summary of offsetting options available to address the offset requirement

Threatened entity	Offsetting options						NSW offset liability met?	Commonwealth offset liability met?
	Existing BioBank sites credit requirement	Establish Stewardship site – Swamp Property (in negotiations)	Establishment Stewardship site – IC landholding	Madden Plains	Swamp rehabilitation and remediation research projects	Payment into the BCT Fund		
HN556 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	✓	-	-	-	-	✓	**Yes**	**Not required**
HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin Bioregion	-	-	✓	-	-	✓	**Yes**	**Not required**
HN651 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion	-	-	✓	-	-	✓	**Yes**	**Not required**
ME044 Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes	-	-	✓	-	-	✓	**Yes**	**Not required**
Coastal Upland Swamp TEC: HN560 Needlebush - banksia wet heath on sandstone plateau of the Sydney Basin Bioregion / HN662 Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin	-	✓	-	-	✓	✓ NSW only	**Yes**	**Yes**
Koala	✓	-	-	-	-	✓	**Yes**	**Not required**
Littlejohn's Tree Frog	-	-	✓	✓	-	✓ NSW only	**Yes**	**Yes**
Broad-headed Snake	-	-	✓	-	-	✓	**Yes**	**Not required**
Giant Burrowing Frog	-	-	✓	✓	-	✓ NSW only	**Yes**	**Yes**
Red-crowned Toadlet	-	-	✓	✓	-	✓	**Yes**	**Not required**
Giant Dragonfly	-	-	-	-	-	✓	**Yes**	**Not required**

12. Conclusion

This report provides a biodiversity assessment to address the potential impacts associated with the Project, and an offset strategy for those impacts that cannot be avoided in accordance with the FBA.

The Project would result in the direct impact to approximately 28.5 ha of native vegetation and habitat associated with the clearing for surface infrastructure. Clearing of 1.5 ha of Shale Sandstone Transition Forest may also occur for surface activities e.g. service boreholes and transmission lines.

This assessment has concluded that native vegetation (non-swamp types) are highly unlikely to be significantly impacted by subsidence related impacts from the Project. However, impacts to Coastal Upland Swamps directly above the proposed longwalls as a result of fracturing from subsidence movements is likely.

Based on MSEC (2019) predictions, it is unlikely that there would be adverse changes in ponding or scouring within swamps due to the mining induced tilt.

It has been concluded that any impacts to Coastal Upland Swamps are not likely to be immediate and may take some time to detect any type of vegetative response. Given the uncertainties around potential long-term impacts, a significant impact was conservatively assumed for assessment purposes for Coastal Upland Swamps.

No threatened flora were recorded within the area to be directly disturbed for the ventilation shaft sites or Dendrobium Pit Top carpark. Furthermore, biodiversity due diligence assessments would be completed for any additional surface disturbance (e.g. service borehole establishment and transmission line alignments) to ensure that no threatened flora would be impacted by the works. The Project would therefore not result in the clearing of any threatened flora.

Through an analysis of MSEC (2019) subsidence predictions and known habitat for threatened flora in the Study Area, it was determined that subsidence impacts resulting in loss of threatened flora is unlikely.

Six species credit fauna were determined to be impacted by the Project, and therefore require offsetting as a result of subsidence related impacts or through clearing associated with the surface infrastructure. Species include: Broad-headed Snake, Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Giant Dragonfly and Koala. Species polygons (or an estimate of polygon size) as per the FBA have been provided in the assessment in order to facilitate the offset liability for each species.

The remainder of threatened fauna considered to be affected by the Project are regarded as ecosystem credit fauna and as such, are offset through the vegetation types offset by the Project.

Those threatened fauna which are listed under the EPBC Act that may be impacted include: Littlejohn's Tree Frog, Giant Burrowing Frog, Greater Glider, Koala and Grey-headed Flying-fox. An EPBC Act Assessment of Significance for each of these species has been completed. Based on the results of the Assessments, a significant impact to the Giant Burrowing Frog and Littlejohn's Tree Frog was considered likely. A significant impact to other threatened fauna listed under the EPBC Act is considered unlikely.

The Project would require a biodiversity offset in accordance with the FBA (including the NSW Offset Policy) and NSW *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence* (OEH 2016) for the following:

- Native vegetation clearing;
- Habitat clearing, potentially impacting Koala habitat;
- Potential subsidence related impacts to Coastal Upland Swamps; and
- Potential subsidence related impacts to habitat associated with Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Broad-headed Snake and Giant Dragonfly.

Under the Commonwealth, only those threatened entities that may be significantly impacted by the Project are required to be offset. Details of the EPBC Act Assessments of Significance are provided in Appendix 7. The Project would therefore require an offset for the following potentially significant impacted entities:

- Coastal Upland Swamps;
- Giant Burrowing Frog; and
- Littlejohn's Tree Frog.

The maximum offset credit liability required to offset the Project was completed using the BioBanking calculator. The credits required include the following (Table 40):

Table 40. Summary of impacted area and credited required for Project

Impacted entity	Area (ha)	Credits required
HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin	25.8	1022
HN651 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion	1.0	80
HN556 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	1.5	120
Coastal Upland Swamps: HN560 Needlebush - banksia wet heath on sandstone plateau of the Sydney Basin Bioregion / HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin	20.9	305
ME044 Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	0.2	6
Broad-headed Snake	0.28	9
Littlejohn's Tree Frog	32.74	851
Giant Burrowing Frog	32.74	426
Red-crowned Toadlet	7.21	94
Giant Dragonfly	13.93	1073
Koala	1.50	39

South32 has provided an offset strategy to address the maximum offset liability for the Project. Due to a variety of factors, most notably the approach to offsetting the NSW and Commonwealth Coastal Upland Swamp liability, South32 proposes a biodiversity offset package that employs a combination of offsetting opportunities including the following:

1. Retirement of FBA credits through existing South32 BioBank sites.
2. Establishment of Stewardship sites on existing and potential future South32 landholdings.
3. Establishment of Stewardship sites on privately owned land.
4. Direct offset actions, such as the rehabilitation and/or remediation of Coastal Upland Swamps or other works consistent with recovery actions and threat abatement.
5. Payment into the BCT Payment Fund.
6. Other direct and supplementary measures/actions.

The offset liability would be refined and included in the Extraction Plans as required for the Project.

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Appendix 1. SEARs Addressed in BAR

Table 41: Project SEARs Reconciliation Table

Requirement	How addressed in the BAR
NSW Department of Planning and Environment (6 February 2017)	
General requirements – Specific Issues Biodiversity – including: - an assessment of the likely biodiversity impacts of the development, including impacts to Coastal Upland Swamps, in accordance with the Framework for Biodiversity assessment by a person accredited in accordance with s142(B)(1)(c) of the Threatened Species Conservation Act 1995, and have regard to OEH's Requirements (Attachment 2); and a strategy to offset any residual impacts of the development in accordance with the NSW Biodiversity Offsets Policy for Major Projects.	Addressed within the BAR for the Project (This report).
While not exhaustive, Attachment 1 lists some of the environmental planning instruments, guidelines, policies and plans that may be relevant to the environmental assessment of this development. Attachment 1 – Biodiversity Framework for Biodiversity Assessment (OEH).	Minimum plot data requirement met in accordance with the FBA. Threatened flora survey undertaken in accordance with the FBA. Validation of vegetation at the ventilation shaft sites and Coastal Upland Swamps in accordance with the FBA. Threatened fauna survey was undertaken in accordance with the FBA. The assumption of presence for certain threatened species (Appendix 2) increases the rigour of the FBA implementation and addresses any limitations of the fauna survey.
NSW Biodiversity Offsets Policy for Major Projects (OEH).	Obtained plot data and survey data which can be used in BioBanking Credit Calculator (BBCC) to determine offset. Detailed throughout section 4 to section 6 of this report.
NSW Swamp Offsets Policy (OEH).	Collection of vegetation data sufficient to inform the determination of offsets required for the Project. See 7.4.3 for a discussion on this Addendum.
Threatened Species Assessment Guidelines (OEH).	Survey effort for threatened flora and vegetation plot collection completed in accordance with the Threatened Species Assessment Guidelines. Survey effort for threatened fauna has been completed in accordance with the Threatened Species Assessment Guidelines.
Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (Fisheries NSW).	Not applicable to this assessment.
NSW State Groundwater Dependent Ecosystem Policy.	LiDAR and aerial photography interpretation used to identify potential Groundwater Dependent Ecosystem sites. These were validated during the field survey.
Risk Assessment Guidelines for Groundwater Dependent Ecosystems.	Coastal Upland Swamps are regarded as Groundwater Dependent Ecosystems. Coastal Upland Swamps have been discussed in detail in Section 4.2.

Requirement	How addressed in the BAR
State Environmental Planning Policy No. 44 Koala Habitat Protections.	SEPP44 identification of potential Koala Habitat addressed in Koala Plan of Management
Water NSW (30 January 2017)	
The location and description of all water and biodiversity monitoring locations/points (including surface and ground waters).	Plot locations provided in this report may be used as monitoring locations.
2. The detailed assessment of the mining proposal on water resources associated with the subsidence should consider the design, construction, operational, decommissioning phases and cumulative impacts and include: Impacts on water quantity and quality of overlying and adjacent water resources including Avon and Cordeaux reservoirs and rivers and their tributaries, rockbars, water pools, waterfalls, cliffs, swamps, and groundwater systems using scientifically sound and rigorous numerical modelling and sufficient, appropriate and representative baseline data.	Impacts are detailed in specialist studies associated with the EIS. MSEC (2019) has been used throughout this assessment to determine the extent of potential subsidence impacts.
Details of proposed measures to be adopted to offset impacts and effectiveness of the measures including environmental performance measures.	Offsets for the Project are detailed in section 11.
Department of Primary Industries (25 January 2017)	
Description of aquatic and riparian environments in the vicinity of the development, particular extent and condition of riparian vegetation and instream aquatic vegetation, water depth and permanence of water flow and snags (large woody debris) within the footprint of the proposal area.	BioBanking plots undertaken in riparian areas which provide sufficient data to support the assessment of riparian vegetation for the Project.
Assessment of impacts on surface and ground water sources (both quality and quantity) related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, wetlands and ground water dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Impacts to watercourses in relation to biodiversity are discussed throughout section 7.6.
Office of Environment and Heritage (25 January 2017)	
The EIS should include an appropriate assessment of the potential impacts on biodiversity, including threatened species, populations, ecological community or their habitats likely to occur within or near the subject site. Please note that the NSW Biodiversity Offsets Policy for Major Projects is now being implemented.	Minimum plot data requirement met in the FBA. Threatened flora survey undertaken in accordance with the FBA. Validation of vegetation at the ventilation shaft sites and Coastal Upland Swamps in accordance with the FBA.
Impacts to biodiversity should be addressed in accordance with the Framework for Biodiversity Assessment (FBA) by a person accredited in accordance with s142B(1)c of the Threatened Species Conservation Act 1995. The offset strategy will be required to meet the minimum requirements outlined in the FBA. The transitional period for implementation of the Policy commence on 1 October 2014 and was recently extended to cover the intervening period leading up to commencement of the new Biodiversity Conservation Act, expected sometime in mid-2017. You should also discuss impacts upon Commonwealth listed entities with the Commonwealth Department of Environment to determine their approvals and offsetting requirements.	FBA used for this assessment and completed by Accredited Assessors as per section 1.5,
Please note that the Addendum to NSW Biodiversity Offsets Policy for Major Projects (Coastal Upland Swamps impacted by longwall mining subsidence) commenced in December 2016. The Project team's attention is drawn to this new Policy addendum, particular in relation to the Coastal Upland Swamp EEC. We also recommend that a full justification for impacts upon Coastal Upland Swamps and 3rd order or above streams, including reasons for the damage, alternatives considered, suggested remediation and offsets for any such damage, be presented. We also request that monitoring data collected during the EIS process should also be supplied to assist in our offices assessment.	Detailed Upland Swamp mapping and sufficient baseline floristic data was completed as part of this assessment. Justification on the impacts to Coastal Upland Swamps and the required offset is discussed and detailed in the BAR.
Attachment A: Biodiversity impacts related to the proposed development are to be assessed and documented in accordance with the FBA including the Addendum to NSW Biodiversity Offsets Policy for Major Projects (Coastal Upland Swamps impacted by longwall mining subsidence)(December 2016), unless otherwise agreed by OEH by a person accredited in accordance with s142B(1)c of the Threatened Species Conservation Act 1995.	Accredited Assessors have completed all calculations, have undertaken field survey and reporting (section 1.5)

Requirement	How addressed in the BAR
Attachment B: Impacts on the following species will require further consideration and provision of the information specific in s9.2 of the FBA: -Shale Sandstone Transition Forest in the Sydney Basin Bioregion Critically Endangered Ecological Community (CEEC) - River-flat Eucalypt Forest on Coastal Floodplain of the NSW North Coast, Sydney Basing and South East Corner Bioregions Endangered Ecological Community (EEC) - Swamp Oak Floodplain Forest on the NSW North Coast, Sydney Basin and South Easter Corner Bioregions EEC	Impacts under section 9.2 is provided in section 8.
NSW Roads and Maritime Services (8 February 2017)	
The Environmental Assessment needs to consider the environmental impact of any roadworks within the road reserve that are required to management the impacts of the development. These impacts include traffic and road safety impacts as well as other impacts such as noise, flora and fauna, heritage and impact to community.	Vehicle strike mitigation measures detailed in section 9.
NSW Department of Planning and Environment in relation to the EPBC Act (9 May 2017)	
8. The EIS must include an assessment of the relevant impacts[1] of the action on threatened species and communities, including: • a description and detailed assessment of the nature and extent of the likely direct, indirect and consequential impacts, including short term and long-term relevant impacts; • a statement whether any relevant impacts are likely to be known, unpredictable or irreversible, and analysis of the significance of the relevant impacts; • any technical data and other information used or needed to make a detailed assessment of the relevant impacts; and • a comparative description of the impacts of alternatives, if any, on the threatened species and communities. [1] Relevant impacts are those impacts likely to significantly impact any matter protected under the EPBC Act	Impacts detailed in section 7
9. For each of the relevant protected matters that are likely to be significantly impacted by the development, the EIS must provide information on proposed avoidance and mitigation measures to deal with the relevant impacts of the action, including: • a description and an assessment of the expected or predicted effectiveness of the mitigation measures; • any statutory policy basis for the mitigation measures; • the cost of the mitigation measures; • a description of the outcomes that the avoidance and mitigation measures will achieve; • an outline of an environmental management plan that sets out the framework for continuing management, mitigation and monitoring programs for the relevant impacts of the action; • the name of any agency responsible for endorsing or approving a mitigation measure or monitoring program; and • a description of the offsets proposed to address the residual adverse significant impacts and how these offsets will be established.	Mitigation measures detailed in section 9 Offsetting detailed in section 11.
10. Where a significant residual adverse impact to a threatened species or community is considered likely, the EIS must provide information on the proposed offset strategy, including discussion of the conservation benefit associated with the proposed offset strategy. Paragraphs 13 & 14 provide further requirements in relation to offsets.	Offset strategy detailed in section 11.
11. The EIS must address the following issues in relation to Biodiversity including separate: • identification of each EPBC Act listed threatened species and community likely to be impacted by the development. Provide evidence why other EPBC Act listed threatened species and communities likely to be located in the Project area or in the vicinity will not be impacted.	EPBC Act listed species and their potential to occur within the Study Area are provided in Appendix 2 and detailed throughout this Assessment.

Requirement	How addressed in the BAR
For each of the relevant EPBC Act listed threatened species and communities likely to be impacted by the development the EIS must provide a separate: • description of the habitat and habits (including identification and mapping of suitable breeding habitat, suitable foraging habitat, important populations and habitat critical for survival), with consideration of, and reference to, any relevant Commonwealth guidelines and policy statements including listing advice, conservation advice and recovery plans, threat abatement plans and wildlife conservation plans; and • details of the scope, timing and methodology for studies or surveys used and how they are consistent with (or justification for divergence from) published Australian Government guidelines and policy statements. • description of the impacts of the action having regard to the full national extent of the species or community's range.	EPBC Act listed species and their potential to occur within the Study Area are provided in Appendix 2. Timing of field surveys are provided in section 4 to section 6. Impacts detailed in section 7.
13. For each of the relevant EPBC Act listed threatened species and communities likely to be significantly impacted by the development the EIS must provide a separate: • identification of significant residual adverse impacts likely to occur after the proposed activities to avoid and mitigate all impacts are taken into account. • details of how the current published NSW Framework for Biodiversity Assessment (FBA) has been applied in accordance with the objects of the EPBC Act to offset significant residual adverse impacts; • details of the offset package to compensate for significant residual impacts including details of the credit profiles required to offset the development in accordance with the FBA and/or mapping and descriptions of the extent and condition of the relevant habitat and/or • threatened communities occurring on proposed offset sites.	Impacts to EPBC Act listed threatened species and communities detailed throughout this report. Details of the offsetting is provided in section 11
Note: For the purposes of approval under the EPBC Act, it is a requirement that offsets directly contribute to the ongoing viability of the specific protected matter impacted by a proposed action (i.e. 'like for like. In applying the FBA, residual impacts on EPBC Act listed threatened ecological communities must be offset with Plant Community Type(s) (PCT) that are ascribed to the specific EPBC listed ecological community. PCTs from a different vegetation class will not generally be acceptable as offsets for EPBC listed communities.	Vegetation communities and alignment to TECs listed under the EPBC Act and PCTs are provided in Section 4.3
14. Any significant residual impacts not addressed by the FBA may need to be addressed in accordance with the EPBC Act Environmental Offset Policy. http://www.environment.gov.au/epbc/publications/epbc-act-environmental-offsets-policy.	Offsetting detailed in section 11
15. For each threatened species and community likely to be significantly impacted by the development, the EIS must provide reference to, and consideration of, relevant approved conservation advice or recovery plan for the species or community.	EPBC Act Assessment Appendix 7

Requirement	How addressed in the BAR
The Department of the Environment's Environment Reporting Tool (ERT) identifies threatened species and communities that may occur within 5 km of the proposed action. Based on the information in the referral documentation, the location of the action, species records and likely habitat present in the area, there are likely to be significant impacts to: - Coastal Upland Swamps in the Sydney Basin Bioregion (Coastal Upland Swamps) In addition, there is some risk that there may be significant impacts on the following matters and levels of impact should be further investigated: - Shale Sandstone Transitional Forest in the Sydney Basin Bioregion - Small-flower Grevillea (*Grevillea parviflor*a subsp. *parviflora*) - Kangaloon Sun-Orchid (*Thelymitra kangaloonica*) - Giant Burrowing Frog (*Heleioporus australiacus*) - Green and Golden Bell Frog (*Litoria aurea*) - Littlejohn's Tree Frog (*Litoria littlejohni*) - Macquarie Perch (*Macquaria australasica*) - Broad-Headed Snake (*Hoplocephalus bungaroides*) - Regent Honeyeater (*Anthochaera Phrygia*) - Eastern Bristlebird (*Oasyornis brachypterus*) - Spot-tailed Quoll (*Dasyurus maculatus*) (SE mainland population) - Greater Glider (*Petauroides volan*s) An assessment in accordance with clauses 11-15 of these requirements for all of these matters above must be presented in the EIS.	An EPBC Act Policy search has been completed for the area with a radius of 10km. The likelihood of occurrence for all the threatened species have been addressed in Appendix 2. Impact assessments associated with the species provided in section 7.

Appendix 2. Threatened Species and Ecological Communities Likelihood of Occurrence

Table 42: Threatened flora and ecological communities likelihood of occurrence

Threatened Ecological Community	Description[5]	BC Act listing	EPBC Act listing	Likelihood of occurrence
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	It occurs primarily in the Castlereagh area in the north-west of the Cumberland Plain (also referred to as the Cumberland sub-region), with other known occurrences near Holsworthy (some patches at Holsworthy are just outside the Cumberland sub-region), Kemps Creek and Longneck Lagoon. The ecological community occurs primarily on Tertiary sands and gravels of the Hawkesbury-Nepean river system. The ecological community occurs primarily at low elevations up to 80 m above sea level, including old ridges, dunes and terraces. The canopy is composed of trees with a mature height of 10 m to around 20 m. The canopy contains, and is often dominated by, one or more of the following species: *Angophora bakeri* (narrow leaved apple), *Eucalyptus racemosa* (syn. *E. sclerophylla*) (scribbly gum, narrow-leaved scribbly gum) and *E. parramattensis subsp. parramattensis* (Parramatta red gum). *Melaleuca* species including *M. decora* (paperbark) may also be prominent in the canopy (and/or mid layer) of the ecological community.	Endangered	Endangered	None – Outside of the known distribution of the community. Not recorded during field survey. Not previously mapped within the Study Area.
Cooks River/ Castlereagh Ironbark Forest	Ranges from open forest to low woodland, with a canopy dominated by Broad-leaved Ironbark (*Eucalyptus fibrosa*) and Paperbark (*Melaleuca decora*). The canopy may also include other eucalypts such as Woolybutt (*E. longifolia*). The dense shrubby understorey consists of Prickly-leaved Paperbark (*Melaleuca nodosa*) and Peach Heath (*Lissanthe strigosa*), with a range of 'pea' flower shrubs, such as *Dillwynia tenuifolia*, Hairy Bush-pea (*Pultenaea villosa*) and Gorse Bitter Pea (*Daviesia ulicifolia*) (can be locally abundant). The sparse ground layer contains a range of grasses and herbs.	Endangered	Critically Endangered	None – Outside of the known distribution of the community. Not recorded during field survey. Not previously mapped within the Study Area.
Swamp Oak Floodplain Forest on the NSW North Coast, Sydney Basin and South East Corner bioregions	Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions is the name given to the ecological community associated with grey-black clay-loams and sandy loams, where the groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes associated with coastal floodplains. Swamp Oak Floodplain Forest generally occurs below 20 m (rarely above 10 m) elevation in the NSW North Coast, Sydney Basin and South East Corner bioregions. The structure of the community may vary from open forests to low woodlands, scrubs or reedlands with scattered trees. Typically these forests, woodlands, scrubs and reedlands form mosaics with other floodplain forest communities and treeless wetlands, and often they fringe treeless floodplain lagoons or wetlands with semi-permanent standing water. This community is found on the coastal floodplains of NSW. It has a dense to sparse tree layer in which *Casuarina glauca* (swamp oak) is the dominant species northwards from Bermagui. Other trees including *Acmena smithii* (lilly pilly), *Glochidion* spp. (cheese trees) and *Melaleuca* spp. (paperbarks) may be present as subordinate species, and are found most frequently in stands of the community northwards from Gosford. Tree diversity decreases with latitude, and Melaleuca ericifolia is the only abundant tree in this community south of Bermagui.	Endangered	Not listed	None – Not recorded during the field survey. No vegetation communities dominated by the characteristic species listed were recorded. Not previously mapped within the Study Area.

5 OEH (2016) Threatened Species Profiles for threatened species, endangered populations and endangered ecological communities listed under the NSW Threatened Species Conservation Act 1999. NSW of Environment and Heritage. Sydney, Australia.

Threatened Ecological Community	Description[5]	BC Act listing	EPBC Act listing	Likelihood of occurrence
River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions	The TEC is found on the river flats of the coastal floodplains. It has a tall open tree layer of eucalypts, which may exceed 40 m in height, but can be considerably shorter in regrowth stands or under conditions of lower site quality. While the composition of the tree stratum varies considerably, the most widespread and abundant dominant trees include *Eucalyptus tereticornis* (forest red gum), *E. amplifolia* (cabbage gum), *Angophora floribunda* (rough-barked apple) and *A. subvelutina* (broad-leaved apple). *Eucalyptus baueriana* (blue box), *E. botryoides* (bangalay) and *E. elata* (river peppermint) may be common south from Sydney, *E. ovat*a (swamp gum) occurs on the far south coast, *E. saligna* (Sydney blue gum) and *E. grandis* (flooded gum) may occur north of Sydney, while E. *benthamii* is restricted to the Hawkesbury floodplain. A layer of small trees may be present, including *Melaleuca decora, M. styphelioides* (prickly-leaved teatree), *Backhousia myrtifolia* (grey myrtle), *Melia azaderach* (white cedar), *Casuarina cunninghamiana* (river oak) and *C. glauca* (swamp oak). The groundcover is composed of abundant forbs, scramblers and grasses including *Microlaena stipoides, Dichondra repens, Glycine clandestina, Oplismenus aemulus, Desmodium gunnii, Pratia purpurascens, Entolasia marginata, Oxalis perennans* and *Veronica plebeia*.	Endangered	Not listed	None – Not recorded during the field survey. Not previously mapped within the Study Area.
Coastal Upland Swamps in the Sydney Basin Bioregion	Coastal Upland Swamp in the Sydney Basin Bioregion is the name given to the ecological community in the Sydney Basin bioregion associated with periodically waterlogged soils on Hawkesbury sandstone plateaus, generally where mean annual rainfall exceeds 950 mm. Coastal Upland Swamp is generally associated with soils that are acidic and vary from yellow or grey mineral sandy loams with a shallow organic horizon to highly organic spongy black peats with pallid subsoils. They vary in depth from a few centimetres (cm) to at least 4 m. The vegetation is dominated by sclerophyll shrubs and/or sedges, with dynamic mosaics of structural forms that may include tall scrub, open heath and/or sedgeland. Although typically treeless, Coastal Upland Swamp may include scattered trees. In NSW all sites are within the Sydney Basin Bioregion.	Endangered	Endangered	Known to occur within the Study Area. Vegetation units recorded during the field survey that align to the TEC include: Coastal Upland Swamps: Banksia Thicket, Coastal Upland Swamps: Tea-Tree Thicket, and Coastal Upland Swamps: Sedgeland-Heath Complex. Note: Upland Swamp Fringing Eucalypt Woodland is not considered to form part of this EEC.
Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion	The Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion is typically tall open eucalypt forests found on basalt and basalt-like substrates in, or adjacent to, the Sydney Basin Bioregion. The Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion is generally confined to the Sydney Basin bioregion in NSW. However, parts of its southern extent at Sassafras, east of Nerriga, NSW may occur just outside the Sydney Basin bioregion boundary. Similarly, patches of the ecological community in the vicinity of Mt Werong, Boyd Plateau and Jenolan Caves occur immediately west of the Sydney Basin bioregion boundary. The ecological community predominantly occupies the Moss Vale, Ettrema, Burragorang, Sydney Cataract, and Wollemi IBRA sub-regions, and may also be present in the Kanangra and Oberon IBRA sub-regions (South Eastern Highlands bioregion) to the west of the Sydney Basin. The ecological community usually occurs at elevations between 650 m and 1050 m above sea level (a.s.l.), although outliers may occur at elevations as low as 350 m (e.g. closer to the coast) or as high as 1200 m a.s.l. (e.g. on higher plateau areas). The structure of the ecological community varies from tall open forest to woodland depending on aspect, slope, soil conditions, soil depth, and previous disturbance. Typically, the ecological community has a sparse to dense layer of shrubs and vines, and a diverse understorey of native grasses, forbs, twiners and ferns.	Endangered	Endangered	None – Outside of the known distribution of the community. Not recorded during field survey. Not previously mapped within the Study Area.

Threatened Ecological Community	Description[5]	BC Act listing	EPBC Act listing	Likelihood of occurrence
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	Occurs at the edges of the Cumberland Plain, where clay soils from the shale rock intergrade with earthy and sandy soils from sandstone, or where shale caps overlay sandstone. The boundaries are indistinct, and the species composition varies depending on the soil influences. The main tree species include Forest Red Gum (*Eucalyptus tereticornis*), Grey Gum (*E. punctata*), stringybarks (*E. globoidea, E. eugenioides*) and ironbarks (*E. fibrosa* and *E. crebra*). Areas of low sandstone influence (more clay-loam soil texture) have an understorey that is closer to Cumberland Plain Woodland. Shale Sandstone Transition Forest in the Sydney Basin Bioregion contains many more species than described for the canopy (above) and other references should be consulted to identify these.	Critically Endangered	Critically Endangered	Known. Recorded within the Study Area. Vegetation mapping units Transitional Shale Dry Ironbark Forest and Transitional Shale Stringybark Forest align to the TEC.
Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion	Southern Highlands Shale Woodland is confined to a small area in the Southern Highlands. It occurs roughly within an area bounded by the Illawarra Escarpment in the east, Burrawang and Bundanoon in the south, Canyonleigh in the west and Berrima and Colo Vale in the north. Occurs in the Wingecarribee local government area, but may occur elsewhere in the Sydney Basin Bioregion. Southern Highlands Shale Woodland is a variable community in terms of both structure and composition. The community may exist as tall open forest, grassy woodland or scrub; though it originally existed as woodland. The dominant canopy species vary across the distribution of the community. Common species throughout much of the community's range are Mountain Grey Gum *Eucalyptus cypellocarpa,* Sydney Peppermint *E. piperita,* Swamp Gum *E. ovata*, Narrow-leafed Peppermint *E. radiata* and White Stringybark *E. globoidea*. Brittle Gum *E. mannifera*, Snow Gum *E. pauciflora*, Cabbage Gum *E. amplifolia* and Rough-barked Apple *Angophora floribunda* are less common. Camden Woollybutt *E. macarthurii* occurs throughout, but appears to be most common in the south-west of the distribution of the community, around Bundanoon. The shrub layer is usually open, though there may be denser patches of shrubs in some areas. As with the canopy layer, the shrub layer of this community varies (e.g. typical species in the north-eastern parts of the distribution of the community include *Oxylobium ilicifolium, Melalueca thymifolia* and *Olearia microphylla*, while in south-western areas these species are rare or absent and *Daviesia ulicifolia* may be locally common). The groundlayer is usually diverse and dominated by native grasses such as *Themeda australis, Austrostipa rudis, Microlaena stipoides* and *Austrodanthonia species.* Common herb species include G*onocarpus tetragynus, Veronica plebeia, Hypericum gramineum, Poranthera microphylla* and *Viola hederacea*.	Critically Endangered	Critically Endangered	None – Outside the known occurrence. Not recorded during field survey. Not previously mapped within the Study Area.
Western Sydney Dry Rainforest and Moist Woodland on Shale	Very restricted and occurs most commonly in the far southern Section of the Cumberland Plain, in the Razorback Range near Picton. Outlying occurrences have been recorded at Grose Vale and Cattai. There are 338 ha remaining intact, the majority of these occurring in the Wollondilly local government area, but occurring to a lesser extent in the Baulkham Hills, Camden, Hawkesbury, Parramatta and Ryde local government areas. A small remnant can be seen in Fairfield City Farm. A dry vine scrub community of the Cumberland Plain, western Sydney. Canopy trees include Prickly Paperbark *(Melaleuca styphelioides*), Hickory Wattle (*Acacia implexa*) and Native Quince (*Alectryon subcinereus*). There are many rainforest species in the shrub layer, such as Mock Olive (*Notolaea longifolia*), Hairy Clerodendrum (*Clerodendrum tomentosum*) and Yellow Pittosporum (*Pittosporum revolutum*). The shrub layer combines with vines, such as Gum Vine (*Aphanopetalum resinosum*), Wonga Vine (*Pandorea pandorana*) and Slender Grape (C*ayratia clematidea*) to form dense thickets in sheltered locations. Contains many more species and other references should be consulted to identify these.	Critically Endangered	Critically Endangered	None – Not recorded during the field survey. Not previously mapped within the Study Area.

Threatened Ecological Community	Description[5]	BC Act listing	EPBC Act listing	Likelihood of occurrence
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Box-Gum Woodland is found from the Queensland border in the north, to the Victorian border in the south. It occurs in the tablelands and western slopes of NSW. White Box Yellow Box Blakely's Red Gum Woodland (commonly referred to as Box-Gum Woodland) is an open woodland community (sometimes occurring as a forest formation), in which the most obvious species are one or more of the following: White Box *Eucalyptus albens*, Yellow Box *E. melliodora* and Blakely's Red Gum *E. blakelyi.* Intact sites contain a high diversity of plant species, including the main tree species, additional tree species, some shrub species, several climbing plant species, many grasses and a very high diversity of herbs. The community also includes a range of mammal, bird, reptile, frog and invertebrate fauna species. Intact stands that contain diverse upper and midstoreys and groundlayers are rare.	Critically Endangered	Critically Endangered	None – Outside of the known extent of the community. Not recorded during field survey. Not previously mapped within the Study Area.
Turpentine-Ironbark Forest in the Sydney Basin Bioregion	Occurs in Sydney and is heavily fragmented, with only 0.5% its original extent remaining intact. Remnants mostly occur in the Baulkham Hills, Hornsby, Ku-ring-gai, Parramatta, Ryde, Sutherland and Hurstville local government areas. Good examples can be seen in small reserves such as Wallumatta Nature Reserve and Newington Nature Reserve. A similar form of the community occurs more widely (particularly in the Wollondilly and Hawkesbury areas) but this is outside the nominated councils that are included in the determination (Ashfield, Auburn, Canterbury, Concord, Drummoyne, Leichhardt, Marrickville, Bankstown, Ryde, Hunters Hill, Baulkham Hills, Ku-ring-gai, Hornsby, Parramatta, Bankstown, Rockdale, Kogarah, Hurstville and Sutherland). This form could be equated to Blue Mountains Shale Cap Forest, although the correlation is less strong for Wollondilly (which is not mentioned in that determination). Open forest, with dominant canopy trees including Turpentine S*yncarpia glomulifera*, Grey Gum *Eucalyptus punctata,* Grey Ironbark *E. paniculata* and Thin-leaved Stringybark *E. eugenoides.* In areas of high rainfall (over 1050 mm per annum) Sydney Blue Gum *E. saligna* is more dominant. The shrub stratum is usually sparse and may contain mesic species such as Sweet Pittosporum *Pittosporum undulatum* and Elderberry Panax P*olyscias sambucifolia*. Contains many more species and other references should be consulted to identify these.	Endangered	Critically Endangered	None – Not recorded during the field survey. Not previously mapped within the Study Area.

Common Name	Scientific Name	EPBC Act	BC Act	Habitat	Likelihood of occurrence within Study Area	Likelihood of occurrence within ventilation shaft sites
Threatened flora						
	Acacia baueri ssp. 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 – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
Bynoe's Wattle	*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 – not detected during field survey but suitable habitat present along fire roads, transmission line, and within Exposed Sandstone Scribbly Gum Woodland.	None – not detected during field survey. Not detected in suitable habitat present along fire roads, existing access tracks and within Exposed Sandstone Scribbly Gum Woodland.
	Allocasuarina glareicola	E	E	Primarily restricted to the Richmond (NW Cumberland Plain) district, but with an outlier population found at Voyager Point, Liverpool.	Low –not detected during field survey. No previous records within Study Area.	None –not detected during field survey. No previous records within Study Area.
Lesser Creeping Fern	*Arthropteris palisotii*	-	E	May be extinct in NSW. Found in rainforest where it usually grows on tree trunks.	Low –not detected during field survey. No previous records within Study Area.	None –not detected during field survey. No previous records within Study Area.
Tessellated Spider Orchid	*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 - This species usually occurs on or near the coast and is generally found in grassy dry sclerophyll woodland on clay loam or sandy soils, less commonly in heathland on sandy loam soils which occurs predominantly within the Study Area. It is only known from six populations in NSW. The nearest population is in Morton National Park (Citation: Duncan, M. 2010. National Recovery Plan for the Thick-lip Spider-orchid Caladenia tessellata. Department of Sustainability and Environment, Melbourne). Whilst unlikely to occur, the survey coincided with the species flowering time and the species was not recorded.	None –not detected during field survey. No previous records within Study Area.
Leafless Tongue Orchid	*Cryptostylis hunteriana*	V	V	Grows in swamp-heath on sandy soils, chiefly in coastal districts, south from the Gibraltar Range.	Low – whilst known from a variety of habitats, this species has not been previously recorded during any previous surveys within the Dendrobium Mine area or surrounds. The nearest population of this species is within the Shoalhaven region. Species was not recorded during the current surveys and previous surveys undertaken by Niche, and it is not considered likely to occur within the Study Area given no records within range of Study Area.	None –not detected during field survey. No previous records within Study Area. Outside of known range.

Common Name	Scientific Name	EPBC Act	BC Act	Habitat	Likelihood of occurrence within Study Area	Likelihood of occurrence within ventilation shaft sites
White-flowered Wax Plant	*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/Moderate –not detected during field survey. No previous records within Study Area.	None –not detected during field survey. No previous records within Study Area.
Illawarra Socketwood	*Daphnandra sp. C 'Illawarra' (Daphnandra johnsonii)*	E	E	Restricted to rainforest and moist eucalypt forest along rocky hillsides and gullies of the Illawarra lowlands, occasionally extending onto the upper escarpment slopes on the Illawarra lowlands where it has been recorded from the local government areas of Shoalhaven, Kiama, Shellharbour and Wollongong.	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
	Epacris purpurascens var. purpurascens	-	V	Grows in sclerophyll forest, scrubs and swamps on sandstone from Gosford and Sydney districts.	High – A record for this species occurs in Area 6 which was obtained from Bionet (2016). The species was not detected during field survey but suitable habitat present along fire roads, transmission line, and within Coastal Upland Swamps, riparian areas, and transition forest vegetation types	None – not detected during field survey but suitable habitat present along fire roads, existing access tracks.
	Eucalyptus macarthurii	V	E	A moderately restricted distribution, recorded from the Moss Vale District to Kanangra Boyd National Park. In the Southern Highlands it occurs mainly on private land, often as isolated individuals in, or on the edges, of paddocks. Isolated stands occur in the north west part of the range on the Boyd Plateau. The only known record in the conservation estate is within Kanangra Boyd National Park. Occurs on grassy woodland on relatively fertile soils on broad cold flats.	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
	Genoplesium baueri	E	E	Grows in dry sclerophyll forest and moss gardens over sandstone. Flowers February to March. Has been recorded between Ulladulla and Port Stephens. Currently the species is known from just over 200 plants across 13 sites. The species has been recorded in Berowra Valley Regional Park, Royal National Park and Lane Cove National Park and may also occur in the Woronora, O'Hares, Metropolitan and Warragamba Catchments.	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area. Outside of recommended flowering time however unlikely to be present as the species has only been recorded from locations between Nowra and Pittwater with half the records made before 1960.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area. Outside of recommended flowering time however unlikely to be present given lack of records and not within previously recorded distribution
Small-flower Grevillea	*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.	High – not detected during field survey but suitable habitat present along fire roads, transmission line, and within Shale Sandstone Transition Forest within the Study Area.	None – not detected during field survey.
	Haloragis exalata subsp. exalata	V	V	Occurs in 4 widely scattered localities in eastern NSW. It is disjunct distributed in the central coast, south coast and north-western slopes botanical subdivisions of NSW. The species appears to require protected and shaded damp situations in riparian habitats.	Low –not detected during field survey. No previous records within Study Area. Outside of known range.	None –not detected during field survey. No previous records within Study Area. Outside of known range.
Woronora Beard-heath	*Leucopogon exolasius*	V	V	Grows in woodland on sandstone. Restricted to the Woronora and Grose Rivers and Stokes Creek, Royal National Park.	Known – not detected during field survey but previously recorded by Biosis Research (2016) within MU26, Sandstone Gully Peppermint Forest adjacent to Donalds Castle Creek. Recorded by Niche (2019)	None – not detected during field survey.

Common Name	Scientific Name	EPBC Act	BC Act	Habitat	Likelihood of occurrence within Study Area	Likelihood of occurrence within ventilation shaft sites
					within Area 5. The species may occur on sandstone vegetation and along creek banks within the Study Area.	
Biconvex Paperbark	*Melaleuca biconvexa*	V	V	Biconvex Paperbark generally grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects. Scattered and dispersed populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north.	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
Dean's Melaleuca	*Melaleuca deanei*	V	V	Grows in wet heath on sandstone in coastal districts from Berowra to Nowra.	Low/Moderate – relatively conspicuous as it is a shrub growth form which is distinctive when not flowering. It was not detected during field survey. Given its conspicuous it can be detected at all times of the year. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
	Pelargonium sp. Striatellum	E	-	Flowering occurs from October to March. Occurs 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. The species is known to form clonal colonies by rhizomatous propagation.	Low – not detected during field survey. No previous records within Study Area.	None –not detected during field survey. No previous records within Study Area.
	Persoonia acerosa	V	V	Occurs in heath or dry sclerophyll forest on sandstone, from central Blue Mountains south to Hill Top.	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
Bargo Geebung	*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.	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
	Persoonia glaucescens	V	E	The Mittagong Geebung's historical distribution places the northern and eastern limit at Couridjah (Thirlmere Lakes), the southern limit at Fitzroy Falls and the western limit at High Range. However, recent surveys have indicated that the species no longer extends to Fitzroy Falls or Kangaloon and that the present southern limit is near Berrima. The northern limit appears to have contracted a few km south to Buxton.	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
	Persoonia hirsuta	E	E	The Hairy Geebung is found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone.	Moderate – relatively conspicuous and not detected during field survey. No previous records within Study Area. Likely to be in transition forest habitat.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
Spiked Rice-flower	*Pimelea spicata*	E	E	Grows on the coast from Lansdowne to Shellharbour and inland to Penrith. In western Sydney, restricted to Cumberland Plain, including disturbed areas that do not support native vegetation. In the coastal Illawarra it occurs commonly in Coast Banksia Open Woodland.	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
Rufous Pomaderris	*Pomaderris brunnea*	V	E	Rufous 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 – Previous record within Study Area, however record is dated (1950s).	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.

Common Name	Scientific Name	EPBC Act	BC Act	Habitat	Likelihood of occurrence within Study Area	Likelihood of occurrence within ventilation shaft sites
	Prasophyllum fuscum	V	CE	The type specimen is from "moist meadows towards the Georges River" in the Sydney area. The species is likely to be extinct from this area. Harden (1993) states that it is confined to the Blue Mountains area. However, some authorities believe Prasophyllum species from this area are not P. fuscum, but an undescribed species. In addition, some authorities believe it is identical to P. uroglossum which occurs in the Wingecarribee area.	Low –not detected during field survey. No previous records within Study Area. Outside of known range.	None –not detected during field survey. No previous records within Study Area. Outside of known range.
Illawarra Greenhood	*Pterostylis gibbosa*	E	E	Grows in open forest or woodland, on flat or gently sloping land with poor drainage. Known from a small number of populations in the Hunter region (Milbrodale), the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near Nowra).	Low – The closest known populations of this species are known from the Yallah-Albion Park and Nowra area. The species has not been previously recorded during any previous surveys within the Dendrobium domain or surrounds. In the Illawarra region, the species grows in woodland dominated by Forest Red Gum Eucalyptus tereticornis, Woollybutt E. longifolia and White Feather Honey-myrtle Melaleuca decora. Near Nowra, the species grows in an open forest of Spotted Gum Corymbia maculata, Forest Red Gum and Grey Ironbark E. paniculata. It is highly unlikely that the species would occur within the Study Area given no previous records, habitat types present not similar to populations known on the south coast, and it was not recorded during the current surveys.	None –not detected during field survey. No previous records within Study Area. Outside of known range.
Sydney Plains Greenhood	*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 – Sydney Plains Greenhood is known currently from only five locations in western Sydney: Georges River National Park, near Yeramba Lagoon; Ingleburn; Holsworthy; Peter Meadows Creek; and St Marys Towers, near Douglas Park. The vegetation communities above the rock shelves where Pterostylis saxicola occurs are either shale/sandstone transitions or shale communities The species has not been previously recorded during any previous surveys within the Dendrobium domain or surrounds. The positioning of Shale Sandstone Transition Forest in the Study Area is located away from rock shelves. It is therefore unlikely the species would be present, however the surveys for the project coincided with the species flowering time and it was not recorded.	None –not detected during field survey. No previous records within Study Area. Outside of known range.

Common Name	Scientific Name	EPBC Act	BC Act	Habitat	Likelihood of occurrence within Study Area	Likelihood of occurrence within ventilation shaft sites
Prickly Bush-pea	*Pultenaea aristata*	V	V	Grows in moist, dry sclerophyll woodland to heath on sandstone, specifically the drier areas of Coastal Upland Swamps. Restricted to the Woronora Plateau, a small area between Helensburgh, south of Sydney, and Mt Keira above Wollongong.	High – relatively conspicuous and not detected during field survey. However is known to occur within Coastal Upland Swamps within the Woronora Plateau.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
	Pultenaea glabra	V	V	Restricted to the higher Blue Mountains and has been recorded from the Katoomba-Hazelbrook and Mount Victoria areas, with unconfirmed sightings in the Mount Wilson and Mount Irvine areas. All known populations occur within the Blue Mountains Local Government Area	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
Rainforest Cassia	*Senna acclinis*	-	E	Coastal districts and adjacent tablelands of NSW from the Illawarra in NSW to Queensland. Grows in or on the edges of subtropical and dry rainforest.	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
	Solanum celatum	-	E	Grows on hills and slopes in eucalypt woodland; commonly found after fire or disturbance. Restricted to an area from Wollongong to a little south of Nowra and west to Bungonia Nature Reserve.	Low – relatively conspicuous and not detected during field survey. No previous records within Study Area.	None – relatively conspicuous and not detected during field survey. No previous records within Study Area.
Kangaloon Sun-orchid	*Thelymitra sp. Kangaloon*	Z	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.	None – Thelymitra sp. Kangaloon is only known to occur on the southern tablelands of NSW in the Moss Vale / Kangaloon / Fitzroy Falls area. The closest population occurs in Budderoo National Park. It is found in swamps in sedgelands over grey silty grey loam soils and is thought to be a short-lived perennial, flowering in late October and early November. The species has not been previously recorded during any previous surveys within the Dendrobium domain or surrounds. It is unlikely the species occurs within the Study Area. It was not recorded during the field survey despite being undertaken during the flowering time for the species.	None –not detected during field survey. No previous records within Study Area. Outside of known range.
	Thesium australe	V	V	Grows in very small populations scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia. Occurs in grassland or grassy woodland. Grows on kangaroo grass tussocks but has also been recorded within the exotic Coolatai grass.	Low – not detected during field survey. No previous records within Study Area. Outside of known range.	None –not detected during field survey. No previous records within Study Area. Outside of known range.

Table 43: Threatened fauna likelihood of occurrence

Common Name	Scientific Name	EPBC Act	BC Act	Credit status if generated within BBCC	Habitat	Likelihood of occurrence	Impact and Assessment
Australasian Bittern	*Botaurus poiciloptilus*	E	E	Not generated by BBCC.	The Australasian Bittern 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 and spikerushes.	Low. Not recorded preferred habitat absent.	No further assessment required.
Australian Painted Snipe	*Rostratula australis*	E	E	Not generated by BBCC.	In NSW, this species has been recorded at the Paroo wetlands, Lake Cowell, Macquarie Marshes and Hexham Swamp. Most common in the Murray-Darling Basin. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.	None. Not recorded preferred habitat absent.	No further assessment required.
Barking Owl	*Ninox connivens*	-	V	Not generated by BBCC.	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.	Low (foraging habitat only). Possible habitat in woodland vegetation types. Not recorded during present study. One record from within 5 km (2007). One record from within 5 km (2007).	No further assessment required.
Broad-headed Snake	*Hoplocephalus bungaroides*	V	E	Species Credit - land within 500 m of sandstone escarpments with hollow-bearing trees, rock crevices or flat sandstone rocks on exposed cliff edges and sandstone outcropping.	Occurs almost exclusively 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 spend most of the year sheltering in and under rock crevices and exfoliating rock. However, some individuals will migrate to tree hollows to find shelter during hotter parts of summer.	Known. Previously recorded from Area 5 with other records nearby (14 within 5 km). Not recorded during present 2016/17 fauna baseline study. Limited prey items observed during present study.	Limited impacts likely for this species confined to subsidence impacts consisting any cracking of potential sheltering habitat. Preferred sheltering habitat does not occur within vent shaft sites.
Brush-tailed Rock-wallaby	*Petrogale penicillata*	V	E	Not generated by BBCC.	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. Not known from area.	No further assessment required.
Diamond Firetail	*Stagonopleura guttata*	-	V	Not generated by BBCC.	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 woodlands. Also occurs in open forest, mallee, natural temperate grassland, and in secondary grassland derived from other communities.	Low. Not recorded during present 2016/17 fauna baseline study.	No further assessment required.

Common Name	Scientific Name	EPBC Act	BC Act	Credit status if generated within BBCC	Habitat	Likelihood of occurrence	Impact and Assessment
Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis*	-	V	Species/Ecosystem. Not generated by BBCC.	Eastern Bentwing-bats occur along the east and north-west coasts of Australia. Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. Form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young.	Known. Single record from both Area 5 and Vent Shaft 3 during present 2016/17 fauna baseline study. Previously recorded nearby in Area 3B and DA5. Twenty three records within 5km. Possible to occur in crevassed/cave rocky outcrops. Not likely to contain maternity roosting habitat.	Maternity caves would not occur within the Study Area. If roosting occurs within the Study Area it is unlikely to be widespread or significant and minimal impacts from subsidence of features such as cliffs are expected to occur. No further assessment of offsetting is considered required.
Eastern Bristlebird	*Dasyornis brachypterus*	E	E	Not generated by BBCC.	Found in coastal woodlands, dense scrub and heathlands, particularly where it borders taller woodlands.	Low. Not recorded during present 2016/17 fauna baseline study despite targeted survey. Closest record 25 km south.	No further assessment required.
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	-	V	Ecosystem	Inhabit sclerophyll forests, preferring wet habitats where trees are more than 20 m high. Two observations have been made of roosts in stem holes of living eucalypts. There is debate about whether or not this species moves to lower altitudes during winter, or whether they remain sedentary but enter torpor. This species also appears to be highly mobile and records showing movements of up to 12 km between roosting and foraging sites.	Known – recorded at single site within Vent Shaft 3 during present 2016/17 fauna baseline study. Potential in variety of woodland. 10 records within 5km.	Roots in hollow trees. Impacts to foraging habitat and possible roosting habitat from clearing for surface infrastructure. No special significance of areas to be cleared in comparison to other extensive areas of habitat within the Study Area and surrounds. Offsets required via ecosystem credits.
Eastern Freetail-bat	*Mormopterus norfolkensis*	-	V	Ecosystem	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.	Known. Recorded at Vent shaft site 3. Potential in all woodland types.	Roots in hollow trees. Impacts to foraging habitat and possible roosting habitat from clearing for surface infrastructure. No special significance of areas to be cleared in comparison to other extensive areas of habitat within the Study Area and surrounds. Offsets required via ecosystem credits.

Common Name	Scientific Name	EPBC Act	BC Act	Credit status if generated within BBCC	Habitat	Likelihood of occurrence	Impact and Assessment
Eastern Pygmy-possum	*Cercartetus nanus*	-	V	Species	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. 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.	Known from Area 5 – Atlas Record. Could occur in parts of the Study Area. Not recorded during present 2016/17 fauna baseline study.	Not recorded. Occurs in parts of the Study Area, however was not detected in vent shaft sites where clearing impacts would occur. No further assessment required. See section 6.4
Flame Robin	*Petroica phoenicea*	-	V	Ecosystem	Breeds in upland tall moist eucalypt forests and woodlands, often on ridges and slopes.Prefers clearings or areas with open understoreys The groundlayer of the breeding habitat is dominated by native grasses.	Low – may occur sporadically. Less likely to occur in proposed cleared areas. Single record within 5km. Not recorded during present 2016/17 fauna baseline study.	Unlikely to be impacted but offset via ecosystem credits.
Gang-gang Cockatoo	*Callocephalon fimbriatum*	-	V	Species/Ecosystem.	In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. Also occur in subalpine snow gum woodland and occasionally in temperate or regenerating forest. 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.	Known. Previously recorded in both Area 5 and Area 6. Recorded near Area 6 during present 2016/17 fauna baseline study but not from Study Area.	Impacts from clearing. No special significance of habitat to be cleared and species was not encountered using these habitats. Offsets required via ecosystem credits.
Giant Burrowing Frog	*Heleioporus australiacus*	V	V	Species	The Giant Burrowing Frog has been recorded breeding in a range of water bodies associated with sandy environments of the coast and adjacent ranges from the Sydney Basin to south of eastern Victoria. It breeds in hanging swamps, perennial non-flooding creeks and occasionally permanent pools, but permanent water must be present to allow its large tadpoles time to reach metamorphosis.	Known record from Area 5 (NSW Wildlife Atlas). Likely in creeks and swamps with potential breeding pools. No additional records from present 2016/17 fauna baseline study although assumed present as difficult to detect and access restricted in ideal survey conditions.	Impacts associated primarily with subsidence. Species considered further.
Giant Dragonfly	*Petalura gigantea*	-	E	Species	Live in permanent swamps and bogs with some free water and open vegetation.	See Aquatic Ecology Assessment for survey details. Recorded from recent survey within the Study Area (Cardno 2019).	Impacts associated primarily with subsidence. Species considered further.

Common Name	Scientific Name	EPBC Act	BC Act	Credit status if generated within BBCC	Habitat	Likelihood of occurrence	Impact and Assessment
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	-	V	Species/Ecosystem.	Inhabits forest with low nutrients, characteristically with key Allocasuarina spp. 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. Endangered population in the Riverina.	High. Previously recorded nearby in Area 3B. Not recorded during present 2016/17 fauna baseline study.	Impacts from clearing. No special significance of habitat to be cleared and species was not encountered using these habitats. Offsets required via ecosystem credits.
Greater Broad-nosed Bat	*Scoteanax rueppellii*	-	V	Ecosystem	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. 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.	Known. Recorded three times within Area 5 and Vent Shaft 3 during present 2016/17 fauna baseline study.	Roots in hollow trees. Impacts to foraging habitat and possible roosting habitat from clearing for surface infrastructure. No special significance of areas to be cleared in comparison to other extensive areas of habitat within the Study Area and surrounds. Offsets required via ecosystem credits.
Greater Glider	*Petauroides volans*	V	-	N/A	The greater glider is an arboreal nocturnal marsupial, largely restricted to eucalypt forests and woodlands. It is primarily folivorous, with a diet mostly comprising eucalypt leaves, and occasionally flowers (Kehl & Borsboom 1984; Kavanagh & Lambert 1990; van der Ree et al., 2004). It is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows (Andrews et al., 1994; Smith et al., 1994, 1995; Kavanagh 2000; Eyre 2004; van der Ree et al., 2004; Vanderduys et al., 2012). The distribution may be patchy even in suitable habitat (Kavanagh 2000). The greater glider favours forests with a diversity of eucalypt species, due to seasonal variation in its preferred tree species (Kavanagh 1984). Note all references above cited in: http://www.environment.gov.au/biodiversity/threatened/species/pubs/254-conservation-advice-20160525.pdf	Recorded within small patch of Sandstone Transition Forest, likely concentrated within this area and additional pockets of taller moist vegetation communities. No previous records from area.	Species considered further in Appendix 7.
Green and Golden Bell Frog	*Litoria aurea*	V	E	Species	Inhabits a very wide range of water bodies including marshes, dams and streams, particularly those containing emergent vegetation such as bullrushes or spikerushes. It also inhabits numerous types of man-made water bodies including quarries and sand extraction sites. Optimum habitat includes water-bodies that are un-shaded, free of predatory fish such as Plague Minnow, have a grassy area nearby and diurnal sheltering sites available.	Low. Preferred habitat not present. No records within 5 km. Not recorded in present survey.	No further assessment required.
Grey-headed Flying-fox	*Pteropus poliocephalus*	V	V	Species/Ecosystem. Not generated by BBCC.	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.	High. Likely to fly over the Study Area from time to time and forage in response to flowering/fruiting pulses – no roost sites are known from the area.	Common and widespread species throughout the region. Impacts from clearing but confined to marginal foraging habitat which is widespread throughout the Study Area and surrounds and has low

Common Name	Scientific Name	EPBC Act	BC Act	Credit status if generated within BBCC	Habitat	Likelihood of occurrence	Impact and Assessment
							productivity. Offsets required via ecosystem credits.
Ground Parrot	*Pezoporus wallicus wallicus*	V	-	Species	The Ground Parrot occurs in high rainfall coastal and near coastal low heathlands and sedgelands, generally below 1 m in height and very dense (up to 90% projected foliage cover).	Low – not observed in current study despite targeted survey. Nearest record 15 km away.	No further assessment required.
Koala	*Phascolarctos cinereus*	V	V	Species	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. Recorded during present 2016/17 fauna baseline study within Area 5 and Area 6. See Koala habitat mapping.	Clearing impacts only. Vegetation within vent shafts does not offer preferred feed trees/habitat, however a Koala was heard around vent shaft site 4 and the species is known to move throughout the Study Area. One hectare of clearing of preferred habitat would likely be impacted by the proposal.
Large-eared Pied Bat	*Chalinolobus dwyeri*	V	V	Species	Located in a variety of drier habitats, including the dry sclerophyll forests and woodlands to the east and west of the Great Dividing Range. Can also be found on the edges of rainforests and in wet sclerophyll forests. This species roosts in caves and mines in groups of between 3 and 37 individuals.	Low. Not recorded during present 2016/17 fauna baseline study. Limited cave habitat. Two records within 5km.	No further assessment required.
Little Bentwing-bat	*Miniopterus australis*	-	V	Species/Ecosystem. Not generated by BBCC.	Coastal north-eastern NSW and eastern Queensland. Little Bentwing-bat is an insectivorous bat that roost in caves, in old mines, in tunnels, under bridges, or in similar structures. They breed in large aggregations in a small number of known caves and may travel 100s km from feeding home ranges to breeding sites. Little Bentwing-bat has a preference for moist eucalypt forest, rainforest or dense coastal banksia scrub where it forages below the canopy for insects.	Known. Single record from Ventilation Shaft 3 during present 2016/17 fauna baseline study. Possible to occur in crevassed/cave rocky outcrops. Not likely to contain maternity roosting habitat. One other record within 5km.	Maternity caves would not occur within the Study Area. If roosting occurs within the Study Area it is unlikely to be widespread or significant and minimal impacts from subsidence of features such as cliffs are expected to occur. No further assessment of offsetting is considered required.
Little Eagle	*Hieraaetus morphnoides*	-	V	Ecosystem	Occupies open eucalypt forest, woodland or open woodland. Sheoak or Acacia woodlands and riparian woodlands of interior NSW are also used.;1|Nests in tall living trees within a remnant patch, where pairs build a large stick nest in winter	Low. Not recorded during present 2016/17 fauna baseline study.	Potential impacts from clearing. Offsets via ecosystem credits.
Little Lorikeet	*Glossopsitta pusilla*	-	V	Ecosystem	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.	Low. Not recorded during present 2016/17 fauna baseline study.	Offsets via ecosystem credits.

Common Name	Scientific Name	EPBC Act	BC Act	Credit status if generated within BBCC	Habitat	Likelihood of occurrence	Impact and Assessment
Littlejohn's Tree Frog	*Litoria littlejohni*	V	V	Species	Occurs in wet and dry sclerophyll forests and heathland associated with sandstone outcrops between 280 and 1000 m AHD? on the eastern slopes of the Great Dividing Range from the Central Coast down into Victoria. Individuals have been collected from a wide range of water bodies that includes semi-permanent dams, permanent ponds, temporary pools and permanent streams, with calling occurring from fringing vegetation or on the banks. Individuals have been observed sheltering under rocks on high exposed ridges during summer and within deep leaf litter adjacent to the breeding site. Calling occurs in all months of the year, often in association with heavy rains. The tadpoles are distinctive, being large and very dark in colouration.	Known. Creeks and swamps with potential breeding pools. Found via tadpole surveys during the present 2016/17 fauna baseline study at three locations within Area 5 and three locations within Area 6.	Impacts associated primarily with subsidence. Species considered further.
Long-nosed Potoroo	*Potorous tridactylus tridactylus*	V	V	N/A	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. Not recorded during present 2016/17 fauna baseline study. Not known from area.	No further assessment required.
Masked Owl	*Tyto novaehollandiae*	-	V	Ecosystem	Inhabits a diverse range of wooded habitat that provide tall or dense mature trees with hollows suitable for nesting and roosting. Mostly recorded in open forest and woodlands adjacent to cleared lands. Nest in hollows, in trunks and in near vertical spouts or large trees, usually living but sometimes dead. Nest hollows are usually located within dense forests or woodlands. Masked owls prey upon hollow-dependent arboreal marsupials, but terrestrial mammals make up the largest proportion of the diet.	Low. Possible habitat in all woodland vegetation but use likely limited. Not recorded during present 2016/17 fauna baseline study. Three historic records within 5 km.	Offsets via ecosystem credits.
New Holland Mouse	*Pseudomys novaehollandiae*	V	-	Ecosystem	The New Holland Mouse currently has a disjunct, fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. Across the species' range the New Holland Mouse is known to inhabit open heathlands, open woodlands with a heathland understorey, and vegetated sand dunes.	Low. Not recorded during present 2016/17 fauna baseline study. Not known from area.	No further assessment required. Offsets via ecosystem credits.
Painted Honeyeater	*Grantiella picta*	-	V	N/A	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird and almost all breeding occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution. Inhabits boree, brigalow and box-gum woodlands and box-ironbark forests.	Low Not recorded during present 2016/17 fauna baseline study.	No further assessment required.
Powerful Owl	*Ninox strenua*	-	V	Species/ Ecosystem	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 turpentine 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	High. Not recorded during present 2016/17 fauna baseline study. 5 records from within 5km. Possible habitat in all woodland vegetation types.	Impacts via clearing of marginal foraging habitat. Very low density of prey throughout all areas to be cleared except 1 ha of clearing within Sandstone Transition Forest. Highly unlikely to nest within vent shaft sites. Offsets via ecosystem credits.

Common Name	Scientific Name	EPBC Act	BC Act	Credit status if generated within BBCC	Habitat	Likelihood of occurrence	Impact and Assessment
					arboreal marsupials. Nest trees for this species are usually emergent with a diameter at breast height of at least 100 cm.		
Red-crowned Toadlet	*Pseudophryne australis*	-	V	N/A	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 and usually contain leaf litter for shelter. Eggs are terrestrial and laid under litter, vegetation or rocks where the tadpoles inside will reach a relatively late stage of development before waiting for flooding waters before hatching will occur.	High. Recorded adjacent to Area 5 in recent years though not recorded in the present 2016/17 fauna baseline study. Possibly difficult to detect in recent surveys due to limited rainfall.	Impacts associated primarily with subsidence. Species considered further.
Regent Honeyeater	*Anthochaera phrygia*	CE	CE	N/A	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal woodlands and forests.	Low. Not recorded. May occur due to migratory nature, but rarely. Not previously recorded from area (5km).	No further assessment required.
Rosenberg's Goanna	*Varanus rosenbergi*	-	V	Recently changed in NSW to ecosystem credit	This species is a Hawkesbury-Narrabeen sandstone outcrop specialist. Occurs in coastal heaths, humid woodlands and both wet and dry sclerophyll forests.	Known. Eight records during present 2016/17 fauna baseline study. Area 5 and Area 6 and Vent Shaft 3.	Clearing impacts to habitat. Offset via ecosystem credits.
Scarlet Robin	*Petroica boodang*	-	V	Ecosystem	The Scarlet Robin is found from SE Queensland to SE South Australia and also in Tasmania and SW Western Australia. In NSW, it occurs from the coast to the inland slopes. The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs.	Known. Previously recorded nearby in Area 3B. Recorded twice during present 2016/17 fauna baseline study in Area 5.	Impacts via clearing of marginal foraging habitat. Offsets via ecosystem credits.
Sooty Owl	*Tyto tenebricosa*	-	V	Ecosystem	Often found in tall old-growth forests, including temperate and subtropical rainforests. In NSW mostly found on escarpments with a mean altitude less than 500 m. Nests and roosts in hollows of tall emergent trees, mainly eucalypts often located in gullies. Nests have been located in trees 125 to 161 cm in diameter.	Low Possible habitat in all woodland communities – potential more likely in the deeper gullies or taller forests on shale but use likely limited. Not recorded during present 2016/17 fauna baseline study. One historic records within 5 km.	Possible impacts via clearing of marginal foraging habitat. Offsets via ecosystem credits.

Common Name	Scientific Name	EPBC Act	BC Act	Credit status if generated within BBCC	Habitat	Likelihood of occurrence	Impact and Assessment
Southern Brown Bandicoot (eastern)	*Isoodon obesulus obesulus*	-	E	Species	Prefers sandy soils with scrubby vegetation and-or areas with low ground cover that are burn from time to time. A mosaic of post fire vegetation is important for this species.	Low Potential in all woodland types. Not recorded during present survey. One record from within 5km. No observations of digging areas.	Species not recorded. No further assessment required.
Southern Myotis *macropus*	Southern *Myotis macropus*	-	V	N/A	The Southern Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage.	Low Potential in all woodland types – more likely near creeks with open flyways	Species not recorded. Not generated in BBCC. No further assessment required.
Spotted-tailed Quoll	*Dasyurus maculatus maculatus*	E	V	Ecosystem	Spotted-tailed Quoll are found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland. Only in Tasmania is it still considered common. 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.	Low. Targeted however not recorded during present 2016/17 fauna baseline study. Single record within 5 km.	Possible impacts via clearing of marginal foraging habitat. Offsets via ecosystem credits.
Squirrel Glider	*Petaurus norfolcensis*	-	V	N/A	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. Within a suitable vegetation community at least one species should flower heavily in winter and one species of eucalypt should be smooth barked. Endangered population in the Wagga Wagga LGA.	Low. Not recorded during present 2016/17 fauna baseline study. Three records within 5km however preferred habitat is limited.	Species not recorded. Not generated in BBCC. No further assessment required.
Stuttering Frog	*Mixophyes balbus*	V	E		Associated with streams in dry sclerophyll and wet sclerophyll forests and rainforests of more upland areas of the Great Dividing Range of NSW and down into Victoria. Breeding occurs along forest streams with permanent water where eggs are deposited within nests excavated in riffle zones by the females and the tadpoles swim free into the stream when large enough to do so. Outside of breeding, individuals range widely across the forest floor and can be found hundreds of metres from water.	Low. No recent records within locality. Outside of OEH's mapped "known distribution".	Species not recorded. Not generated in BBCC. No further assessment required.
Swift Parrot	*Lathamus discolor*	CE	E	Ecosystem	The Swift Parrot occurs in woodlands and forests of NSW from May to August, where it feeds on eucalypt nectar, pollen and associated insects. The Swift Parrot is dependent on flowering resources across a wide range of habitats in its wintering grounds in NSW. This species is migratory, breeding in Tasmania and also nomadic, moving about in response to changing food availability.	Low Not recorded during present 2016/17 fauna baseline study. No records within 5km.	Possible impacts via clearing of marginal foraging habitat. Offsets via ecosystem credits.
Turquoise Parrot	*Neophema pulchella*	-	V	Ecosystem	The Turquoise Parrot's range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range. Lives on the edges of eucalypt	Low Not recorded during present 2016/17 fauna	Unlikely to be impacted. Offsets via ecosystem credits.

Common Name	Scientific Name	EPBC Act	BC Act	Credit status if generated within BBCC	Habitat	Likelihood of occurrence	Impact and Assessment
					woodland adjoining clearings, timbered ridges and creeks in farmland. Nests in tree hollows, logs or posts, from August to December. It lays four or five white, rounded eggs on a nest of decayed wood dust.	baseline study. No records within 5km.	
Varied Sittella	*Daphoenositta chrysoptera*	-	V	Ecosystem	Inhabits 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 in areas with rough-barked trees, such as stringybarks or ironbarks, but also in paperbarks or mature eucalypts with hollows.	Known record from Area 5. Recorded during present 2016/17 fauna baseline study in Area 6. Could occur throughout the Study Area in multiple habitats.	Impacts related to clearing. Offsets via ecosystem credits.
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	-	V	Species/Ecosystem	Habitats are characterised by the presence of large areas of open water including larger rivers, swamps, lakes, and the sea.	Known. Observed flying over site.	Unlikely to be impacted. Breeding habitat would not be impacted. Offsets via ecosystem credits.
Yellow-bellied Glider	*Petaurus australis*	M	V	Ecosystem	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. Not recorded though typically conspicuous via vocalisations. Five records within 5km.	Unlikely to be impacted. Offsets via ecosystem credits.

Appendix 3. Vegetation Mapping Descriptions

Code	Vegetation community	BVT equivalent based on key diagnostic features and species	TEC	Vegetation community descriptions (NPWS 2003)
MU18	Highlands Shale Tall Open Forest	HN601 Sydney Peppermint - White Stringybark moist shrubby forest on elevated ridges, Sydney Basin Bioregion	The BVT is associated with Southern Highlands Shale Woodlands in the Sydney Basin Bioregion TEC which is listed under the BC Act and EPBC Act. However, the location of the Study Area is not within the distribution location of the TEC, and as such does not align to it.	Highlands Shale Tall Open Forest occurs at elevations greater than 600 m on soils that are heavily influenced by shale material. The depth of the shale soil and its proximity to adjoining basalt and sandstone parent material varies the composition of the overstorey species while having less affect on the floristic composition overall. Tall *Eucalyptus piperita* and *E. globoidea* are frequently recorded, with the latter as an associate species. There are a wide variety of other species, unique to these higher elevations that appear to respond to slight changes in soil composition. *Eucalyptus obliqua* and *E. cypellocarpa* occur on deeper shale soils in combination with *E. piperita*. At higher elevations towards Mittagong, the forest comprises *Eucalyptus quadrangulata, E. elata* and *E. punctata*, with *E. smithii* occurring in localised patches. *Acacia binervata* forms a distinctive small tree stratum, infrequently occurring with *A. melanoxylon* or *Allocasuarina torulosa*. The smaller shrub layer is characterised by *Leucopogon lanceolatus var. lanceolatus* with other species such as *Bursaria spinosa, Coprosma quadrifida* and *Helichrysum elatum* less common. At sites with greater sandstone influence, *Leptospermum polygalifolium subsp. polygalifolium, Persoonia linearis* and *Banksia spinulosa var. spinulosa* occur in this stratum. Ground cover is invariably a cover of *Lomandra longifolia, Pteridium esculentum* and *Dianella caerulea* in combination with herbs such as *Viola hederacea, Pratia purpurascens, Dichondra repens* and *Hydrocotyle laxiflora.*
MU22	Transitional Shale Dry Ironbark Forest	HN556 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	Shale Sandstone Transition Forest TEC listed under BC Act and EPBC Act.	Localised in isolated shale cappings or gradual as distance from shale soil increases into sandstone geology. Ironbarks (*Eucalyptus crebra, E. fibrosa* and *E. paniculata* subsp. *paniculata*) and Stringybarks (*E. globoidea* and *E. eugenioides*) characterise the canopy species in this community, with Eucalyptus punctata a regular associate species. Other associated canopy species depend upon the thickness of the shale soil. At greater thickness, boxes (*Eucalyptus moluccana* and *E. bosistoana*) and Forest red gum (*E. tereticornis*) are more pronounced, while *Corymbia gummifera* marks the sandstone end of the gradient. The shrub stratum responds similarly to slight changes in soil fertility. *Bursaria spinosa* is the characteristic species of the small shrub layer in areas with greater shale influence. Scattered individuals of *Allocasuarina littoralis, Acacia irrorata* subsp. *irrorata* and *A. decurrens* are an occasional taller shrub stratum. In contrast, additional species such as *Kunzea ambigua, Persoonia linearis, Banksia ericifolia* subsp. *ericifolia* and *B. spinulosa* var. *spinulosa* are more common in the shrub layer where the sandstone influence is greater. The ground cover is distinctly grassy, supporting an amalgam of *Themeda australis, Entolasia stricta, E. marginata, Imperata cylindrica* var. *major* and *Echinopogon caespitosus* var. *caespitosus*. *Lepidosperma laterale, Lomandra longifolia, Pomax umbellata, Glycine clandestina* and *Hardenbergia violacea* also feature prominently.
MU23	Transitional Shale Stringybark Forest	HN556 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	Shale Sandstone Transition Forest TEC listed under BC Act and EPBC Act.	Transitional Shale Stringybark Forest is usually distributed on the margins of residual shale caps as the forest slowly grades into open sandstone woodlands. It is a moderately tall forest of Eucalyptus globoidea and other closely associated stringybarks (*E. eugenioides* and *E. oblonga*). *Eucalyptus punctata* is a regular associate species along with a wide variety of other Eucalypts that mark the transition with greater shale influence (eg. *E. crebra* and *E. fibrosa*) to that of greater sandstone influence (*Corymbia gummifera, E. piperita* and *E. sclerophylla*). The understorey is similarly variable as a result of the changes in soil. Most commonly the ground cover is a combination of grasses such as *Entolasia stricta, E. marginata* and *Aristida ramosa* with *Lomandra longifolia* often present. A shrubby understorey species such as *Acacia terminalis, Banksia spinulosa var. spinulosa* and *Kunzea ambigua* are found in combination with taller species such as *Leptospermum polygalifolium* subsp. *polygalifolium*.
MU26	Sandstone Gully Peppermint Forest	HN651 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin	Not listed	Sandstone Gully Peppermint Forest occupies sheltered slopes and gullies on Hawkesbury Sandstone Plateau south from Bulli Tops. It is a tall dry shrubby forest dominated by *Eucalyptus piperita* and *Corymbia gummifera,* with *E. sieberi* and *E. globoidea* less common. A diverse shrub layer that includes *Banksia spinulosa var. spinulosa, Bossiaea obcordata, Persoonia levis, P. linearis, Acacia longifolia subsp. longifolia, A. myrtifolia, A. ulicifolia, A. binervata, Pultenaea hispidula* and *Leucopogon lanceolatus* var. *lanceolatus* is present. *Telopea speciosissima* and *Boronia ledifolia* are also common and are conspicuous when in flower. Banksia serrata is common as a sparse tall shrub or small tree. The ground cover is similarly diverse with combinations of *Entolasia stricta, Lomandra obliqua, L. longifolia, L. filiformis, Patersonia glabrata, Dianella caerulea, Billardiera scandens, Gonocarpus teucrioides, Lomatia silaifolia* and P*hyllanthus hirtellus* found consistently within sites. Variation occurs within this Map Unit in response to degree of shelter and rainfall. Near the escarpment edge this community is found on ridgetops particularly near the convergence of Hawkesbury and Narrabeen Sandstones. In drier locations, in shallow gullies and upper slopes the composition of this community can resemble that found within sandstone ridgetop woodlands
MU27	Nepean Sandstone Gully Forest	HN586 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin	Not listed	another form of sandstone forest characterises the more open gullies and slopes. The Nepean Sandstone Gully Forest features *Corymbia gummifera, Eucalyptus piperita, E. punctata* and *E. agglomerata* as the prominent canopy species. The shrub layer is moderately dense, typified by a mix of small trees and shrubs. On lower, more protected slopes typical species include *Allocasuarina torulosa, Persoonia linearis, Elaeocarpus reticulatus, Leucopogon lanceolatus* var. *lanceolatus, Xylomelum pyriforme* and *Ceratopetalum gummiferum.* The ground cover is frequently comprises *Lomatia silaifolia, Pteridium esculentum, Entolasia stricta* and *Lepidosperma laterale. Banksia serrata* and *B. spinulosa var. spinulosa* are found in drier locations associated with upper slopes and exposed aspects. Rocky outcrops, chutes and benches are common.
MU29	Exposed Sandstone Scribbly Gum Woodland	HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin	Not listed	The ridges and exposed slopes across the Hawkesbury Sandstones of the Woronora Plateau support a low open woodland complex. A combination of different Scribbly Gums (*Eucalyptus sclerophylla, E. racemosa, E. haemastoma* and hybrids between each) occurs with *E. oblonga, Corymbia gummifera, E. sieberi* and *E. piperita.* Angophora costata occurs occasionally within this complex north from Bulli Tops. The density of the shrub layer is variable depending on fire history. Species present can include *Banksia spinulosa var. spinulosa, Leptospermum trinervium, Isopogon anemonifolius, Acacia ulicifolia, Hakea dactyloides, Eriostemon australasius* and *Bossiaea heterophylla*. The ground cover is not dense, with species such as *Lomandra glauca* and *Entolasia stricta,* and small shrubs including *Dampiera stricta* and tangles of *Caustis flexuosa* frequently encountered. This vegetation community occurs on skeletal sandy soils of low fertility. On exposed slopes the ground is often rocky, with large boulders outcropping on ridgetop peaks and on slope benches.
MU29	Exposed Sandstone Scribbly Gum Woodland (other)	HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin	Not listed	Floristically contains more sedges and rushes due to presence within a damper portion of the Study Area. The area is generally more open than the surrounding Exposed Sandstone Scribbly Gum Woodland.

Code	Vegetation community	BVT equivalent based on key diagnostic features and species	TEC	Vegetation community descriptions (NPWS 2003)
MU29	Exposed Sandstone Scribbly Gum Woodland (high)	HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin	Not listed	Regenerating condition class or naturally open class of Exposed Sandstone Scribbly Gum Woodland as described above. Generally lacking a canopy and midstorey.
MU38	Rock Pavement Heath	HN540 Hairpin Banksia - Kunzea ambigua - Allocasuarina distyla heath on coastal sandstone plateaus, Sydney Basin	Not listed	Rock Pavement Heath describes an often isolated community that is restricted to large exposed sandstone rock outcrops. These plates or pavements occur on ridgetops and often feature within a broader complex of exposed rocky knolls, benches and outcrops. The low heathcover may include *Kunzea ambigua, Darwinia fascicularis subsp. fascicularis, Epacris microphylla var. microphylla* and *Leptospermum trinervium*. The patchiness of understorey vegetation cover is determined by available moisture present within minor cracks and depression in the rock. Bare rock surfaces comprise a dominant component of the habitat. Low growing *Lepidosperma viscidum, Thelionema umbellatum* and *Lepyrodia scariosa* are found amongst the ground cover. Rock pavements and outcrops also appear to provide shelter from intense fire to allow the persistence of *Callitris endlicheri.*
MU4	Sandstone Riparian Scrub	HN607 Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin	Not listed	A low mesic scrub less than 5 m tall occurs along deeply incised creeklines on Hawkesbury Sandstones across the Woronora Plateau. The Riparian Scrub features a variable cover of shrubs that include *Tristaniopsis laurina, Tristania neriifolia, Leptospermum morrisonii, Allocasuarina littoralis, Ceratopetalum apetalum* and *Backhousia myrtifolia*. The latter two species tend to be more prominent amongst stream boulders and around minor waterfalls. The smaller shrub layer is dominated by *Lomatia myricoides with Acacia obtusifolia, Grevillea oleoides, Micrantheum hexandrum, Pseudanthus pimeleoides* and *Bauera rubioides.* The ground cover consists of an abundant cover of moisture loving ferns such as *Sticherus flabellatus var. flabellatus* and *Gleichenia microphyll*a. The fern cover is often broken by a series of rock pools, recent sandy alluvial deposits and rock pavements. Branches of the surrounding Eucalypt forest form an occasional shade cover across the gully line. Tree species are vary between locations but are frequently *Eucalyptus piperita, E. agglomerata* or *Angophora costata.* Sandstone Riparian Scrub occurs in Woronora, O'Hares, Cataract, Cordeaux and Nepean Catchments.
MU42	Coastal Upland Swamps: Banksia Thicket	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin	Coastal Upland Swamps of the Sydney Basin Bioregion (BC Act and EPBC Act)	Banksia Thicket is described in NPWS (2003) as a low dense heath that forms on the fringes of the Upland Swamp complex within the O'Hares Creek Catchment. These thickets extend beyond this catchment to cover similar habitat across the Woronora Plateau. Banksia Thickets occur throughout the Woronora Plateau. In some locations *Banksia ericifolia* subsp. *ericifolia* completely dominates the understorey of adjoining stands of Exposed Sandstone Scribbly Gum Woodland. These areas have been included within this Map Unit although the species composition will vary from that found growing within the Upland Swamp complex. Areas of dense *Banksia ericifolia* subsp. *ericifolia* growing on broad rock plates are also included within the Map Unit. Niche typically recorded the following species within Coastal Upland Swamps Banksia Thicket: *Banksia ericifolia* subsp. *ericifolia* and *Hakea dactyloides* and *Dillwynia floribunda.* Common understorey species recorded by Niche include: *Empodisma minus, Dampiera stricta, Entolasia stricta, Selaginella stricta* and *Leptocarpus tenax* and *Lepyrodia scariosa.*
MU43	Coastal Upland Swamps: Tea-Tree Thicket	HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin	Coastal Upland Swamps of the Sydney Basin Bioregion (BC Act and EPBC Act)	A low dense blend of Coral ferns (*Gleichenia dicarpa, G. microphylla*) and sedges (*Gahnia sieberiana, Empodisma minus*) are found along drainage lines within the Sedgeland-Heath Complex on soils with impeded drainage of the Woronora Plateau. Niche recorded the following species within Coastal Upland Swamps Tea-tree Thicket: *Leptospermum juniperinum, Leptospermum trinervium, and L. polygalifolium* subsp. *polygalifolium*, *Acacia rubida, Banksia ericifolia* subsp. *ericifolia* and *Melaleuca squarrosa* All these species are diagnostic species discussed in NPWS (2003). The thickets of the Tea-trees ranged from may being sparse to absent depending on water table fluctuation and long term fire history. Occasional individuals of *Banksia robur* and *Conospermum ellipticum* are present in the sparse low shrub layer. Other ground covers included *Lepidosperma laterale, Baumea teretifolia* and *Tetrarrhena juncea*.
MU44	Coastal Upland Swamps: Sedgeland-Heath Complex - sedgeland	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin	Coastal Upland Swamps of the Sydney Basin Bioregion (BC Act and EPBC Act)	Sedgeland is distinct component of this map unit that forms part of the Upland Swamp Complex on the Woronora Plateau. Sites from the Holsworthy area (French et al., 2000) reflect a closely related species composition to that described by Keith (1994) for O'Hares Creek Catchment. Sedgeland forms a low dense cover of sedges and small shrubs on the perimeter of Coastal Upland Swamps or in minor depressions within the same complex. Niche generally recorded the following species: *Leptocarpus tenax, Schoenus brevifolius, Baeckea imbricata, Epacris obtusifolia, Sprengelia incarnata,* and *Boronia parviflora.* *Hakea teretifolia* and *Banksia ericifolia subsp. ericifolia* were also recorded, however were generally in low abundance.
MU44	Coastal Upland Swamps: Sedgeland-Heath Complex – Restioid heath	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin	Coastal Upland Swamps of the Sydney Basin Bioregion (BC Act and EPBC Act)	Restioid heath was quite common within all Coastal Upland Swamps of the Study Area. Typically, the community consisted of a low shrub layer of *Banksia oblongifolia, Hakea teretifolia and Epacris obtusifolia* with occasional *B. robur, Melaleuca thymifolia* and *M. squarrosa.* A diverse combination of rushes, herbs and grasses are present forming a dense ground cover. Species present include *Empodisma minus, Lepyrodia scariosa, Leptocarpus tenax, Lindsaea linearis, Xanthorrhoea resinifera, Stackhousia nuda, Mitrasacme polymorpha* and *Schoenus brevifolius*.
MU44	Coastal Upland Swamps: Sedgeland-Heath Complex – cyperoid heath	HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin	Coastal Upland Swamps of the Sydney Basin Bioregion (BC Act and EPBC Act)	Cyperoid Heath forms part of the Upland Swamp complex found on the Woronora Plateau (Keith, 1994). Cyperoid Heath grows on seepage and water discharge sites that are periodically water logged. Species from the Cyperaceae family characterise the dense ground cover that grows up to 1 m in height. Niche recorded the following diagnostic species within the community: *Lepidosperma limicola, Gymnoschoenus sphaerocephalus, Chorizandra sphaerocephala* and *Baumea rubiginosa.* These species were frequent and abundant. A number of other species common to Restioid Heath are also consistently recorded within this community. These include *Empodisma minus, Leptocarpus tenax* and *Mitrasacme polymorpha. Xyris operculata* and *Selaginella uliginosa* are less frequently observed, though they are characteristic of the assemblage. A low, open shrub layer is present and includes species such as *Banksia robur, Melaleuca squarrosa, Hakea teretifolia* and *Leptospermum juniperinum*. Small shrubs such as *Pultenaea divaricata* and *Baeckea linifolia* are also found.

Code	Vegetation community	BVT equivalent based on key diagnostic features and species	TEC	Vegetation community descriptions (NPWS 2003)
MU45	Coastal Upland Swamps: Fringing Eucalypt Woodland	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin	Not listed	Fringing Eucalypt Woodland has been delineated to highlight the ecotone between the Coastal Upland Swamps communities and the surrounding Sandstone Woodlands. The transition between the two can be either abrupt or very gradual. In the case of the latter, a very open woodland with a canopy cover less than 10% consisting of widely spaced *Eucalyptus racemosa, E. oblonga or E. sieberi.* The understorey characteristics are transitional, with some sites sharing greater similarity with the drier components of Restioid Heaths) than Exposed Sandstone Scribbly Gum Woodland.
MU9	Nepean Gorge Moist Forest	HN606 Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion	Not listed	The Nepean Catchment is characterised by a number of deeply dissected Hawkesbury sandstone gorges and valleys. A tall forest with a moist subcanopy occupies sheltered aspects in these environments. Tall *Eucalyptus elata* are a feature of the canopy. Other canopy species include E*ucalyptus agglomerata, E. punctata* and *E. piperita*. The understorey can be a moderately tall small tree and shrub layer. In the most protected sites *Ceratopetalum apetalum, Backhousia myrtifolia, C. gummiferum* and *Acacia elata* can grow up to around 12 m in height. The smaller shrub stratum is less dense. It includes ferns, such as C*yathea australis,* and shrubs, such as *Elaeocarpus reticulatus* and *Notelaea longifolia f. longifolia.* The shady habitat provides sufficient shelter for an abundant ground cover of ferns such as *Calochlaena dubia, Pteridium esculentum, Sticherus flabellatus var. flabellatus, Blechnum cartilagineum* and A*diantum formosum.* Small succulent climbers such as *Tylophora barbata* and *Cissus hypoglauca* are also abundant.
-	Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	ME044 Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	Not listed	his community was not mapped or described by NPWS (2003). The area of Sydney Blue Gum x Banglay – Lilly Pilly moist forest was in a relatively low condition due to previous clearing. The site generally lacked a canopy layer, however had a sparse scattered mistorey consisting of *Acmena smithii* and *Pittosporum undulatum.* The ground cover was a mixture of native and introduced species. Native species include: *Pteridium esculentum, Doodia aspera , Oplismenus imbecillis , Microlaena stipoides.*

Appendix 4. Flora Species List

Family	Species	lb10 25	lb10 28	lb10 30	lb10 33	lb10 39	lb10 46	lb10 53	lb10 59	lb10 65	lb10 72	lb10 76	lb10 82	lb10 83	lb10 84	lb10 88	lb10 90	lb10 91	lb10 95	lb11 03	lb11 08	lb11 11	lb11 14	lb11 32	lb11 34	lb11 38	lb11 56	lb11 57	lb11 58	lb11 59	lb11 60	lb11 61	lb11 65	lb11 66	lb11 67	lb11 68	lb11 69	lb11 70	lb11 71	lb2 31	lb2 39	lb2 57	lb2 66
Acanthaceae	*Pseuderanthemum variabile*																																									1	
Anthericaceae	*Thysanotus spp.*																										2																
Anthericaceae	*Thysanotus tuberosus*						2																																				
Apiaceae	*Actinotus helianthi*	1																		1														3									
Apiaceae	*Actinotus minor*											2																					2	3	3	2					2	
Apiaceae	*Centella asiatica*		1																																							2
Apiaceae	*Platysace linearifolia*	2	3				2						2					2							2		2			3	2	3					2		3	2			
Apiaceae	*Xanthosia pilosa*	2	2										2							2				2												2	2	2					
Apiaceae	*Xanthosia tridentata*	2					2						2				2			2				2	2					2	3			2					1			
Araliaceae	*Astrotricha longifolia*	2												2																													
Asteraceae	*Euchiton gymnocephalus*																																										2
Blechnaceae	*Blechnum cartilagineum*																																										3
Casuarinaceae	*Allocasuarina littoralis*									2														2							1									1			
Colchicaceae	*Burchardia umbellata*						2	3														2			2																		
Cunoniaceae	*Bauera microphylla*																		3		2					2																	
Cunoniaceae	*Bauera rubioides*			3												1		3		3	2	2		2	2															2			
Cunoniaceae	*Callicoma serratifolia*		1										3				3			2																						
Cunoniaceae	*Ceratopetalum gummiferum*												3	3																												
Cyatheaceae	*Cyathea australis*																																									2
Cyperaceae	*Baumea teretifolia*																																							4		6
Cyperaceae	*Bulboschoenus caldwellii*																					3	4			3																
Cyperaceae	*Caustis flexuosa*																	3							2													2	2	3			
Cyperaceae	*Chorizandra sphaerocephala*																																									2
Cyperaceae	*Cyathochaeta diandra*	4	2		3	2	4	2										2	4	3		2	4		2		3	4	4	4	4	3	4	4	4	2	4	4	3	3		4	
Cyperaceae	*Cyperus spp.*																																									1
Cyperaceae	*Eleocharis spp.*												2																													
Cyperaceae	*Gahnia microstachya*												2																													
Cyperaceae	*Gahnia sieberi*													3																												4
Cyperaceae	*Gahnia sieberiana*												2																													
Cyperaceae	*Gymnoschoenus sphaerocephalus*							3	3						5																										4		
Cyperaceae	*Lepidosperma laterale*				2										3		2	2		2					1						2	2		2	3	3				5		
Cyperaceae	*Lepidosperma limicola*									5																3																3
Cyperaceae	*Lepidosperma lineare*	1																																								
Cyperaceae	*Ptilothrix deusta*				2		2	2				2							4		4		2		2	2														2	3	2	2
Cyperaceae	*Schoenus brevifolius*		2					3	3	3		2			2											3															2		
Cyperaceae	*Schoenus maschalinus*												3																													
Cyperaceae	*Schoenus melanostachys*	2	2							3				4		3	3	2		2				5																		
Cyperaceae	*Schoenus paludosus*																																2	2			2					
Dennstaedtiaceae	*Hypolepis muelleri*																																									2
Dennstaedtiaceae	*Pteridium esculentum*		2	3									4	3		3				4				3	1																	3
Dilleniaceae	*Hibbertia aspera*																										2		2		2						2					
Dilleniaceae	*Hibbertia bracteata*													2																												
Dilleniaceae	*Hibbertia circumdans*	1																2																								
Dilleniaceae	*Hibbertia cistiflora*																																2									

Family	Species	lb10 25	lb10 28	lb10 30	lb10 33	lb10 39	lb10 46	lb10 53	lb10 59	lb10 65	lb10 72	lb10 76	lb10 82	lb10 83	lb10 84	lb10 88	lb10 90	lb10 91	lb10 95	lb11 03	lb11 08	lb11 11	lb11 14	lb11 32	lb11 34	lb11 38	lb11 56	lb11 57	lb11 58	lb11 59	lb11 60	lb11 61	lb11 65	lb11 66	lb11 67	lb11 68	lb11 69	lb11 70	lb11 71	lb2 31	lb2 39	lb2 57	lb2 66
Dilleniaceae	*Hibbertia riparia*	3		2	2		3	2			3											2	3		2		2		2	2	3	2		2	2	2	2	3		2		3	
Droseraceae	*Drosera binata*			2	2					2					2																									2		
Droseraceae	*Drosera burmanni*																					2																				
Droseraceae	*Drosera lanata*							1																																		
Droseraceae	*Drosera peltata*				2		2	2	2	2													2	2		2																
Droseraceae	*Drosera spatulata*			2								2			2		1		2		2					2					2								2		
Ericaceae	*Astroloma pinifolium*																																		2							
Ericaceae	*Epacris longiflora*																	1																								
Ericaceae	*Epacris microphylla*				2	2	2					2					2	2						2					2		3		2						3	2		
Ericaceae	*Epacris obtusifolia*						2		2	2		3			2				2																					3		
Ericaceae	*Epacris pulchella*		1	2																			2																			
Ericaceae	*Leucopogon ericoides*																2	2																								
Ericaceae	*Leucopogon lanceolatus*												2	3																												
Ericaceae	*Lissanthe strigosa*																										2															
Ericaceae	*Monotoca scoparia*		1		2																									3				3		2	2	3				
Ericaceae	*Sprengelia incarnata*							2		2					2																									2		
Ericaceae	*Styphelia longifolia*																																						1			
Ericaceae	*Styphelia tubiflora*																																								2	
Ericaceae	*Woollsia pungens*																															2										
Euphorbiaceae	*Monotaxis linifolia*	2						2		2					3																									2		
Euphorbiaceae	*Ricinocarpos pinifolius*		2																																						
Fabaceae (Faboideae)	*Almaleea paludosa*								2										2			1																		2		
Fabaceae (Faboideae)	*Almaleea spp.*				2	2																				2															
Fabaceae (Faboideae)	*Bossiaea heterophylla*	2	2		2												2	2		2		1		2	2		3	2	2	2	2	2			2		2	3			3	
Fabaceae (Faboideae)	*Bossiaea obcordata*										3																3	2	3		3		2	3	3	2	3	3				
Fabaceae (Faboideae)	*Bossiaea prostrata*																	2																					2			
Fabaceae (Faboideae)	*Bossiaea scolopendria*	1																2										2						2	2			1			2	
Fabaceae (Faboideae)	*Dillwynia floribunda*				2		2	3	2	2		4				2		2	3		4	4	4	2	3	2				3	3	3		3				3		3	2	
Fabaceae (Faboideae)	*Dillwynia retorta*						2	3	2						3			2		2		2			3	2	2	2	2	3				2	2	3	2	3		3	3		
Fabaceae (Faboideae)	*Dillwynia tenuifolia*		3			2																																				
Fabaceae (Faboideae)	*Gompholobium grandiflorum*													2				2															2			2		1	2				
Fabaceae (Faboideae)	*Gompholobium minus*																																								2	
Fabaceae (Faboideae)	*Kennedia rubicunda*												2																													
Fabaceae (Faboideae)	*Mirbelia rubiifolia*	3						2							3		4																		2								
Fabaceae (Faboideae)	*Phyllota grandiflora*																										2															
Fabaceae (Faboideae)	*Pultenaea elliptica*	1																																						2		
Fabaceae (Faboideae)	*Pultenaea flexilis*																	2		1							2		2			3										
Fabaceae (Faboideae)	*Pultenaea linophylla*												3														2															
Fabaceae (Faboideae)	*Pultenaea spp.*																																							1		
Fabaceae (Faboideae)	*Sphaerolobium minus*								2														1																2			
Fabaceae (Faboideae)	*Sphaerolobium vimineum*							2		2					2				2		3					2																
Fabaceae (Faboideae)	*Viminaria juncea*		1	4	2																5																				2
Fabaceae (Mimosoideae)	*Acacia linearifolia*	2	2				2				2		2					2		2		2		2	2			2	2	2	2			2	2	2		2			2	
Fabaceae (Mimosoideae)	*Acacia linifolia*																																						2			
Fabaceae (Mimosoideae)	*Acacia longifolia*																																						2			

Family	Species	lb10 25	lb10 28	lb10 30	lb10 33	lb10 39	lb10 46	lb10 53	lb10 59	lb10 65	lb10 72	lb10 76	lb10 82	lb10 83	lb10 84	lb10 88	lb10 90	lb10 91	lb10 95	lb11 03	lb11 08	lb11 11	lb11 14	lb11 32	lb11 34	lb11 38	lb11 56	lb11 57	lb11 58	lb11 59	lb11 60	lb11 61	lb11 65	lb11 66	lb11 67	lb11 68	lb11 69	lb11 70	lb11 71	lb2 31	lb2 39	lb2 57	lb2 66
Fabaceae (Mimosoideae)	*Acacia myrtifolia*																3										2	2															
Fabaceae (Mimosoideae)	*Acacia obliquinervia*																																2										
Fabaceae (Mimosoideae)	*Acacia obtusata*												2	5						1																							
Fabaceae (Mimosoideae)	*Acacia rubida*															3	3																										
Fabaceae (Mimosoideae)	*Acacia spp.*									1																																	1
Fabaceae (Mimosoideae)	*Acacia suaveolens*																										2			2												
Fabaceae (Mimosoideae)	*Acacia terminalis*												2	3	1			1		4																					1		
Fabaceae (Mimosoideae)	*Acacia ulicifolia*													2						1							2		2		3						2	2			
Geraniaceae	*Geranium spp.*																																									2
Gleicheniaceae	*Gleichenia dicarpa*		3							6			2		3	6	3	2		3																				5		4
Goodeniaceae	*Dampiera purpurea*	2	2		2		2	2	2					3			2	2																								
Goodeniaceae	*Dampiera stricta*										2				2	2	2	1	3	2	2	3	3	2	2	2			2	3	3	3	2		2		2	3	3	2	2	2	
Goodeniaceae	*Goodenia bellidifolia*			2							3											2			2	4														2		2	
Goodeniaceae	*Goodenia hederacea*	2	2		2			2	2	2				3	2		2	1	2					2		1		2		2	2	2				2	2				
Goodeniaceae	*Goodenia heteromera*												2		2														2													
Goodeniaceae	*Goodenia heterophylla*																										2															
Haemodoraceae	*Haemodorum corymbosum*																		2			2	2																	2		1	
Haloragaceae	*Gonocarpus tetragynus*	2	2				2		2	2				5				1		4																			2		2	
Haloragaceae	*Gonocarpus teucrioides*	2											3				3			2				3					2	2				3							
Iridaceae	*Patersonia glabrata*	2																2		2																						
Iridaceae	*Patersonia sericea*	2	2		2		2							2			2		3				3	2	1		2	2	2		2	3	2	2		2	2	2	2			2	
Juncaceae	*Juncus prismatocarpus*																																								2
Lamiaceae	*Chloanthes stoechadis*																			1																						
Lamiaceae	*Clerodendrum tomentosum*																										2															
Lauraceae	*Cassytha glabella*		2				2	2	2		2	3	2	2			2			2	3	2	3	2				2	2		2	3			2	2	2		3	3	2	2	
Lindsaeaceae	*Lindsaea linearis*	1	1	3		2	2			2					2		2	1		2				2	2		2	2		2		2			3				2	2		2	
Lindsaeaceae	*Lindsaea microphylla*																1																									
Lobeliaceae	*Pratia purpurascens*																																									2
Loganiaceae	*Mitrasacme paludosa*							2										1	3						2																	
Loganiaceae	*Mitrasacme pilosa*		2		2							2												2		2														2		
Loganiaceae	*Mitrasacme polymorpha*						2																																			
Loganiaceae	*Mitrasacme spp.*														2																											
Lomandraceae	*Lomandra confertifolia*																1			2																						
Lomandraceae	*Lomandra cylindrica*						1										1	2		1					1										2						
Lomandraceae	*Lomandra filiformis*	2					1				3							2						1				2			2	3	2	2		2	3	2	2			2	
Lomandraceae	*Lomandra gracilis*																	1																								
Lomandraceae	*Lomandra longifolia*		1								3		3	3			3	2		3				4																		
Lomandraceae	*Lomandra obliqua*										3									2					1		2	2	2		3	3		2	2	2	2	3	2			2	
Myrsinaceae	*Rapanea variabilis*																																									
Myrtaceae	*Baeckea crassifolia*																								2																	
Myrtaceae	*Baeckea imbricata*					2		2				3										4				3														3	3	
Myrtaceae	*Baeckea linearis*														2							2		4																		
Myrtaceae	*Baeckea linifolia*											2																														
Myrtaceae	*Baeckea ramosissima*																					2																			
Myrtaceae	*Callistemon citrinus*			3											2		2			2	3	1																			

Family	Species	lb10 25	lb10 28	lb10 30	lb10 33	lb10 39	lb10 46	lb10 53	lb10 59	lb10 65	lb10 72	lb10 76	lb10 82	lb10 83	lb10 84	lb10 88	lb10 90	lb10 91	lb10 95	lb11 03	lb11 08	lb11 11	lb11 14	lb11 32	lb11 34	lb11 38	lb11 56	lb11 57	lb11 58	lb11 59	lb11 60	lb11 61	lb11 65	lb11 66	lb11 67	lb11 68	lb11 69	lb11 70	lb11 71	lb2 31	lb2 39	lb2 57	lb2 66
Myrtaceae	*Callistemon lilacinus*																2																									
Myrtaceae	*Callistemon linearifolius*																					2																				
Myrtaceae	*Callistemon linearis*																																							3	
Myrtaceae	*Corymbia gummifera*													4													4	4	4		3					4	4	4				
Myrtaceae	*Darwinia grandiflora*																																	2								
Myrtaceae	*Eucalyptus piperita*										2		5				5			5																						
Myrtaceae	*Eucalyptus racemosa*	2	2				4	1			4				2	4		3				3					5	3	4	2	3	2	3	4	5	3	3	3	3	4		5	
Myrtaceae	*Eucalyptus sieberi*		4															3						3			3	6	3		4					3	5	4	3			
Myrtaceae	*Eucalyptus spp.*																				2																					
Myrtaceae	*Kunzea ambigua*																													2												
Myrtaceae	*Leptospermum continentale*		2	3		6	2		2		3				2							2	2			3	2	3				3	3	3	4	4	4	3			2	
Myrtaceae	*Leptospermum juniperinum*								2			3												2					2		3								2	3		
Myrtaceae	*Leptospermum polyanthum*																			3																		2			3
Myrtaceae	*Leptospermum polygalifolium*	3	3				2		2	3			3	4	3	2	3	4	2	2	5			4	3					2									3		
Myrtaceae	*Leptospermum squarrosum*			3	2	2																																		3
Myrtaceae	*Leptospermum trinervium*	3				4	2																3		4					4	2	3		5	4				3		4	
Myrtaceae	*Melaleuca linariifolia*																				2			2																	
Myrtaceae	*Melaleuca squamea*	1																																							
Myrtaceae	*Melaleuca thymifolia*				3	5	2	2	3	2									4				4		2	4				5		5						2		2	
Myrtaceae	*Micromyrtus minutiflora*				3		2		2														3	2																	
Orchidaceae	*Acianthus spp.*												1																												
Orchidaceae	*Chiloglottis spp.*													1																											
Orchidaceae	*Thelymitra spp.*																	1					1																	1	
Osmundaceae	*Todea barbara*												3																												
Phormiaceae	*Dianella caerulea*	2					2						2	2																											
Phormiaceae	*Dianella prunina*								2																																
Phormiaceae	*Dianella spp.*																																							1	
Phyllanthaceae	*Phyllanthus hirtellus*																											2	2								2				
Pittosporaceae	*Billardiera scandens*		2									2										1			2		2	2	2	2	2	3						2		2	
Poaceae	*Anisopogon avenaceus*		1		2	2	2				3							2	3			2	2					2		2		3	2							3	1
Poaceae	*Cymbopogon refractus*																																							1	
Poaceae	*Entolasia stricta*	3	2	3	3	3	3	2	3	1	4	3	3	2	2	3	3	3	2		3	3	3	3	4	3	2	2	2	2	3	3	2	3	3	2	3	3	3	3		4	2
Poaceae	*Hemarthria spp.*				2																4																				
Poaceae	*Hemarthria uncinata*																					3																				
Poaceae	*Microlaena stipoides*													2																											
Proteaceae	*Banksia ericifolia*	3	2		3	2	4	2	4						6		3	4			4					5							2		4	3				3		
Proteaceae	*Banksia oblongifolia*						4	3	2																													2				
Proteaceae	*Banksia paludosa*	1			3	3																																	5		
Proteaceae	*Banksia robur*		2	3						3					3				2		3																		2		2	
Proteaceae	*Banksia serrata*	2	3										2	3			2			2		2		2	3							3	2	3	4	4	4	3				
Proteaceae	*Banksia spinulosa*	2	2		2				3	2	3			3		5			2	2		2	2	4	3	1	3	2	3	4	4	4	2	3			3	2	2	4		4	
Proteaceae	*Conospermum ericifolium*										3		2				3			2							3	3	2	2	3		2	3	3		3	2	2				
Proteaceae	*Conospermum longifolium*	2	2										3	2				2															2	3		2		2					
Proteaceae	*Grevillea diffusa*																									2																
Proteaceae	*Grevillea linearifolia*																										2		2		2											

Family	Species	lb10 25	lb10 28	lb10 30	lb10 33	lb10 39	lb10 46	lb10 53	lb10 59	lb10 65	lb10 72	lb10 76	lb10 82	lb10 83	lb10 84	lb10 88	lb10 90	lb10 91	lb10 95	lb11 03	lb11 08	lb11 11	lb11 14	lb11 32	lb11 34	lb11 38	lb11 56	lb11 57	lb11 58	lb11 59	lb11 60	lb11 61	lb11 65	lb11 66	lb11 67	lb11 68	lb11 69	lb11 70	lb11 71	lb2 31	lb2 39	lb2 57	lb2 66
Proteaceae	*Grevillea mucronulata*	3	3								3		3	2		2	3	2		4				3	2		2	3	2			2				2						
Proteaceae	*Grevillea speciosa*	2	1				2		2																2					2				3		3	3				
Proteaceae	*Grevillea sphacelata*																															2	3	3								
Proteaceae	*Hakea dactyloides*	2	2		2	2	2				3					3		2			2	2	4	2	3		2	3	2	2	2	3	2	2	3	4	3	3	2	4		5	
Proteaceae	*Hakea sericea*	3	2	3	2	2	2		2	2	2		2			3	2	2		1				2								3	2	2	2	2	2	2		2	3	
Proteaceae	*Hakea teretifolia*							2	2						3				2		2	2			2																
Proteaceae	*Isopogon anemonifolius*	2	2		2		2										3	2		1		2			2		2		3		3	3	2	3	3	4	4	3	3	2		2	
Proteaceae	*Lambertia formosa*	3	3				2				3			2			3			3					2		3	2	3	3	2	3	3			3	4	4		4			
Proteaceae	*Lomatia silaifolia*	2	2								2		3	3						1				3			2	2		2	3				2	2	2	2	2			1	
Proteaceae	*Persoonia levis*		2				1				3		2		2	2	2	1		2		2		2	2		3	2	3		3		2	3	3		3	3	3	2			
Proteaceae	*Persoonia linearis*										3			3																												
Proteaceae	*Petrophile sessilis*	2	2				1		2		3	3				2		3	2	2		2	2	2	3	1	3	2	3	2		2	2	2	3	3		3	3	4	2	1	
Proteaceae	*Telopea speciosissima*		2								1		2	2		2				1				1			2	2	2							2					
Proteaceae	*Xylomelum pyriforme*																										2	2	2								1					
Ranunculaceae	*Clematis aristata*												2	2																												
Ranunculaceae	*Ranunculus spp.*														2																											3
Restionaceae	*Empodisma minus*	2	2	3		4		3	5	3		4			5	2	2		2		4	2		3																4		4
Restionaceae	*Leptocarpus tenax*	3	2	3	6		5	6	5	2	1	4			4	3	3	2	6	2	3	3	1	3	3	3				3		2			2					4	2	3
Restionaceae	*Lepyrodia scariosa*	4	2	3	6	3	3	3	4	2	3	5			3			3	4	2		5	3	3	3	3				4		3	3	2	4			3	3	3	4	4	2
Rhamnaceae	*Pomaderris ferruginea*																	2																								
Rhamnaceae	*Pomaderris spp.*													2																												
Rubiaceae	*Opercularia diphylla*												2																													
Rubiaceae	*Pomax umbellata*																											2		2											2	
Rutaceae	*Boronia ledifolia*						2	2	2	2					2				2		2	4				3																
Rutaceae	*Boronia parviflora*											3																														
Rutaceae	*Eriostemon australasius*		3								3														1		3	2	2		3		2	2	3	3	3	3	3				
Santalaceae	*Choretrum candollei*													2						2																						
Santalaceae	*Exocarpos cupressiformis*															2	2																		3							
Santalaceae	*Exocarpos strictus*	1	2																						3																	
Sapindaceae	*Dodonaea triangularis*													3																												
Schizaeaceae	*Schizaea dichotoma*																					1																				
Selaginellaceae	*Selaginella uliginosa*	1	2				2					2			2		2			2	2			2	3																	
Sterculiaceae	*Lasiopetalum joyceae*																2																									
Stylidiaceae	*Stylidium graminifolium*											3																														
Stylidiaceae	*Stylidium spp.*																																2		2							
Thymelaeaceae	*Pimelea linifolia*	3	3								3			2						2		1		2	2		3	2	2	2	2		2	2	3	2	2	2					
Violaceae	*Hybanthus monopetalus*	2																		1						1	2	2	2		2			2		2						
Violaceae	*Viola hederacea*																													2										2		2
Violaceae	*Viola sieberana*											2	2	2			2									2															1	
Violaceae	*Viola sieberiana*																														2										
Xanthorrhoeaceae	*Xanthorrhoea media*	2	2																								2	1	2	2	2		2		2	2		2		3		
Xanthorrhoeaceae	*Xanthorrhoea resinifera*																																									1
Xyridaceae	*Xyris gracilis*																		4							2					3	2									
Xyridaceae	*Xyris operculata*																		3			3																				2
Xyridaceae	*Xyris spp.*																																							3		

BioBanking plot attributes

NPS = native species richness, NOS = native overstorey cover, NMS = native midstorey cover, NGCG = native ground cover (grasses), NGCS = native ground cover (shrubs), NGCO = native ground cover (other), EPC = exotic cover, OR = overstorey regeneration, NTH = number of trees with hollows, FL = total length of fallen logs, BT = Banksia Thicket, TTT = Teatree Thicket, SC = Sedgeland Complex, CH = Cyperoid Heath, EFW = Eucalypt Fringing Woodland

PlotName	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL	Easting	Northing	Zone	Area	BVT
3107lb1025	51	10	10	2	70	78	0	1	1	36	290059	6201012	56	Riparian	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1028	54	15.5	3	4	4	79	0	4	1	15	290721	6201306	56	Riparian	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1072	29	8.5	6.5	0	36	36	0	3	1	15	290148	6199969	56	Riparian	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1082	38	13	1.5	2	14	74	0	3	1	33	288312	6196839	56	Riparian	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1083	40	31	3	12	22	66	0	3	1	22	288713	6197354	56	Riparian	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1090	42	13.5	50	8	48	60	0	1	1	22	286209	6194476	56	Riparian	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1091	48	21.5	12.5	0	32	46	0	3	1	26	285818	6194596	56	Riparian	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1103	49	22.5	2	0	42	60	0	3	1	22	286409	6197540	56	Riparian	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lp01	27	20	1	0	24	58	0	3	1	66	286411	6193765	56	Riparian	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lp130	30	16	3	0	30	55	0	4	1	52	286060	6193495	56	Riparian	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107AC239	34	0	0	0	12	100	0	0	1	1	291369	6202353	56	Coastal Upland Swamps - CH	HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin
3107AC 257	46	0.5	0	6	66	88	0	0	1	11	291369	6202353	56	Upland Swamp - EFW	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107AC232	34	20	0	22	48	50	0	0	1	0	291369	6202353	56	Upland Swamp – TTT	HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin
3107AC266	32	22	0	0	34	100	0	0	1	0	292399	6198965	56	Upland Swamp - EFW	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1084	34	4	65	0	16	84	0	0	1	0	289296	6196543	56	Upland Swamp - BT	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1088	20	1	75	6	12	70	0	0	1	0	286616	6195214	56	Upland Swamp – BT	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1088	21	0	60	4	14	40	0	0	1	0	289469	6195054	56	Upland Swamp – BT	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1065	26	0	0	0	20	80	0	0	1	0	292095	6199136	56	Upland Swamp – CH	HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin
3107lb1046	43	5	2.5	0	76	96	0	0	1	2	292178	6200811	56	Upland Swamp – EFW	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1132	40	8	15.5	0	62	86	0	3	1	25	285191	6195538	56	Upland Swamp – EFW	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb131		14	3	0	8	47	0	7	1	0	288042	6194302	56	Upland Swamp – EFW	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1030	18	0	40	0	44	100	0	0	1	5	291065	6201220	56	Upland Swamp - SC	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1033	30	0	0	20	6	74	0	0	1	8	290506	6201926	56	Upland Swamp - SC	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1053	29	0	0	2	28	70	0	0	1	0	291666	6200390	56	Upland Swamp - SC	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion

PlotName	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL	Easting	Northing	Zone	Area	BVT
3107lb1059	30	0	0	2	36	100	0	0	1	0	291972	6199867	56	Upland Swamp - SC	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1076	22	0	0	44	18	68	0	0	1	0	285281	6196081	56	Upland Swamp - SC	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1095	27	0	0	20	14	96	0	0	1	0	286517	6196541	56	Upland Swamp - SC	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1111	40	0	0	4	66	100	0	0	1	0	285821	6196730	56	Upland Swamp - SC	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1114	23	0	0	12	26	82	0	0	1	0	286025	6196522	56	Upland Swamp - SC	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1138	28	0	0	16	64	100	0	0	1	0	288139	6194991	56	Upland Swamp - SC	HN560 Needlebush - banksia wet heath on sandstone plateaus of the Sydney Basin Bioregion
3107lb1039	18	0	60	16	78	100	0	0	1	0	291030	6201579	56	Upland Swamp - TTT	HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin
3107lb1108	23	0	0	8	60	74	0	0	1	8	286830	6197570	56	Upland Swamp - TTT	HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin
3107lb1134	45	0	15.5	18	40	100	0	0	1	5	285893	6195731	56	Upland Swamp - TTT	HN662 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin
3107lb1156	42	17.5	19	0	46	40	0	3	1	56	287931	6177692	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1157	36	22.5	17	6	14	30	0	2	1	9	287880	6197533	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1158	36	14.5	1	0	22	38	0	3	1	32	287771	6197653	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1159	37	4.5	6	16	44	54	0	2	1	10	287363	6195393	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1160	38	11	2	0	16	32	0	4	1	41	287481	6195451	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1161	34	2	5.5	8	62	36	0	0	1	2	287686	6195187	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1165	30	16.5	10	6	22	32	0	4	1	8	291235	6197772	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1166	37	5.5	0	2	38	26	0	2	1	26	291123	6197678	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1167	36	10	25.5	18	30	38	0	2	1	4	291145	6197473	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1168	33	3.5	16.5	0	26	16	0	2	1	28	291087	6197307	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1169	35	10	20.5	8	32	18	0	1	1	6	291603	6198410	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1170	38	12.5	8	0	36	4	0	3	1	38	291746	6198541	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb1171	33	13	10	4	46	24	0	1	1	11	291853	6198695	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion
3107lb05	42	15	20	4	22	38	0	2	1	44	287961	6195129	56	Ventilation shaft	HN566 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus of the Sydney Basin Bioregion

Appendix 5. Fauna Species List

Common Name	Scientific Name	BC Act Status	EPBC Act Status	Total Records	Relative Abundance*
Australian Hobby	*Falco longipennis*	P	-	1	U
Australian King-Parrot	*Alisterus scapularis*	P	-	1	O
Australian Magpie	*Cracticus tibicen*	P	-	3	C
Australian Owlet-nightjar	*Aegotheles cristatus*	P	-	2	C
Australian Pelican	*Pelecanus conspicillatus*	P	-	1	U
Australian Raven	*Corvus coronoides*	P	-	3	C
Bearded Dragon	*Pogona barbata*	P	-	1	R
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	P	-	1	O
Blackish Blind Snake	*Ramphotyphlops nigrescens*	P	-	3	U
Bleating Tree Frog	*Litoria dentata*	P	-	2	O
Blue Mountains Tree Frog	*Litoria citropa*	P	-	4	C
Brown Falcon	*Falco berigora*	P	-	1	U
Brown Thornbill	*Acanthiza pusilla*	P	-	2	C
Brown-headed Honeyeater	*Melithreptus brevirostris*	P	-	2	U
Cat	*Felis catus*	-	-	4	O
Channel-billed Cuckoo	*Scythrops novaehollandiae*	P	-	1	U
Chocolate Wattled Bat	*Chalinolobus morio*	P	-	8	C
Common Brushtail Possum	*Trichosurus vulpecula*	P	-	2	O
Common Eastern Froglet	*Crinia signifera*	P	-	14	C
Common Ringtail Possum	*Pseudocheirus peregrinus*	P	-	2	O
Common Wombat	*Vombatus ursinus*	P	-	16	C
Copper-tailed Skink	*Ctenotus taeniolatus*	P	-	16	C
Crimson Rosella	*Platycercus elegans*	P	-	7	C
Eastern Banjo Frog	*Limnodynastes dumerilii*	P	-	4	C
Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis*	V	-	2	U
Eastern Broad-nosed Bat	*Scotorepens orion*	P	-	4	U
Eastern Brown Snake	*Pseudonaja textilis*	P	-	2	O
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V	-	1	U
Eastern Freetail-bat	*Mormopterus norfolkensis*	V	-	1	U
Eastern Grey Kangaroo	*Macropus giganteus*	P	-	2	O
Eastern Small-eyed Snake	*Cryptophis nigrescens*	P	-	2	U
Eastern Spinebill	*Acanthorhynchus tenuirostris*	P	-	22	C
Eastern Water Dragon	*Physignathus lesueurii*	P	-	1	O
Eastern Water-skink	*Eulamprus quoyii*	P	-	4	C
Eastern Whipbird	*Psophodes olivaceus*	P	-	2	O
Eastern Yellow Robin	*Eopsaltria australis*	P	-	3	O
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	P	-	4	O
Fox	*Vulpes vulpes*	-	-	4	O
Golden Whistler	*Pachycephala pectoralis*	P	-	4	O
Golden-tipped Bat	*Kerivoula papuensis*	V	-	1	R

Common Name	Scientific Name	BC Act Status	EPBC Act Status	Total Records	Relative Abundance*
Gould's Wattled Bat	*Chalinolobus gouldii*	P	-	14	C
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V	-	3	O
Greater Glider	*Petauroides volans*	P	V	3	U
Grey Butcherbird	*Cracticus torquatus*	P	-	1	O
Grey Currawong	*Strepera versicolor*	P	-	2	U
Grey Fantail	*Rhipidura albiscapa*	P	-	19	C
Grey Shrike-thrush	*Colluricincla harmonica*	P	-	11	C
Haswell's Frog	*Paracrinia haswelli*	P	-	1	U
House Mouse	*Mus musculus*	-	-	6	O
Jacky Lizard	*Amphibolurus muricatus*	P	-	4	O
Koala	*Phascolarctos cinereus*	V	V	6	O
Lace Monitor	*Varanus varius*	P	-	6	O
Large Forest Bat	*Vespadelus darlingtoni*	P	-	25	C
Laughing Kookaburra	*Dacelo novaeguineae*	P	-	3	O
Leaden Flycatcher	*Myiagra rubecula*	P	-	1	U
Leaf Green River Tree Frog	*Litoria nudidigita*	P	-	7	C
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	P	-	31	C
Lesueur's Frog	*Litoria lesueuri*	P	-	11	C
Lesueur's Velvet Gecko	*Oedura lesueurii*	P	-	7	O
Little Bentwing-bat	*Miniopterus australis*	V	-	1	U
Little Forest Bat	*Vespadelus vulturnus*	P	-	22	C
Little Wattlebird	*Anthochaera chrysoptera*	P	-	2	O
Littlejohn's Tree Frog	*Litoria littlejohni*	V	V	6	O
Mormopterus ridei	*Mormopterus ridei*	P	-	4	O
New Holland Honeyeater	*Phylidonyris novaehollandiae*	P	-	7	C
Noisy Friarbird	*Philemon corniculatus*	P	-	9	C
Peron's Tree Frog	*Litoria peronii*	P	-	3	O
Pied Currawong	*Strepera graculina*	P	-	10	C
Pilotbird	Pycnoptilus floccosus	P		1	R
Rabbit	*Oryctolagus cuniculus*	-	-	1	U
Red Wattlebird	*Anthochaera carunculata*	P	-	2	O
Red-bellied Black Snake	*Pseudechis porphyriacus*	P	-	2	O
Red-throated Skink	*Acritoscincus platynota*	P	-	2	U
Rocket Frog	*Litoria nasuta*	P	-	3	U
Rockwarbler	*Origma solitaria*	P	-	8	C
Rosenberg's Goanna	*Varanus rosenbergi*	V	-	8	O
Rufous Whistler	*Pachycephala rufiventris*	P	-	7	C
Sacred Kingfisher	*Todiramphus sanctus*	P	-	2	O
Satin Bowerbird	*Ptilonorhynchus violaceus*	P	-	1	O
Satin Flycatcher	*Myiagra cyanoleuca*	P	M	2	O
Scarlet Robin	*Petroica boodang*	V	-	2	O

Common Name	Scientific Name	BC Act Status	EPBC Act Status	Total Records	Relative Abundance*
Shining Bronze-Cuckoo	*Chalcites lucidus*	P	-	2	O
Short-beaked Echidna	*Tachyglossus aculeatus*	P	-	10	O
Silvereye	*Zosterops lateralis*	P	-	1	O
Skink sp.	*Scincidae sp.*	P	-	1	N/A
Snake-eyed Skink	*Crytoblephalus virgatus*	P	-	1	U
Southern Boobook	*Ninox novaeseelandiae*	P	-	4	O
Southern Emu-wren	*Stipiturus malachurus*	P	-	2	R
Southern Forest Bat	*Vespadelus regulus*	P	-	4	O
Spotted Grass Frog	*Limnodynastes tasmaniensis*	P	-	2	U
Spotted Pardalote	*Pardalotus punctatus*	P	-	15	C
Spotted Quail-thrush	*Cinclosoma punctatum*	P	-	8	C
Striated Pardalote	*Pardalotus striatus*	P	-	2	O
Striated Thornbill	*Acanthiza lineata*	P	-	14	C
Striped Marsh Frog	*Limnodynastes peronii*	P	-	1	U
Sugar Glider	*Petaurus breviceps*	P	-	3	O
Superb Fairy-wren	*Malurus cyaneus*	P	-	3	O
Superb Lyrebird	*Menura novaehollandiae*	P	-	13	C
Swamp Wallaby	*Wallabia bicolor*	P	-	28	C
Tawny Frogmouth	*Podargus strigoides*	P	-	1	O
Tree Martin	*Petrochelidon nigricans*	P	-	1	O
Unidentified Antechinus	*Antechinus sp.*	P	-	4	O
Varied Sittella	*Daphoenositta chrysoptera*	V	-	1	R
Variegated Fairy-wren	*Malurus lamberti*	P	-	4	U
Vespadelus sp.	*Vespadelus sp.*	P	-	20	C
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	V	M	1	R
White-browed Scrubwren	*Sericornis frontalis*	P	-	1	O
White-eared Honeyeater	*Lichenostomus leucotis*	P	-	4	O
White-striped Freetail-bat	*Tadarida australis*	P	-	2	U
White-throated Gerygone	*Gerygone albogularis*	P	-	1	U
White-throated Nightjar	*Eurostopodus mystacalis*	P	-	2	O
White-throated Treecreeper	*Cormobates leucophaea*	P	-	12	C
Wonga Pigeon	*Leucosarcia picata*	P	-	3	C
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	V	-	1	U
Yellow-faced Honeyeater	*Lichenostomus chrysops*	P	-	6	O
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*	P	-	1	O

* P = Protected under BC Act; V = Vulnerable under BC Act or EPBC Act; M = Migratory under EPBC Act; R = Rare; U = Uncommon; O = Occasional; C = Common.

Appendix 6. Weather Conditions During Field Survey

Table 44. Campbelltown (068257), New South Wales September 2016 Daily Weather Observations (BOM 2017).

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	9am relative humidity (%)	9am wind direction	9am wind speed (km/h)	3pm relative humidity (%)	3pm wind direction	3pm wind speed (km/h)
01/09/2016	5.8	22.5	0	72	-	Calm	32	ENE	9
02/09/2016	12.5	17.1	7.4	99	S	4	99	ESE	6
03/09/2016	12.9	20	22.2	54	WNW	17	42	WSW	19
04/09/2016	6.3	19.7	0	54	WSW	9	32	W	13
05/09/2016	4.7	21.3	0	68	SSW	7	30	NE	9
06/09/2016	5.2	23.7	0	74	W	7	30	NE	9
07/09/2016	7.4	23.3	0	82	SW	9	53	ENE	11
08/09/2016	13.6	23.7	0	87	NE	7	47	NE	9
09/09/2016	9.4	25.7	0	79	N	7	52	ENE	13
10/09/2016	12.9	21.9	2	65	NNW	19	35	WSW	15
11/09/2016	6.4	21.3	0	53	WSW	7	34	E	7
12/09/2016	6.2	21.2	0	63	SSW	7	42	NNE	7
13/09/2016	11.8	20.8	0	72	SSE	6	61	N	7
14/09/2016	13.7	23.8	0.8	99	SW	2	60	N	13
15/09/2016	7.6	20.8	0.2	32	NW	19	33	NNW	20
16/09/2016	10.2	20.8	0.2	63	SW	7	30	SW	15
17/09/2016	4.3	22.1	0.2	61	N	4	34	NNW	7
18/09/2016	8.7	16.6	0	79	S	7	95	NE	6
19/09/2016	9.7	19.6	12	60	W	17	35	SW	13
20/09/2016	4.6	19.4	0.2	53	SW	6	32	N	9
21/09/2016	10.7	19.3	0	66	NNW	4	82	N	11
22/09/2016	8.2	18.3	1.6	59	WSW	13	54	WSW	11
23/09/2016	12.9	22	0.2	50	SSW	19	46	S	13
24/09/2016	6.9	23.6	0	63	S	6	47	NE	11
25/09/2016	12.8	23.1	0	65	NW	7	46	S	9
26/09/2016	7.8	22.5	0.4	46	WSW	15	31	SSW	7
27/09/2016	3.3	21.8	0	58	N	9	22	SW	22
28/09/2016	3.7	20.9	0	53	SW	9	34	E	9
29/09/2016	6.9	21.3	3.6	98	-	Calm	60	N	17
30/09/2016	7.4	18.1	1.4	39	NW	17	36	NW	20

Table 45: Campbelltown (068257), New South Wales October 2016 Daily Weather Observations (BOM 2017)

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	9am relative humidity (%)	9am wind direction	9am wind speed (km/h)	3pm relative humidity (%)	3pm wind direction	3pm wind speed (km/h)
01/10/2016	6.2	20.1	0	53	W	11	36	WNW	22
02/10/2016	4.7	26.4	0	66	N	6	24	NNE	11
03/10/2016	13.4	24	0	48	N	22	17	WSW	20
04/10/2016	12.7	23	0	37	W	11	22	WNW	20
05/10/2016	8.6	21.6	0	40	WSW	13	15	WSW	22
06/10/2016	11	27.1	0	31	W	11	19	W	19
07/10/2016	9.6	29.7	0	49	NW	9	12	WSW	17
08/10/2016	12.6	22.5	0	55	SE	7	55	S	11
09/10/2016	7.8	23.7	0	56	W	6	36	NNE	15
10/10/2016	9.6	31.4	0	61	NNW	9	32	SW	19
11/10/2016	10.5	19.7	0	32	W	19	23	WSW	13
12/10/2016	3.4	22.3	0	52	WSW	11	25	SW	11
13/10/2016	9.1	19.5	0	54	SSW	15	38	S	13
14/10/2016	3.3	22	0	63	SW	9	18	NE	9
15/10/2016	4.2	26.7	0	64	WSW	6	19	NNW	13
16/10/2016	6	30.2	0	47	NNW	13	18	NW	15
17/10/2016	17.2	19.8	0	53	SW	11	73	NE	6
18/10/2016	5.5	24.7	0.8	45	NNW	9	22	NW	17
19/10/2016	8.7	22.5	0	35	WSW	13	13	SW	13
20/10/2016	9.1	23.4	0	62	NNE	7	44	ENE	17
21/10/2016	8.9	28.1	0	73	N	11	27	N	9
22/10/2016	15.4	21.1	4.6	97		Calm	36	SW	13
23/10/2016	6	20.7	0	45	SSW	19	41	SE	13
24/10/2016	5.5	23.1	0	51	SSW	11	31	SE	13
25/10/2016	4.7	27	0	66	NNW	6	20	N	9
26/10/2016	7.3	29.6	0	51		Calm	13	WNW	11
27/10/2016	10.2	24.2	0	62	SE	9	59	ESE	15
28/10/2016	12.2	19.4	2.2	96	SW	7	73	ESE	6
29/10/2016	12.9	25.3	0.4	80	SE	7	61	ENE	13
30/10/2016	17.6	27.5	0	75	N	13	41	N	22
31/10/2016	12.7	22.1	6.8	24	SW	17	13	WSW	15

Table 46: Campbelltown (068257), New South Wales November 2016 Daily Weather Observations (BOM 2017)

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	9am relative humidity (%)	9am wind direction	9am wind speed (km/h)	3pm relative humidity (%)	3pm wind direction	3pm wind speed (km/h)
01/11/2016	5.7	24.7	0	36	SSW	7	17	WNW	15
02/11/2016	5.6	26.9	0	39	W	9	14	SW	13
03/11/2016	8.4	29.6	0	42	SW	6	17	NNW	17
04/11/2016	10.1	30.3	0	49	NW	6	11	SW	19
05/11/2016	13.6	23.8	0	11	WSW	24	14	WSW	20
06/11/2016	7.8	24.9	0	27	W	15	17	SW	15
07/11/2016	7.9	33.9	0	39	NW	7	12	NW	15
08/11/2016	12.8	28.5	0	65	-	Calm	39	E	9
09/11/2016	16.3	24.1	1.6	82	ENE	6	81	ESE	11
10/11/2016	14	28.4	2.2	89	SSW	7	49	ENE	13
11/11/2016	14.8	26.4	0	66	SSE	2	49	ENE	15
12/11/2016	17.3	34.7	8.6	95	N	6	28	WNW	9
13/11/2016	14	28.6	0.2	30	WNW	9	13	WNW	28
14/11/2016	16.2	24.2	0	42	SW	19	44	SE	15
15/11/2016	12.7	24	2.8	72	SSW	7	42	SE	17
16/11/2016	9.3	25.4	0	51	SSW	9	47	ESE	15
17/11/2016	13.1	27.6	0	57	N	7	30	N	11
18/11/2016	11.2	37.4	0.2	62	NNW	7	11	SW	13
19/11/2016	15.1	26.1	0	57	SE	6	60	SE	13
20/11/2016	17.6	30.6	0	71	NNE	9	35	NNE	11
21/11/2016	15.1	34.7	0	60	NNE	7	27	N	15
22/11/2016	15	36.3	0	48	NNE	4	12	N	6
23/11/2016	18.1	32.5	0	62	N	7	78	SE	15
24/11/2016	9.3	24.6	11.2	40	SSW	17	35	E	17
25/11/2016	8.8	27.1	0	42	WSW	7	38	ESE	19
26/11/2016	12.2	30.3	0	61	N	9	20	N	9
27/11/2016	16	26.4	0	70	ESE	9	52	E	17
28/11/2016	18	32.4	0	66	N	9	36	NNE	13
29/11/2016	16.7	26.8	0	61	SSW	7	51	SE	13
30/11/2016	15.9	27.4	0	63	N	9	49	ENE	15

Table 47: Campbelltown (068257), New South Wales December 2016 Daily Weather Observations (BOM 2017)

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	9am relative humidity (%)	9am wind direction	9am wind speed (km/h)	3pm relative humidity (%)	3pm wind direction	3pm wind speed (km/h)
01/12/2016	14.9	33.6	0	83	N	7	50	S	9
02/12/2016	14.4	35.8	0.8	40	SSW	6	11	WSW	13
03/12/2016	19.5	29.2	0	61	ESE	7	48	ESE	15
04/12/2016	15.4	31	0	64	N	9	42	ENE	15
05/12/2016	20.6	34.2	0.6	74	N	9	80	NNW	2
06/12/2016	19.8	25.8	3	73	SE	6	93	NNW	4
07/12/2016	15.7	26.8	9.6	72	S	7	50	NE	11
08/12/2016	16.9	33.7	0.2	70	N	7	38	ENE	13
09/12/2016	16.5	26.8	0	31	WSW	24	15	WNW	19
10/12/2016	11.5	25.8	0	58	N	9	42	ENE	17
11/12/2016	16.8	29	0	60	NE	9	42	ESE	17
12/12/2016	16	32.4	0	65	N	11	37	NNE	15
13/12/2016	16.1	38.7	0	52	N	9	8	W	15
14/12/2016	19	35.1	0	18	WNW	11	24	SW	11
15/12/2016	16.1	18.1	6.4	95	SSE	6	85	ESE	9
16/12/2016	15.5	25.2	17.8	99	SSW	6	92	NW	6
17/12/2016	17.2	33.3	7.6	61	NNW	11	25	NW	13
18/12/2016	16.7	21.2	0	58	SE	9	50	SSE	9
19/12/2016	13.1	24.5	0	62	N	11	42	NE	13
20/12/2016	11.6	36.1	0	61	N	7	19	NW	17
21/12/2016	13.9	29.5	0	62	SE	4	46	E	15
22/12/2016	18.2	24.4	0	74	ENE	6	50	E	13
23/12/2016	18.9	27.5	0	63	N	11	49	NNE	13
24/12/2016	15.8	30.1	0	70	N	6	46	N	6
25/12/2016	15.6	30.7	3	69	SSW	2	46	ENE	11
26/12/2016	17	34.5	0.2	70	NNW	6	36	NE	17
27/12/2016	18.7	31.2	3.8	65	E	6	46	ESE	13
28/12/2016	17.6	34.6	0	72	N	6	36	NE	15
29/12/2016	20.8	38.6	0	59	S	6	15	W	11
30/12/2016	22.7	34.7	0	42	WSW	6	32	NW	13
31/12/2016	22.7	32.4	0.8	63	S	7	51	E	15

Table 48: Campbelltown (068257), New South Wales May 2017 Daily Weather Observations (BOM 2017)

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	9am relative humidity (%)	9am wind direction	9am wind speed (km/h)	3pm relative humidity (%)	3pm wind direction	3pm wind speed (km/h)
01/05/2017	7.1	23.9	0	83		Calm	46	N	9
02/05/2017	9.5	22.6	0	61	SW	4	44	SSW	9
03/05/2017	10	18.7	0	59	SSW	9	55	S	9
04/05/2017	9.4	18.9	1.4	79	SSW	9	62	ENE	9
05/05/2017	8.2	22.2	0	75	SW	7	35	NE	9
06/05/2017	6.4	24.3	0	86		Calm	42	NNW	13
07/05/2017	8.2	20.8	0	39	WSW	15	19	SW	9
08/05/2017	3.7	19	0	64	SSW	7	45	SE	4
09/05/2017	6.3	21.3	0	72	SW	7	46	SE	13
10/05/2017	4.6	21.2	0	81	SW	7	34	N	6
11/05/2017	5	21.3	0	79	SSW	6	46	SSE	6
12/05/2017	6.8	20	0	87	SW	6	63		Calm
13/05/2017	10	21.9	0	88	WNW	6	53	NNE	9
14/05/2017	9.8	20.1	0	99	SSW	9	64	E	9
15/05/2017	9.1	20.9	0.2	82	SW	9	33	S	13
16/05/2017	5.2	21.2	0	72	SSW	9	33	SSE	6
17/05/2017	5.2	20.4	0	79	SW	6	47	NNE	7
18/05/2017	8.7	22.3	0	85		Calm	69	E	9
19/05/2017	12.2	18.4	0	87	SE	2	81	NNE	11
20/05/2017	15	22.9	6	99	NNW	4	58	ESE	6
21/05/2017	8.9	22.4	0	76	S	4	38	SE	6
22/05/2017	10	21.6	0	92	SSW	9	51	NNE	9
23/05/2017	10	22.9	0	93	SW	6	48	N	9
24/05/2017	9	21.4	7.6	94	S	4	31	W	19
25/05/2017	7.1	20.4	0	69	SSW	9	32	NNE	7
26/05/2017	5.7	20.5	0	71	SSW	7	52	SE	9
27/05/2017	7.5	21	0	88	S	6	52	N	9
28/05/2017	4.8	22	0.2	99	SSW	2	36	WNW	9
29/05/2017	6.5	16.5	0.2	45	WSW	11	29	WSW	11
30/05/2017	0	17.8	0	66	SW	7	36	W	17
31/05/2017	6.8	15.9	0	68	SSW	9	35	S	13

Table 49: Campbelltown (068257), New South Wales June 2017 Daily Weather Observations (BOM 2017)

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	9am relative humidity (%)	9am wind direction	9am wind speed (km/h)	3pm relative humidity (%)	3pm wind direction	3pm wind speed (km/h)
01/06/2017	2.7	17.7	0	57	SW	15	36	S	9
02/06/2017	4.6	18.2	0	65	SSW	7	37	S	9
03/06/2017	7.6	18.1	0	67	SW	9	60	S	9
04/06/2017	6	19.8	0	87	SSW	6	42	NE	4
05/06/2017	4.8	18.8	0	86	SSW	7	35	NNW	6
06/06/2017	2.5	17.2	0	65	SW	7	30	SSW	13
07/06/2017	7.7	14.8	22.4	95	SW	11	85	S	11
08/06/2017	10.9	19	17.8	98	SSW	7	67	S	9
09/06/2017	7.2	19.4	0.4	86	SSW	6	62	SSE	11
10/06/2017	11.8	16	29.4	99	SSW	7	84	S	7
11/06/2017	8.1	18.1	4	99	-	Calm	73	-	Calm
12/06/2017	7.6	21.3	0.2	99	SSW	2	67	E	9
13/06/2017	6.2	20	0.4	83	SSW	11	55	SSE	9
14/06/2017	8.7	20.3	0	79	SSW	6	60	NNW	9
15/06/2017	6.1	19.6	0.2	99	S	6	60	N	6
16/06/2017	8.9	16.2	0	90	-	Calm	73	-	Calm
17/06/2017	10.9	18.6	0	79	SSW	9	75	SSW	7
18/06/2017	7.6	18.1	0	87	SSW	9	52	S	13
19/06/2017	8.7	19.7	0	72	WSW	6	50	S	9
20/06/2017	7.2	20.2	0	86	SW	7	53	NNW	6
21/06/2017	2.3	19.2	0	77	S	4	45	SSE	9
22/06/2017	4.7	18.4	0	90	SW	7	45	N	9
23/06/2017	4.1	17.1	0.2	99	S	6	62	NNW	7
24/06/2017	1.7	18.6	0	91	NW	2	32	SW	13
25/06/2017	0.5	17.8	0.2	99	-	Calm	32	WSW	17
26/06/2017	1.9	18	0	90	-	Calm	33	W	6
27/06/2017	2.2	15.7	0	86	SSW	6	64	-	Calm
28/06/2017	6.4	14.4	0	99	S	6	91	N	9
29/06/2017	6.7	17.1	0.6	77	SSW	7	37	SW	11
30/06/2017	2.2	15.5	0	69	S	7	26	SSW	13

Table 50: Campbelltown (068257), New South Wales July 2017 Daily Weather Observations (BOM 2017)

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	9am relative humidity (%)	9am wind direction	9am wind speed (km/h)	3pm relative humidity (%)	3pm wind direction	3pm wind speed (km/h)
01/07/2017	1	16.4	0	64	SSW	6	36	SW	7
02/07/2017	0	16	0	87	S	7	29	N	9
03/07/2017	-0.7	13.8	0.2	97	W	2	76	-	Calm
04/07/2017	2.3	21.4	0.4	99	-	Calm	25	SSE	4
05/07/2017	3	20	0.2	80	N	6	39	SW	6
06/07/2017	3	17.6	0	80	-	Calm	30	SW	11
07/07/2017	-1.2	18.2	0	99	-	Calm	26	NW	6
08/07/2017	-0.7	17.1	0	91	-	Calm	35	WSW	13
09/07/2017	-0.5	17	0	84	WNW	6	29	WSW	9
10/07/2017	-0.6	17	0.2	87	SW	2	32	SW	13
11/07/2017	0.8	18	0.2	79	S	6	40	S	11
12/07/2017	2.2	17	0	75	SW	6	51	SSE	9
13/07/2017	2.5	17.1	0	83	SSW	6	50	N	9
14/07/2017	0.6	18.6	0	99	-	Calm	44	N	9
15/07/2017	6.8	18.4	0	78	NNW	6	31	SSW	6
16/07/2017	0	16.6	0	67	SSW	6	28	NNE	9
17/07/2017	1.3	17.9	0	82	SW	6	53	N	4
18/07/2017	1	22.3	0	99	-	Calm	20	WNW	15
19/07/2017	7.2	16.3	0	51	W	13	35	W	19
20/07/2017	3.5	15.3	0	48	SW	9	29	W	19
21/07/2017	2.6	-	0	56	SW	13	-	-	-

Table 51: Campbelltown (068257), New South Wales May 2018 Daily Weather Observations (BOM 2017)

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	9am relative humidity (%)	9am wind direction	9am wind speed (km/h)	3pm relative humidity (%)	3pm wind direction	3pm wind speed (km/h)
01/05/2018	7.2	25.4	0	77	S	6	24.7	13	NNE
02/05/2018	7.9	21.8	0	67	SW	6	20.5	51	N
03/05/2018	8.2	27.8	0	73	SW	6	27.1	22	N
04/05/2018	15.3	27.2	0	41	NNW	17	22.9	19	W
05/05/2018	5.5	24	0	42	NNE	7	23.3	14	NNW
06/05/2018	4.5	23.8	0	56	W	6	22.5	19	N
07/05/2018	6.3	25.2	0	70	SW	4	24.2	25	N
08/05/2018	7.6	26.1	0	89		Calm	25.7	19	NE
09/05/2018	7.5	26	0	64	S	6	25.4	21	N
10/05/2018	7.3	24.8	0	80		Calm	23.1	14	WNW
11/05/2018	3.5	16.6	0	42	NNW	13	15.1	27	W
12/05/2018	5	16.5	0	42	SSW	17	16.3	54	WSW
13/05/2018	12.2	19.8	0.6	58	SW	13	18	46	SSW
14/05/2018	11.9	20.9	0	56	SSW	15	19.5	33	S
15/05/2018	6.3	21.6	0	70	SW	6	21	20	ENE
16/05/2018	5.8	20	0	59	SSW	11	17.7	42	ESE
17/05/2018	6.1	20.4	0	70	S	4	19.5	33	N
18/05/2018	2.6	22.3	0	43	SSW	7	21.8	21	SSW
19/05/2018	3.9	21.5	0	74	S	6	20.1	30	ENE
20/05/2018	1.6	22.8	0	59	NW	7	22.1	18	WSW
21/05/2018	5.9	21.5	0	46	SW	9	19.4	28	WSW
22/05/2018	6.1	23.5	0	44	SSW	9	22.2	28	WSW
23/05/2018	10.7	22.7	0	61	S	9	22	29	NNW
24/05/2018	7.1	21.6	0	69	SSW	7	18	63	ESE
25/05/2018	11.5	19.7	0	65	WSW	6	17.3	47	ESE
26/05/2018	4.2	22.2	0	85	S	6	21.4	30	N
27/05/2018	4.7	21.9	0	89	SW	6	19.6	35	N
28/05/2018	6.8	21.7	0	77	SSW	6	20.3	38	NNW
29/05/2018	5.3	24.5	0.2	78		Calm	24.2	26	NNE
30/05/2018	10.1	18.1	4	65	SW	11	16.5	31	WSW
31/05/2018	3.3	18.3	0	57	SSW	7	17	23	SSW

Table 52: Campbelltown (068257), New South Wales June 2018 Daily Weather Observations (BOM 2017)

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	9am relative humidity (%)	9am wind direction	9am wind speed (km/h)	3pm relative humidity (%)	3pm wind direction	3pm wind speed (km/h)
01/06/2018	7.8	18.2	0.2	52	WSW	9	36	S	15
02/06/2018	10	16.5	0	50	SSW	15	53	SSW	19
03/06/2018	10.6	19.7	0	68	SW	11	47	S	15
04/06/2018	8.5	19.1	0	71	SSW	13	48	S	13
05/06/2018	6.2	17.6	0	71	SSW	13	89	S	13
06/06/2018	10.2	19.1	23.4	95	SSW	9	82	ESE	7
07/06/2018	5.6	20.1	10.2	99		Calm	45	NE	13
08/06/2018	7.4	14	0.2	99		Calm	77		Calm
09/06/2018	9.1	15.2	8.2	99		Calm	85	SW	6
10/06/2018	5.9	18.3	0.4	86	SSW	11	70	SSW	13
11/06/2018	7.4	19.6	0	79	SW	7	44	SSE	9
12/06/2018	2.7	16.6	0.2	99		Calm	65		Calm
13/06/2018	4.9	19	0	82	N	7	36	WSW	13
14/06/2018	2.1	18.3	0	94	N	6	25	W	17
15/06/2018	3	19.3	0	46	N	19	34	W	26
16/06/2018	5.3	17.6	0	34	W	13	24	NNW	22
17/06/2018	2.4	14.7	0	47	WSW	17	31	WSW	19
18/06/2018	8.2	17.6	0	51	SSW	17	31	SSW	20

Appendix 7. EPBC Act Assessments of Significance

Matters for Assessment

Assessments of Significance and supplementary information (where relevant) are presented for the following MNES in relation to the Project:

- Threatened Ecological Communities
  - Coastal Upland Swamps of the Sydney basin bioregion
  - Shale Sandstone Transition Forest
- Threatened flora
  - *Leucopogon exolasius*
  - *Pultenaea aristata*
  - *Pomaderris brunnea*
- Threatened Fauna
  - Littlejohn's Tree Frog
  - Giant Burrowing Frog
  - Koala
  - Grey-headed Flying-fox
  - Greater Glider

Coastal Upland Swamps	Endangered Ecological Community	Likelihood
An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:		
1. reduce the extent of an ecological community		
A total of 46 Coastal Upland Swamps were mapped by Niche within the Study Area totalling an area of 87.5 ha of which 37.6 ha is Eucalypt Fringing Woodland and is not listed under the TEC. Each of the Coastal Upland Swamps within the Study Area have been shown in Figure 8. The impact predictions provided in MSEC (2019) indicate that those Coastal Upland Swamps above longwalls are more susceptible to the effects of subsidence, compared to Coastal Upland Swamps located further away, and that it is unlikely that there would be large-scale adverse changes in the levels of ponding or scouring of the swamps based on the predicted vertical subsidence and tilt. Of the 46 Coastal Upland Swamps recorded within the Study Area, 25 are located above longwalls, or occur within 60 m from the proposed longwalls. The area of the 25 Coastal Upland Swamps equates to 21.6 ha. Using the MSEC (2019) predictions, fracturing could occur within the bedrock beneath these Coastal Upland Swamps. The remaining Coastal Upland Swamps are predicted by MSEC (2019) to be unlikely to experience significant fracturing. Given the reliance of Coastal Upland Swamps on hydrology it is therefore reasonable to assume that the following key impacts have the potential to occur to Coastal Upland Swamps that have hydrology changes: 1. Reduction in groundwater levels or desaturation of the Coastal Upland Swamp sediments. 2. Transition of the Coastal Upland Swamp to a drier vegetation type. 3. Desaturation of soil particles exposing the swamp to peat desiccation. 4. Exposure to bushfire of greater intensity due to loss of inundation. 5. Scour and erosion events. Each of these impacts and their likelihood of occurrence is described in Appendix 8. In summary, there is the possibility that Coastal Upland Swamps directly above the longwalls, may transition to a drier woodland vegetation type and thus the extent of the ecological community may be reduced.		Possible
2. fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines		
There is the potential for Coastal Upland Swamps, or areas within the swamp to transition to drier vegetation should subsidence-induced cracking result in hydrological changes. To date, this has not been observed in monitoring data (Appendix 8). However, should vegetation transition to Eucalypt Fringing Woodland, or a woodland community, then the area that has transitioned, would no longer meet the EEC determination. There is potential for fragmentation to occur if the transition to a non-EEC vegetation type splits the Coastal Upland Swamp into smaller areas. To date, this has not been observed in the historical mapping completed by Biosis (2015; 2017).		Possible
3. adversely affect habitat critical to the survival of an ecological community		
According to the Scientific Committee (2012) approximately 5,360 ha of Coastal Upland Swamps have been mapped based on an amalgamation of best available regional vegetation mapping throughout the range of the community, with approximately 83% of this area occurring on the Woronora Plateau (DECCW 2009, Tozer et al. 2010). The majority of the EEC is within land managed by WaterNSW and is within a benchmark condition. The Project is likely to have impacts upon those Coastal Upland Swamps occurring above longwalls with minor and isolated fracturing possible outside of the longwall areas (MSEC 2019). Whilst not predicted, if at an extreme scale, if all 21.6 ha of Coastal Upland Swamp were to be impacted and transition to non-EEC units, this would account for less than 1% of the known occurrence of Coastal Upland Swamps. As such, the remaining areas of Coastal Upland Swamp, much of which are already informally protected within WaterNSW landholdings, would still persist. The Project is therefore unlikely to adversely affect habitat important to the survival of the Coastal Upland Swamp EEC.		Unlikely
4. modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological		
Subsidence from longwall mining may cause the water table to drop from the near surface to below the sandstone base, under the swamp sediments (Young 2017). This in turn impacts upon the natural recharge and discharge system of the Coastal Upland Swamp. This process is described in Young (2017) as involving the following: • Water table within the swamp rises to near surface from rainfall event. • Water is lost from the swamp through evapotranspiration, and during high rainfall the runoff can exceed the storage capacity of the sediments so that water flows out at the swamp exit. • After a swamp is mined under and where there is an impact on the groundwater levels, the water table drops rapidly, and even after heavy rain, rises only briefly before sinking again to below the bedrock base. • The swamps inundate occasionally but much less frequently and for a much shorter period than prior to mining. It is known based on existing monitoring data (Appendix 8), that changes to groundwater recession rates occur in Coastal Upland Swamps when a longwall passes beneath. Of the Coastal Upland Swamps in the Study Area, 24 will be mined directly beneath, and as such are likely to experience some degree of recession change. Estimates of the recovery to natural baseline are not known. A reduction in the water table from subsidence may result in changes to the cohesion of the soils within a Coastal Upland Swamp. The organic matter within the soil may undergo a hydrophobic reaction, which in turn results in the organic matter, which binds the sand grains, becoming loose and resulting in sediments that are highly erodible (Young 2017, DPE 2015). At an extreme range, the effect of this occurring may expose a Coastal Upland Swamp to erosion and scouring events. However, it should be noted that MSEC (2019) state that erosion and scouring events are unlikely to occur in the Study Area. The associated effect from the groundwater change, is a transition of a Coastal Upland Swamp to a drier woodland vegetation type over time. This process has been discussed in Appendix 8 and has not yet been detected in the monitoring analysis to date.		Possible

Coastal Upland Swamps	Endangered Ecological Community	Likelihood
In regards to the Coastal Upland Swamps of the Study Area, it is therefore likely that swamps located above longwalls (25 are located above longwalls), would experience some degree of groundwater impact, which in turn may change the soil cohesion and vegetation composition of the community.		
5. modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns		
As discussed above, of the Coastal Upland Swamps within the Study Area, 25 may be mined beneath and therefore may be subject to some degree of fracturing compared to the other Coastal Upland Swamps in the Study Area. Indirect impacts associated with this include: • change in groundwater recession and flow • change in surface water flow • transition of Coastal Upland Swamp to a drier woodland vegetation type • Soil cohesion changed to erodible particles. In total the area of impact is likely to be 21.6 ha, which constitutes the Coastal Upland Swamps located above longwalls only. Predicted impacts to Coastal Upland Swamps located outside these areas are considered to be minor and isolated (MSEC 2019).		Possible
6. cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting		
Coastal Upland Swamp vegetation is likely to be relatively resilient to short-term changes in groundwater level and soil moisture, demonstrated by the persistence of the swamp vegetation communities during extended periods of drought. However, it is reasonable to suggest that changes to swamp hydrology that are extensive and persistent may result in a vegetation response. The thresholds that influence such a vegetation transition is unknown. The Coastal Upland Swamps within the Study Area comprise the predominately drier vegetation types including: approximately 49% of Eucalypt Fringing Woodland, 32% of Restioid heath, and 5% of Banksia Thicket. Wetter vegetation communities consisted of 10% of Teatree Thicket, 0.4% Sedgeland Complex and 3.5% Cyperoid Heath. It is reasonable to suggest that a decrease in species distribution or abundance, or extent of sub-communities, that are reliant on semi-permanent to permanent waterlogging (such as Tea-tree Thicket and Cyperoid Heath) within a swamp that has experienced lower water levels following mining, may signify a vegetative impact from mining. Similarly, an increase in drier vegetation types within swamps that have experienced lower water levels following mining, such as Banksia Thicket or Eucalypt Fringing Woodland, may also serve as an indicator of mining impacts. Given the majority (86%) of Coastal Upland Swamps of the Study Area are made of up of drier subvegetation communities (Eucalypt Fringing Woodland, Banksia Thicket and Restioid Heath), it is also possible that these communities are more resilient to hydrological changes, given they are not as dependent on waterlogged peat compared to wetter subvegetation communities (Teatree Thicket, and Cyperoid Heath). However to date, no studies have been completed to support this. Within recent years, LiDAR and historic aerial mapping of Coastal Upland Swamps has been incorporated in both Dendrobium and Wollongong Coal monitoring programs, to determine if Coastal Upland Swamp boundaries have changes as a result of longwall mining. The LiDAR and historic aerial mapping analysis completed by Biosis (2015, 2016, 2017) indicates that there has been a decline in the size of Coastal Upland Swamps and sub-vegetation communities within the Dendrobium and Russell Vale mining domains. This decline in size of swamps was evidenced by the inward contraction of the swamp perimeter, leading to an encroachment of Eucalypt Fringing Woodland. The historical mapping of Coastal Upland Swamps for Dendrobium and Russell Vale showed that a decline in the size of Coastal Upland Swamps has occurred regardless of mining status, although impacted swamps showed a greater decline on average. Monitoring at Russell Vale indicated that the size of Coastal Upland Swamps remained stable between 1951 and 1984, with a significant decline occurring between 1984 and 2012 (Biosis 2015). The decline in swamp size was attributed to rainfall, given a strong relationship between declines in Coastal Upland Swamps and a decline in monthly rainfall since the mid-1980s. LiDAR monitoring at Dendrobium Mine indicates that the size of Coastal Upland Swamps at all control and impact swamps in the Dendrobium 3A and 3B areas in 2014, 2015 and 2016 was smaller than the extent measured in the baseline year of 2012. There was a substantial decline in swamp extent from 2012 to 2014, followed by a small increase in swamp extent in 2015, relative to the 2014 extent, and a subsequent decline again in 2016 (Biosis 2017a). Similarly, the change in the extent of Coastal Upland Swamp sub-communities typically decreased substantially from 2012 to 2014, then increased or remained stable from 2014 to 2015, and subsequently decreased again between 2015 and 2016. Whilst there are a number of significant limitations associated with the LiDAR and historic mapping analysis (Biosis 2015; 2016; 2017), the results are similar to the vegetation monitoring; namely that to date, there insufficient evidence to indicate that any observed decrease in swamp extent is a direct result of mining. It is likely that any large-scale vegetative response of Coastal Upland Swamps within the Study Area, would be gradual and may take several years to be fully revealed. However, regardless of this, as detailed in the Scientific Determination for the community, longwall mining has the potential to decrease the size of a Coastal Upland Swamp over time. The Coastal Upland Swamps located above the mining areas within the Study Area therefore have the potential to be impacted and may exhibit such a vegetation change.		Possible
7. cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: **— assisting invasive species, that are harmful to the listed ecological community, to become established, or** **— causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community**		
The Project is not likely to result in the introduction of a disease that may lead to the decline of the EEC. All construction and operation work would not involve direct impacts to the Coastal Upland Swamp EEC. There is potential for increases of iron flocc to occur at fractured areas of bedrock, however no impacts associated with this have been reported at Dendrobium mine.		Unlikely

Coastal Upland Swamps	Endangered Ecological Community	Likelihood
8. interfere with the recovery of an ecological community.		
There is no Coastal Upland Swamp Recovery Plan, however the Project will result in a key threatening process - *Alteration of habitat following subsidence due to longwall mining*, which may impact upon the longevity of the Coastal Upland Swamp EEC in the Study Area.		Possible
Conclusion: The Project is likely to result in a significant impact on the Coastal Upland Swamp EEC as the Project may: 1. reduce the extent of an ecological community 2. cause a substantial change in the species composition of an occurrence of an ecological community 3. modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community to survive 4. interfere with the recovery of the EEC.		

Shale Sandstone Transition Forest	Critically Endangered Ecological Community	Likelihood
An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:		
1. reduce the extent of an ecological community		
The Project would involve the removal of approximately 1.5 ha of Shale Sandstone Transition Forest (SSTF) as a result of clearing required for the Project. For the service boreholes, removal would be done by leaving the rootball of the vegetation intact, to aid rehabilitation following decommissioning of the service boreholes. The clearing would avoid mature and hollow-bearing trees where possible and active restoration including brushmatting would be undertaken immediately upon decommissioning. Only vegetation above an approximate height of 2 m within the transmission line corridor would be cleared and maintained via slashing. Notwithstanding, a full loss scenario has been assumed for the purposes of this assessment an offset strategy. Subsidence as a result of the Project may cause cracking of the soil within the community, however SSTF occurs within drier soils and is not solely dependent on groundwater interaction that may be impacted by surface cracking. Previous vegetation mapping by NPWS (2003) has mapped approximately 641 ha of SSTF as occurring within a 10,000 ha radius of the Study Area. The Project will therefore result in a short-term reduction in the extent of the SSTF in the locality by less than 1%.		Short-term
2. fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines		
Approximately 1.5 ha of SSTF would be impacted by the required clearing for the Project. The precise location of the clearing has not yet been determined, however the placement of the service boreholes and transmission line is likely to be adjacent to existing fire roads and access tracks. Any impact for the service boreholes would be regenerated shortly upon decommissioning. The Project is unlikely to result in long-term fragmentation of a patch given the transmission line would occur adjacent to the fire road.		Short-term
3. adversely affect habitat critical to the survival of an ecological community		
The habitat for SSTF that may be impacted within the Study Area consists of approximately 1 ha which equates to less than 1% of the SSTF within a 10,000 ha radius of the Study Area. The SSTF within the area is informally protected within WaterNSW Catchment landholdings. No large-scale clearing events are likely to take place within the surrounding SSTF given its informal protection. With respect to the amount of SSTF mapped within the locality, the component of the CEEC that would be impacted by the proposed development is unlikely to be critical to the survival of the community. Furthermore, the areas disturbed would be actively regenerated following decommissioning.		Unlikely.
4. modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological		
The Project would involve disturbance to approximately 1.5 ha of SSTF. The areas to be disturbed for the service boreholes would be actively regenerated following the works. It is unlikely that the clearing regime would modify the water, soil and nutrients in such a manner that would prevent regeneration of the TEC after the works. In relation to the to the transmission line corridor, only vegetation above an approximate height of 2 m would be cleared and maintained via slashing. It is unlikely that the clearing events would result in long-term impact on abiotic factors important for SSTF survival in the Study Area.		Unlikely.
5. modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns		
The Project would involve disturbance to approximately on 1.5 ha of SSTF. The areas to be disturbed for the service boreholes would be actively regenerated following the works. It is unlikely that the clearing events would result in long-term impact on abiotic factors important for SSTF survival in the Study Area. In relation to the to the transmission line corridor, only vegetation above an approximate height of 2 m would be cleared and maintained via slashing. Whilst subsidence can impact upon surface water flows, and alter hydrology, given SSTF is not reliant upon waterlogging, or inundation regimes, it is highly unlikely subsidence would result in impacts to the TEC. Furthermore, the Project would not result in the removal of all SSTF within the locality: over 641 ha has been mapped by NPWS (2003) as occurring with 10,000 ha of the Study Area. As such, the SSTF to be cleared would not adversely affect all abiotic factors critical to the survival of the community within the locality.		Unlikely.
6. cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting		
The Project would result in the clearing of approximately 1.5 ha of SSTF. The service boreholes would be actively regenerated following the decommissioning of the additional service boreholes. In relation to the to the transmission line corridor, only vegetation above an approximate height of 2 m would be cleared and maintained via slashing. As stated above, the remaining areas of SSTF within the locality would not impacted directly by the Project and would remain viable. The proposed development is not likely to cause changes to the remainder of the CEEC within the locality that would lead to the decline or loss of functionally important species.		Unlikely.
7. cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: **— assisting invasive species, that are harmful to the listed ecological community, to become established, or**		

Shale Sandstone Transition Forest	Critically Endangered Ecological Community	Likelihood
— causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community		
The Project would result in the short-term reduction of SSTF within the Study Area through the clearing of approximately 1.5 ha of the CEEC. The Project would require the implementation of a number of environmental management plans which would contain protocols to manage the clearing of SSTF and prevent the potential spread of weeds, fertilisers, herbicides or other chemicals or pollutants into the CEEC.		Unlikely.
8. interfere with the recovery of an ecological community.		
An approved recovery plan exists for SSTF as part of the recovery plan for the Cumberland Plain (DECCW 2010). The main recovery objectives of this recovery plan include (DECCW 2010): - To build a protected area network, comprising public and private lands, focused on the priority conservation lands - To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the priority management objectives are compatible with biodiversity conservation - To develop and understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management and the recovery program - To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner. The Study Area has been identified as part of a priority conservation land in the Cumberland Plain Recovery Plan (DECW 2010). Given the project will only result in a short-term impact to a relatively small area of SSTF, the Project is considered unlikely to interfere significantly with the recovery of SSTF.		Unlikely
Conclusion: The Project is unlikely to result in a significant impact to SSTF.		

Leucopogon exolasius	Vulnerable Species	Likelihood
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:		
1. lead to a long-term decrease in the size of an important population of a species;		
Leucopogon exolasius has previously been recorded by Biosis Research (2016) at two locations in the far north-east corner of Area 5 (Figure 9). Both records were within relatively close proximity to each other along Donalds Castle Creek within vegetation mapped as HN651 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies. Numerous individuals were also recorded in the south of Area 5 by Niche (2019). The known records for the species would not be impacted for surface infrastructure associated with the Project, and as such would not impact upon the population. Subsidence is unlikely to impact the known records as: • The species is unlikely to be impacted by subsidence given the population of the species does not occur within the riparian inundation area of the creek within the Study Area. Thus any potential hydrological change as a result of subsidence is unlikely to impact upon *Leucopogon exolasius*. • Gas emissions as a result of subsidence are predicted to be rare, and given the species is known to occur on rock hill slopes, die-back from gas emission would be unlikely and largely be avoided (section 7.4.2). • It is highly unlikely that falling cliffs/rocks as a result of subsidence would impact the species. Based on the above, it is highly unlikely that the Project would result in a long-term decrease in the size of an important population of the species.		Unlikely
2. reduce the area of occupancy of an important population;		
As per the reasons stated above, the Project would not reduce the area of a known *Leucopogon exolasius* population. No surface infrastructure is proposed in the area where the species is known to occur, and it seems unlikely that subsidence would result in a reduction in the area of occupancy of the population.		Unlikely
3. fragment an existing important population into two or more populations;		
The Project would not result in fragmentation of the known records. No records for *Leucopogon exolasius* occur within the surface disturbance footprint. Nor is it likely that subsidence would result in the records being impacted or fragmented.		Unlikely
4. adversely affect habitat critical to the survival of a species;		
The Project is likely to have a negligible impact on the extent of habitat for *Leucopogon exolasius* within the locality. According to DoE (2018e) the species inhabits woodland on sandstone (and sandy alluvium) and prefers rocky hillsides along creek banks. The area proposed for the surface infrastructure avoids such habitat given the disturbance is located away from creek banks. As discussed in section 7.4.2, it is highly unlikely that any substantial impact to vegetation would occur as a result of subsidence. Within the Study Area potential habitat is likely to coincide with: HN651 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, HN586 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest, Sydney Basin and HN607 Water Gum - Coachwood riparian scrub along sandstone streams vegetation communities. The total area of these communities in the Study Area is 1,150 ha. It is highly unlikely that the area of this potential habitat of *Leucopogon exolasius* would decrease to such an extent as to affect habitat critical to its survival.		Unlikely
5. disrupt the breeding cycle of an important population		
As stated above, it is highly unlikely that the Project would impact upon known records for *Leucopogon exolasius* or affect the potential habitat so much that the lifecycle of the specie would be impacted. It is considered highly unlikely that the Project would disrupt pollinators of the species (cited as bees as major pollinators, with flies, butterflies, wasps and moths minor but significant pollinators (Ooi 2002)) such that a pollinating cycle of the species would be disrupted.		Unlikely
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;		
As discussed in section 7.4.3, it is highly unlikely that any substantial impact to vegetation would occur as a result of surface infrastructure clearing and mine subsidence. Within the Study Area potential habitat is likely to coincide with: HN651 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, HN586 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest, Sydney Basin and HN607 Water Gum - Coachwood riparian scrub along sandstone streams vegetation communities. The total areas of these communities in the Study Area is 1,150 ha. None of these areas would be cleared for the surface infrastructure. As detailed in section 7.5.2, subsidence is highly unlikely to result in any substantial impact to these vegetation communities. It is highly unlikely that the Project would lead to a decrease in the area of potential habitat for *Leucopogon exolasius* such that the species is likely to decline.		Unlikely
7. result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;		
The Study Area is located in an area of extensive intact bushland, with minimal weeds scattered within previously disturbed areas (such as easements, and fire roads). An increase in weeds has the potential to occur during the construction and operation phase of the Project, mainly attributed to weed seed being carried into the Study Area on machinery/personnel. In order to prevent the spread or introduction of weed species into the Study Area, protocols in regards to control of weeds and pests would be provided in the relevant Biodiversity Management Plans for the Project. Through implementation of the Plans, it is highly unlikely that introduced species would become established in the relatively intact habitat of the Study Area, so much so that the species would be impacted.		Unlikely
8. introduce disease that may cause the species to decline, or		

Leucopogon exolasius	Vulnerable Species	Likelihood
The Project is not likely to result in the introduction of a disease that may lead to the decline of this species. During the construction phases, machinery would be washed down accordingly to reduce the risk of *Phytophthora cinnamomi* becoming established within the Study Area.		Unlikely
9. Interfere substantially with the recovery of the species.		
Given the species is unlikely to be impacted by the Project, the Project is considered unlikely to interfere with the recovery of the species or with any Approved Conservation Advice for *Leucopogon exolasius*.		Unlikely
Conclusion: The Project is unlikely to result in a significant impact on *Leucopogon exolasius*.		

Pomaderris brunnea	Vulnerable Species	Likelihood
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:		
1. lead to a long-term decrease in the size of an important population of a species;		
Pomaderris brunnea has previously been recorded at two locations near the south-east corner of Area 5 ( ). Records occurred within Exposed Sandstone Scribbly Gum Woodland and along the Cordeaux Dam entrance road, however both records are dated (1950s) and the status and accuracy of the records is unknown. The known records for the species would not be impacted for surface infrastructure associated with the Project, and as such would not impact upon the population. Subsidence is unlikely to impact the known records as: • The species is unlikely to be impacted by subsidence given the population of the species does not occur within the riparian inundation area of the creek within the Study Area. Thus any potential hydrological change as a result of subsidence is unlikely to impact upon *Pomaderris brunnea*. • Gas emissions as a result of subsidence are predicted to be rare, and given the species is known to occur on rock hill slopes, die-back from gas emission would be unlikely and largely be avoided (section 7.4.2). • It is highly unlikely that falling cliffs/rocks as a result of subsidence would impact the species. Based on the above, it is highly unlikely that the Project would result in a long-term decrease in the size of an important population of the species.		Unlikely
2. reduce the area of occupancy of an important population;		
As per the reasons stated above, the Project would not reduce the area of a known *Pomaderris brunnea* population. No surface infrastructure is proposed in the area where the species is known to occur, and it seems unlikely that subsidence would result in a reduction in the area of occupancy of the population.		Unlikely
3. fragment an existing important population into two or more populations;		
The Project would not result in fragmentation of the known records. No records for *Pomaderris brunnea* occur within the surface disturbance footprint. Nor is it likely that subsidence would result in the records being impacted or fragmented.		Unlikely
10. adversely affect habitat critical to the survival of a species;		
The Project is likely to have a negligible impact on the extent of habitat for *Pomaderris brunnea* within the locality. According to DoE (2018f) the species 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. The area proposed for the surface infrastructure avoids such habitat given the disturbance is located away from creek banks. As discussed in section 7.4.2, it is highly unlikely that any substantial impact to vegetation would occur as a result of subsidence.		Unlikely
11. disrupt the breeding cycle of an important population		
As stated above, it is highly unlikely that the Project would impact upon known records for *Pomaderris brunnea* or affect the potential habitat so much that the lifecycle of the species would be impacted. It is considered highly unlikely that the Project would disrupt pollinators of the species such that a pollinating cycle of the species would be disrupted.		Unlikely
12. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;		
As discussed in section 7.4.3, it is highly unlikely that any substantial impact to vegetation would occur as a result of surface infrastructure clearing and mine subsidence. As detailed in section 7.5.2, subsidence is highly unlikely to result in any substantial impact to these vegetation communities. It is highly unlikely that the Project would lead to a decrease in the area of potential habitat for *Pomaderris brunnea* such that the species is likely to decline.		Unlikely
13. result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;		
The Study Area is located in an area of extensive intact bushland, with minimal weeds scattered within previously disturbed areas (such as easements, and fire roads). An increase in weeds has the potential to occur during the construction and operation phase of the Project, mainly attributed to weed seed being carried into the Study Area on machinery/personnel. In order to prevent the spread or introduction of weed species into the Study Area, protocols in regards to control of weeds and pests would be provided in the relevant Biodiversity Management Plans for the Project. Through implementation of the Plans, it is highly unlikely that introduced species would become established in the relatively intact habitat of the Study Area, so much so that the species would be impacted.		Unlikely
14. introduce disease that may cause the species to decline, or		
The Project is not likely to result in the introduction of a disease that may lead to the decline of this species. During the construction phases, machinery would be washed down accordingly to reduce the risk of *Phytophthora cinnamomi* becoming established within the Study Area.		Unlikely
15. Interfere substantially with the recovery of the species.		
Given the species is unlikely to be impacted by the Project, the Project is considered unlikely to interfere with the recovery of the species or with any Approved Conservation Advice for *Pomaderris brunnea*.		Unlikely
Conclusion: The Project is unlikely to result in a significant impact on *Pomaderris brunnea*.		

Pultenaea aristata	Vulnerable Species	Likelihood
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:		
1. lead to a long-term decrease in the size of an important population of a species;		
Pultenaea aristata was not recorded within the Study Area but the species is known to be associated with Coastal Upland Swamp vegetation (NSW NPWS, 2003) and known to occur in association with areas of impeded drainage and creek lines within sandstone woodland and gully forest plant communities (NSW NPWS, 2003; B. Smith, 2007, pers. comm.). Large populations of the species have been recorded within Coastal Upland Swamp habitat types in Dendrobium Area 3B by Niche (2012), which occur outside of the Study Area. Whilst not recorded during the surveys within the Study Area, it is acknowledged that *Pultenaea aristata* has potential habitat within Coastal Upland Swamps of the Study Area, and also sandstone woodland. Should a population be present within a Coastal Upland Swamp that may be impacted by subsidence, it could impact the species. However, the likelihood of this occurring as a result of the Project is relatively low given the species was not detected, and the likelihood of subsidence impacts is also low. Furthermore, as discussed in section 7.4.2 and Appendix 8, to date, no significant changes to vegetation/habitat as a result of subsidence has been detected within swamps monitored as part of the Dendrobium Mine, Metropolitan Mine and Wollongong Coal monitoring programs within Coastal Upland Swamps. Catastrophic events such as erosion and gullying have only been observed at three Coastal Upland Swamps despite over 500 Coastal Upland Swamps historically mined under since the early and mid 1900s, and such events have also been attributed by parties to a number of man-made and natural events independent of subsidence impacts (Appendix 8). It should be noted that species can also inhabit Eucalypt Fringing Woodland or Exposed Sandstone Scribbly Gum vegetation communities which Coastal Upland Swamp could eventually transition to over time in response to hydrological change. Based on the lack of detection of the species within Coastal Upland Swamps in the Study Area, the low likelihood for catastrophic events, and potential habitat within drier vegetation communities, this assessment concludes that the likelihood of impacts to potential habitat within Coastal Upland Swamps for *Pultenaea aristata* are relatively low. In relation to changes to water flow and standing pools along creekline habitats, this is unlikely to affect *Pultenaea aristata* given the species does not occur submerged, immersed or directly connected via roots to the water within pools. The drying of pools, or predicted changes to the hydrological regime to watercourses within the Study Area are therefore unlikely to result in impacts to the species. Gas emissions as a result of subsidence are predicted to be rare, and given the species does not occur within the riparian area, die back from gas emission would be unlikely and would largely be avoided (section 7.4.2). It is also highly unlikely that falling cliffs/rocks as a result of subsidence would impact the species. Based on the above, it is considered unlikely that the Project would result in a long-term decrease in the size of an important population, should it occur.		Unlikely
2. reduce the area of occupancy of an important population;		
As per the reasons stated above, the Project would not reduce the area of a known *Pultenaea aristata* population. No surface infrastructure is proposed in the areas where the species is known to occur, and it is considered unlikely that subsidence would result in a substantial reduction (if any) in the area of occupancy of the population given the species can also occur within sandstone woodland habitats, that are less susceptible to subsidence impacts.		Unlikely
3. fragment an existing important population into two or more populations;		
The proposal would not result in fragmentation of the known records of the species. No records for *Pultenaea aristata* occur within the surface disturbance footprint or Coastal Upland Swamp habitat types. Nor is it likely that subsidence would result in the records being impacted or fragmented.		Unlikely
4. adversely affect habitat critical to the survival of a species;		
The surface infrastructure associated with the proposal is likely to have a negligible impact on the extent of habitat for *Pultenaea aristata* within the locality. The species was not recorded within the surface infrastructure footprint, and the area of equivalent habitat within the Study Area is over 2,538 ha (PCT1083, 1804, 978)(Table 10). In relation to potential habitat within Coastal Upland Swamps, there is the potential for vegetative response in regards to subsidence related impacts. The potential for this to occur is detailed in Appendix 8. At a worst-case scenario there is the potential for vegetation within Coastal Upland Swamps to transition over many years into a dry woodland. As noted in DoE (2018g) the species can occur within low nutrient sandstone soils in both moist and dry areas. As such, should the vegetation within Coastal Upland Swamps transition to a drier community type as a result of subsidence, the vegetation community would likely still provide suitable habitat for the species. For these reasons, the Project is considered unlikely to adversely impact habitat critical to the survival of the species.		Unlikely
5. disrupt the breeding cycle of an important population		
As stated above, it is unlikely that the Project would impact upon known records for *Pultenaea aristata* or affect the potential habitat to such an extent that it would impact upon habitat critical to the survival of the species. It is highly unlikely that the Project would disrupt pollinators of the species so much so that a pollinating cycle of the species would be disrupted. Given no individuals or populations were recorded in the Study Area, there is a low likelihood that populations would be impacted.		Unlikely
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;		
As discussed in section 7.4.1, it is highly unlikely that any substantial impact to vegetation would occur as a result of surface infrastructure clearing. The availability of similar habitat types to that impacted by the surface infrastructure exceeds 2,468 ha within the Study Area. As discussed in relation to Coastal Upland Swamp habitat, there is the potential for such habitat types to transition to a drier vegetation community. However, as noted in DoE (2018g) the species can occur within habitat with low nutrient sandstone soils in both moist and dry areas, and as such, should the vegetation within Coastal Upland Swamps transition to the drier community type as a result of subsidence, potential habitat for the species would still exist.		Unlikely

Pultenaea aristata	Vulnerable Species	Likelihood
As such, the Project is unlikely to adversely impact the availability or quality of habitat to an extent that the species is likely to decline.		
7. result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;		
The Study Area is located in an area of extensive intact bushland, with minimal weeds scattered within previously disturbed areas (such as easements, and fire roads). An increase in weeds has the potential to occur during the construction and operation phase of the Project, mainly attributed to weed seed being carried into the Study Area on machinery/personnel. In order to prevent the spread of introduced species into the Study Area, protocols in regards to control of weeds and pests would be provided in relevant Management Plans. Through implementation of the Plan, it is highly unlikely that introduced species would become established in the relatively intact habitat of the Study Area, so much so that the species would be impacted.		Unlikely
8. introduce disease that may cause the species to decline, or		
The Project is not likely to result in the introduction of a disease that may lead to the decline of this species. During the construction phases, machinery would be washed down to reduce the risk of *Phytophthora cinnamomi* becoming established within the Study Area.		Unlikely
9. Interfere substantially with the recovery of the species.		
There is no Recovery Plan for this species. Given the species was not recorded during the field survey, and habitat it unlikely to be impacted to such an extent that the species would become adversely affected, it is likely that the Project would not substantially interfere with the recovery of the species.		Unlikely
Conclusion: The Project is unlikely to result in a significant impact on *Pultenaea aristata.*		

Broad-headed Snake (*Hoplocephalus bungaroides*)	
Criteria for vulnerable species	*Likelihood*
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
1. Lead to a long-term decrease in the size of an important population of a species;	
It is considered unlikely that the proposed action would lead to a long term decrease in the size of any Broad-headed Snake population due to the following: • An important population was not recorded in the Study Area. • Clearing associated with surface infrastructure has been positioned away from ridgeline habitat where the species could reside. • The Broad-headed Snake has a limited potential occurrence across the study area as habitat required for sheltering is very specific to the species needs. Requiring shelter under rocks with a west to north-west aspect, usually found in rocky outcrops and in sandstone ridgetops (DoE 2018b). • 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. 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 sources are unlikely to be greatly impacted by subsidence. • Furthermore potential habitat within Exposed Sandstone Scribbly Gum Woodland and Sandstone Gully Peppermint Forest within available in the Study Area and within the Locality which would not be impacted by the Proposal is extensive. • Additional safeguards are recommended to protect fauna within the catchment: • Rock outcrops with potential habitat for the endangered Broad-headed Snake and its prey species (such as exfoliating sandstone or crevices) will be avoided	Unlikely
2. Reduce the area of occupancy of an important population;	
The Project is unlikely to reduce the occupancy of an important population due to the following: • An important population was not recorded in the Study Area. • Clearing associated with surface infrastructure has been positioned away from ridgeline habitat where the species could reside. • The Broad-headed Snake has a limited potential occurrence across the study area as habitat required for sheltering is very specific to the species needs. Requiring shelter under rocks with a west to north-west aspect, usually found in rocky outcrops and in sandstone ridgetops (DoE 2018b). • 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. 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 sources are unlikely to be greatly impacted by subsidence. • Furthermore potential habitat within Exposed Sandstone Scribbly Gum Woodland and Sandstone Gully Peppermint Forest within available in the Study Area and within the Locality which would not be impacted by the Proposal is extensive.	Unlikely
3. Fragment an existing important population into two or more populations;	
Fragmentation of an existing important population is unlikely due to the following: • A population of the species was not recorded during the field survey. • No clearing would take place along ridgelines, overhangs and cliffs, of which the species resides. • There is the potential for rock falls associated with subsidence, however this is unlikely to result in fragmentation of a population.	Unlikely
4. Adversely affect habitat critical to the survival of a species;	
The following species are listed on the EPBC Act Register of Critical Habitat: • Wandering Albatross (*Diomedea exulans*) - Macquarie Island • *Lepidium ginninderrense* (Ginninderra peppercress) - Northwest corner Belconnen Naval Transmission Station, ACT • Black-eared Miner (*Manorina melanotis*) - Gluepot Reserve, Taylorville Station and Calperum Station. • Shy Albatross (*Thalassarche cauta*) - Albatross Island, The Mewstone, Pedra Branca • Grey-headed Albatross (*Thalassarche chrysostoma*) - Macquarie Island. No critical habitat has been declared for the Broad-headed Snake.	Unlikely

Broad-headed Snake (*Hoplocephalus bungaroides*)	
5. Disrupt the breeding cycle of an important population	
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 current surveys however, potential breeding and foraging habitat for this species occurs on ridge lines – particularly around sandstone outcrops. 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. 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 sources are unlikely to be greatly impacted by subsidence The proposal is not likely to disrupt the breeding cycle of any population as it will not impact any limiting shelter, breeding or foraging habitat.	Unlikely
6. Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;	
The Broad-headed Snake has a limited potential occurrence across the study area as habitat required for sheltering is very specific to the species needs. Requiring shelter under rocks with a west to north-west aspect, usually found in rocky outcrops and in sandstone ridgetops (DoE 2018b). Survey for Broad-headed Snake did not detect the species, however it has been recorded on the edge of Area 5 previously and in adjacent areas. Survey was not conducted during the optimal season for the species according to the BBCC (August-September), however was conducted during months where the species can be detected, late spring through to mid-summer, November to January (DoEE 2011). Potential breeding and foraging habitat for this species occurs on ridge lines – particularly around sandstone outcrops. Vegetation communities include: Exposed Sandstone Scribbly Gum Woodland and Sandstone Gully Peppermint Forest. 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 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. 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 sources are unlikely to be greatly impacted by subsidence. Furthermore potential habitat within Exposed Sandstone Scribbly Gum Woodland and Sandstone Gully Peppermint Forest within 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 the Project would reduce the availability and quality of habitat to the extent that the species is likely to decline.	Unlikely
7. Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;	
The Project is not likely to result in the introduction of invasive species that may become established in habitat for the species. Clearing associated with the project is located away from habitat associated with the Broad-headed Snake.	Unlikely
8. Introduce disease that may cause the species to decline, or	
Whilst there is some potential for works plant and machinery to transport and disperse soil pathogens throughout the Study Area, this risk will be managed through the use of vehicle wash down procedures. It is considered unlikely that the proposed action will introduce disease that may cause the Broad-headed Snake to decline.	Unlikely
9. Interfere substantially with the recovery of the species.	
Broad-headed Snake in NSW has been assigned as a site managed species under the Saving Our Species program. Three sites have been identified as management sites for this species. Woronora Plateau is a listed management site which is likely to include the study area. Management actions proposed at this site include: • Reduce bushrock removal from the site • Minimise illegal collection of the species • Determine area of occupancy of the species • Increase understanding of the species ecological requirements The proposal would not involve removal of bushrock or illegal collection of the species. The proposal is not likely to interfere with the recovery of Broad-headed Snake.	Unlikely
Conclusion: The proposed action is unlikely to have a significant impact on the Broad-headed Snake.	

Giant Burrowing Frog (*Heleioporus australiacus*)	Vulnerable Species	Likelihood
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:		
1. lead to a long-term decrease in the size of an important population of a species;		
The Giant Burrowing Frog has been recorded in preferred habitats once in the north-east of the study area along a 3rd order tributary to Donalds Castle Creek, as well as south and east of the study area approximately 1 km away. Given limitation with survey for the species discussed in section 7 of the assessment, it is assumed that the Giant Burrowing is present throughout the preferred habitats of the Study Area despite its lack of detection in the present survey. Within the Study Area, the species relies upon semi-permanent pools for tadpole development, with maturation times for tadpoles having been observed to take 3-11 months (Watson and Martin 1973). Pools of sufficient depth and hydroperiod within the catchment area were almost exclusively located along second order or higher streams or else first order streams where headwater swamps are positioned upstream. The clearing associated with the Project is located away for potential Giant Burrowing Frog habitat. Subsidence however, has the potential to impact on pools in which the species may occupy, through reduction and re-direction of water flow. Should the pool contain a population of tadpoles for the species, this may reduce the population. However, it should be noted that not all pools would become dry as a result of subsidence and thus only a small percentage of habitat may be impacted. The Project therefore has the potential to decrease the population should a pool containing tadpoles of the species be impacted. The following safeguards will be employed to protect fauna within the catchment: • All creeks and drainage lines that contain flowing or stagnant water are to be avoided for direct surface disturbance. A 40 m buffer is to be maintained around all 2nd or 3rd order creek lines wherever practical. • Disturbance to small ephemeral drainage lines is to be minimised, with tracks to run perpendicular to the drainage lines where crossings are necessary. No drilling will occur within creek lines. • Measures to prevent the spread of Chytrid fungus will be employed in accordance with – Threatened Frog Management – Chytrid Fungus Issues		Potential
2. **reduce the area of occupancy of an important population;**		
The Giant Burrowing Frog was not recorded during the current survey, however it has been recorded within the Study Area during the SIS survey. The species has also been recorded within the Dendrobium Area 3 during past monitoring (Biosis 2016). The areas of habitat that may be potentially impacted by subsidence, include Coastal Upland Swamps, creeks and rock outcrops. Drainage lines which are directly mined beneath, are likely to incur some fracturing in the uppermost bedrock. Where the bases of the creek and drainage lines have exposed bedrock, there may be some diversion of surface water flows into the dilated strata beneath the beds and the draining of pooled water within their alignments. In times of low flow, surface water flows could be diverted into the dilated strata below the beds and this could affect the quality and quantity of the water flowing in the streams. It is also possible, that surface water flow diversions could occur in some locations along these streams, however, based on the previous experience at the mine, the incidence of this occurring is considered low. Direct impacts to the species are possible and likely breeding habitat affected. The species has been previously recorded within the Donalds Castle Creek and Wongawilli Creek south of the Study Area. Breeding pools along Donalds Castle Creek may be impacted due to loss of surface flow and deep pools from the creek. Complete draining of a breeding pool containing eggs, tadpoles or metemorphs of the frog would potentially result in the loss of a generation of Giant Burrowing Frogs within that creek line, or population. Given the isolated occurrences of the species, known populations within the Study Area, and the specific breeding conditions for the species (e.g. after heavy rain), the predicted subsidence events are likely to cause disruption to the area of occupancy for the species.		Possible
3. fragment an existing important population into two or more populations;		
The subsidence predicted has the potential to alter a portion of Giant Burrowing Frog habitat features within the Study Area. It is highly unlikely that all potential habitats would be impacted by subsidence. However, potential changes to Coastal Upland Swamps due to hydrological changes, or alteration of surface flow in creeks, loss of deep pools, may isolate and reduce the number of breeding sites.		Possible
4. adversely affect habitat critical to the survival of a species;		
The clearing of native vegetation for the Project is unlikely to impact upon habitat critical for the survival of the species. However, should subsidence result in the complete draining of a breeding pool containing eggs, tadpoles or metemorphs of the frog would likely result in the loss of an entire generation of Giant Burrowing Frogs within that creek line, or population. This potential subsidence impact is not predicted by MSEC (2019) to occur within all pools of the Study Area. As such, whilst some habitat pools may be impacted, it is likely that other pools would not be impacted and thus the population would still remain.		Unlikely
5. disrupt the breeding cycle of an important population		
The areas of habitat that may be potentially impacted by subsidence, include Coastal Upland Swamps, creeks and rock outcrops. Drainage lines which are directly mined beneath, are likely to incur some fracturing in the uppermost bedrock. Where the bases of the creek and drainage lines have exposed bedrock, there may be some diversion of surface water flows into the dilated strata beneath the beds and the draining of pooled water within their alignments. In times of low flow, surface water flows could be diverted into the dilated strata below the beds and this could affect the quality and quantity of the water flowing in the streams. It is also possible, that surface water flow diversions could occur in some locations along these streams, however, based on the previous experience at the mine, the incidence of this occurring is considered low.		Possible

Giant Burrowing Frog (*Heleioporus australiacus*)	Vulnerable Species	Likelihood
Any draining of a breeding pool containing eggs, tadpoles or metemorphs of the frog would likely result in the loss of an entire generation of Giant Burrowing Frogs within that creek line, or population. Given the isolated occurrences of the species, known populations within the Study Area, and the specific breeding conditions for the species (e.g. after heavy rain), the predicted subsidence events is likely to cause disruption to the life cycle of one or more populations within the Study Area to the extent that a local population may be placed at risk of extinction.		
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;		
The Project has the potential to impact upon breeding pools, and habitat with Coastal Upland Swamps (appendix 8). Any draining of a breeding pool containing eggs, tadpoles or metemorphs of the frog would likely result in the loss of an entire generation of Giant Burrowing Frogs within that creek line, or population.		Possible
7. result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;		
The Project is not likely to result in the introduction of invasive species that may become established in habitat for the species.		Unlikely
8. introduce disease that may cause the species to decline, or		
Whilst there is some potential for works plant and machinery to transport and disperse soil pathogens throughout the Study Area, this risk will be managed through the use of vehicle wash down procedures. Furthermore, all vegetation clearing does not occur within watercourses, and thus the potential for the spread of Chytrid fungus will be minimised.		Unlikely
9. Interfere substantially with the recovery of the species.		
A Recovery Plan does not exist for Giant Burrowing Frog.		Unlikely
Conclusion: The Project is likely to result in a significant impact on Giant Burrowing Frog due to the following: • Proposal has the potential to impact the Giant Burrowing Frog through alteration of known and potential foraging, sheltering and breeding habitat through potential hydrological changes to Coastal Upland Swamps, draining of creeks. • The disturbance has the potential to impact on the reproductive and dispersal viability of the Giant Burrowing Frog. • Habitat exists throughout the locality, however the loss of breeding sites may reduce the immediate reproduction of the species.		

Littlejohn's Tree Frog (*Litoria littlejohni*)	Vulnerable Species	Likelihood
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:		
1. lead to a long-term decrease in the size of an important population of a species;		
The Littlejohn's Tree Frog has been recorded in preferred habitats across the Project areas and surrounds, found mainly in semi-permanent pools. These pools of sufficient depth and hydroperiod within the catchment area were almost exclusively located along first and second order streams downstream of headwater swamps. Within the Study Area, the species relies upon these semi-permanent pools for tadpole development, with maturation times for tadpoles having been observed to take approximately four (4) months (Anstis 2002). The Project has the potential to impact on pools in which the species may occupy. The Coastal Upland Swamps provide a buffer for continuous and even water flows along streams after rain events, thus connecting water flow to pools that can maintain water for longer and allow sufficient time for metamorphosis of tadpoles. However, it should be noted that not all pools would become dry as a result of subsidence and thus only a small percentage of habitat may be impacted. Littlejohn's Tree Frog has been found in pools that do not have Coastal Upland Swamps directly associated with pools. The Project therefore has the potential to decrease the population should a pool containing tadpoles of the species be impacted.		Potential
2. reduce the area of occupancy of an important population;		
The Littlejohn's Tree Frog was recorded during the current survey and has had ongoing monitoring programs across Dendrobium Areas 2, 3A and 3B to quantify subsidence impacts. The areas of habitat that may be potentially impacted by subsidence, include Coastal Upland Swamps, creeks and rock outcrops. Drainage lines which are directly mined beneath, are likely to incur some fracturing in the uppermost bedrock. Where the bases of the creek and drainage lines have exposed bedrock, there may be some diversion of surface water flows into the dilated strata beneath the beds and the draining of pooled water within their alignments. In times of low flow, surface water flows could be diverted into the dilated strata below the beds and this could affect the quality and quantity of the water flowing in the streams. It is also possible, that surface water flow diversions could occur in some locations along these streams, however, based on the previous experience at the mine, the incidence of this occurring is considered low. Direct impacts to the species are possible and likely breeding habitat affected. The species has been previously recorded within Area 5 and three locations within Area 6 during the fauna field survey. Any draining of a breeding pool containing eggs, tadpoles or metemorphs of the frog would likely result in the reduction in individuals for a generation of Littlejohn's Tree Frog within that creek line, or population.		Possible
3. fragment an existing important population into two or more populations;		
The subsidence predicted has the potential to alter a portion of Littlejohn's Tree Frog habitat features within the Study Area. It is unlikely that all potential habitats would be impacted by subsidence. However, potential changes to Coastal Upland Swamps due to hydrological changes, or alteration of surface flow in creeks, loss of deep pools, may isolate and reduce the number of breeding sites. Not all potential habitats are likely to be impacted by the proposal.		Possible
4. adversely affect habitat critical to the survival of a species;		
The clearing of native vegetation for the Project is unlikely to impact upon habitat critical for the survival of the species. However, should subsidence result in the draining of a breeding pool containing eggs, tadpoles or metemorphs of the frog would likely result in the loss of an entire generation of Littlejohn's Tree Frogs within that creek line, or population. This potential subsidence impact is not predicted by MSEC (2019) to occur within all pools of the Study Area. As such, whilst some habitat pools may be impacted, it is likely that other pools would not be impacted and thus the population would remain.		Unlikely
5. disrupt the breeding cycle of an important population		
The areas of habitat that may be potentially impacted by subsidence, include Coastal Upland Swamps, creeks and rock outcrops. Drainage lines which are directly mined beneath, are likely to incur some fracturing in the uppermost bedrock. Where the bases of the creek and drainage lines have exposed bedrock, there may be some diversion of surface water flows into the dilated strata beneath the beds and the draining of pooled water within their alignments. In times of low flow, surface water flows could be diverted into the dilated strata below the beds and this could affect the quality and quantity of the water flowing in the streams. It is also possible, that surface water flow diversions could occur in some locations along these streams, however, based on the previous experience at the mine, the incidence of this occurring is considered low. Any draining of a breeding pool containing eggs, tadpoles or metemorphs of the frog would likely result in the reduction in individuals of an entire generation of Littlejohn's Tree Frog within that creek line, or population. .		Possible
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;		
The Project has the potential to impact upon breeding pools, and habitat with Coastal Upland Swamps (appendix 8). Any draining of a breeding pool containing eggs, tadpoles or metemorphs of the frog would likely result in reduction in individuals of an entire generation of Littlejohn's Tree Frog within that creek line, or population.		Possible
7. result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;		
The Project is not likely to result in the introduction of invasive species that may become established in habitat for the species.		Unlikely
8. introduce disease that may cause the species to decline, or		
Whilst there is some potential for works plant and machinery to transport and disperse soil pathogens throughout the Study Area, this risk will be managed through the use of vehicle wash down procedures. Furthermore, all vegetation clearing does not occur within watercourses, and thus the potential for the spread of Chytrid fungus will be minimised.		Unlikely
9. Interfere substantially with the recovery of the species.		
To date there is no adopted or Recovery Plan for this species.		-

Littlejohn's Tree Frog (*Litoria littlejohni*)	Vulnerable Species	Likelihood

Conclusion: The Project is likely to result in a significant impact on Littlejohn's Tree Frog due to the following:

- Proposal has the potential to impact the Littlejohn's Tree Frog through alteration of known and potential foraging, sheltering and breeding habitat through potential hydrological changes to Coastal Upland Swamps, draining of creeks.
- The disturbance has the potential to impact on the reproductive and dispersal viability of the Littlejohn's Tree Frog.
- Habitat exists throughout the locality, however the loss of breeding sites may reduce the immediate reproduction of the species.

Koala (*Phascolarctos cinereus)*	**Vulnerable Species**	**Likelihood**
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:		
1. lead to a long-term decrease in the size of an important population of a species;		
The survey included six records of the Koala within the Study Area (at two locations in Area 6 and four locations in Area 5), comprising a total of eight individuals. These results include two direct observations of Koalas, two recordings on camera traps and two instances where Koalas were heard calling across the landscape. The clearing of habitat around the ventilation shaft sites did not have any individuals recorded during surveys and does not contain feed trees of significance, therefore clearing is unlikely to lead to long-term decrease in the size of an important population of this species. The clearing of potential koala habitat for the additional service boreholes will be restricted to 1 ha of Shale Sandstone Transitional Forest (SSTF). An additional 0.5 ha may be cleared for the transmission line. Clearing would be done in a matter to avoid impacts to habitat trees via the following: • large trees and stags will be avoided. • Observe speed limits at all times and reduce vehicle speed in early mornings or in the later afternoon when fauna are more likely to be foraging on the roadside.		Unlikely
2. reduce the area of occupancy of an important population;		
Koalas are expected to occur within the vicinity of the Study Area. However the Project would not impact the area of occupancy of any population of the Koala given the ventilation shaft sites are not within core koala habitat, and the area of Shale Sandstone Transition Forest to be impacted, would be done in a manner to avoid large feed trees, and where possible, place the service borehole site within open areas. Given the large habitat available, the area of impact is not at a scale whereby an important population would be reduced.		Unlikely
3. fragment an existing important population into two or more populations;		
Clearing within potential habitat of up to 1.5 ha will occur within SSTF, which is regarded as core habitat. The works associated would not lead to fragmentation or isolation of an existing important population into two or more populations due to the restricted scale of the clearing impacts.		Unlikely
4. adversely affect habitat critical to the survival of a species;		
Given the extensive habitat within the Study Area and the wider locality, clearing of habitat is unlikely to have a significant impact on the extent of habitat for the Koalas within the locality. Therefore, the habitat is likely to be of little or no importance to the long-term survival of the Koalas.		Unlikely
5. disrupt the breeding cycle of an important population		
One hectare of potential core habitat may be impacted by for the service borehole sites. An additional 0.5 ha may be impacted for the transmission line. As previously discussed, areas to be disturbed would minimise impacts to habitat trees where possible. Given the extensive habitat available, it is highly unlikely that a breeding cycle of the Koala would be impacted.		Unlikely
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;		
The Project may impact on potential habitat for Koalas but as mentioned previously the lack of species sightings within the impact zone and the removal of such a small area of potential habitat is not likely to contribute to decline of the species.		Unlikely
7. result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;		
The Project is not likely to result in the introduction of invasive species that may become established in habitat for the species.		Unlikely
8. introduce disease that may cause the species to decline, or		
The main diseases affecting Koalas are chlamydial infections. The Project would not increase exposure to such infections as Koalas from the local population would not have increased contact with other Koala populations including infected populations		Unlikely
9. Interfere substantially with the recovery of the species.		
The Project does not interfere in any way with any recovery plans in place for the Koalas. Current strategies for recovery of this species at a State level.		Unlikely
Conclusion: The Project is unlikely to result in a significant impact on the Koala due to the size of the habitat cleared (1.5 ha) and the clearing of non-core koala habitat around the vent shaft sites.		

Grey Headed Flying Fox (*Pteropus poliocephalus*)	Vulnerable Species	Likelihood
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:		
1. lead to a long-term decrease in the size of an important population of a species;		
No Grey Headed Flying Fox were found within the Study Area, however they are likely to fly over the Study Area from time to time and forage in response to flowering/fruiting pulses. No roost sites are known from the Study Area and no breeding camps are located within the Study Area. It is assumed that a viable population of this species does exist within the locality and will therefore not lead to a long-term decrease in the size of an important population of this species.		Unlikely
2. reduce the area of occupancy of an important population;		
As stated above, Grey Headed Flying Fox were not sighted nor do they have any breeding camps that exist within the locality and will therefore not reduce the area of occupancy of an important population.		Unlikely
3. fragment an existing important population into two or more populations;		
The proposal would result in potential subsidence impacts to watercourses and swamps, as well as clearing within woodland habitat which may be used for foraging. The works associated with this Project would not lead fragmentation or isolation of an existing important population into two or more populations due to no populations being present within the Study Area.		Unlikely
4. adversely affect habitat critical to the survival of a species;		
The Project is likely to have a negligible impact on the extent of habitat for the Grey Headed Flying Fox within the locality. Therefore, the habitat potentially affected by the proposal is likely to be of little or no importance to the long-term survival of the Grey Headed Flying Fox.		Unlikely
5. disrupt the breeding cycle of an important population		
As stated above, it is assumed that the site does not contain important populations of Grey Headed Flying Fox and will therefore not disrupt the species breeding cycle.		Unlikely
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;		
The proposal may impact on potential foraging habitat for the Grey Headed Flying Fox through the clearing of native vegetation for the surface infrastructure. However, the removal of this vegetation is unlikely to reduce the extent of habitat to the extent that the species is likely to decline due to the extensive habitat available throughout the locality.		Unlikely
7. result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;		
The Project is not likely to result in the introduction of invasive species that may become established in habitat for the species.		Unlikely
8. introduce disease that may cause the species to decline, or		
Whilst there is some potential for works plant and machinery to transport and disperse soil pathogens throughout the Study Area, this risk will be managed through the use of vehicle wash down procedures. It is considered unlikely that the proposed action will introduce disease that may cause the Grey Headed Flying Fox to decline.		Unlikely
9. Interfere substantially with the recovery of the species.		
The Project does not interfere with any recovery plans in place for the Grey Headed Flying Fox.		Unlikely
Conclusion: The Project is unlikely to result in a significant impact on the Grey Headed Flying Fox.		

Greater Glider (*Petauroides volans)*	**Vulnerable Species**	**Likelihood**
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:		
1. lead to a long-term decrease in the size of an important population of a species;		
The Greater Glider was recorded during the field survey within a patch of Sandstone Transition Forest during spotlighting. There are no previous records from the Study Area. The habitat at the ventilation shaft sites did not have any individuals recorded during surveys. The clearing of potential habitat for the additional service boreholes within Shale Sandstone Transition Forest could possible impact upon potential habitat for the species given the species was recorded within that habitat type during the field survey. Habitat to be impacted for the additional service boreholes would be restricted to 1 ha of Shale Sandstone Transition Forest. Measures would be employed to avoid removal of hollow-bearing trees and mature trees, and all areas of impact to actively rehabilitated following decommissioning. The activity is unlikely to lead to long-term decrease in the size of an important population of this species given the over 620 ha of similar habitat within Shale Sandstone Transition Forest would not be impacted by the Project.		Unlikely
2. reduce the area of occupancy of an important population;		
Greater Gliders are expected to occur within the vicinity of the Study Area and locality. As mentioned above, the clearing associated with the Project may impact upon 1.5 ha of Shale Sandstone Transition Forest in which the species has been previously recorded. Measures would be employed to avoid removal of hollow-bearing trees and mature trees, and all areas of impact to actively rehabilitated following decommissioning associated with the service boreholes.		Minimal
3. fragment an existing important population into two or more populations;		
Clearing within suitable habitat for Greater Glider of up to 1.5 ha will occur, although, the works associated with this proposal would not lead to fragmentation or isolation of an existing important population into two or more populations due to the restricted scale of the clearing impacts.		Unlikely
4. adversely affect habitat critical to the survival of a species;		
Habitat to be impacted for the additional service boreholes would be restricted to 1.5 ha of Shale Sandstone Transition Forest. Measures would be employed to avoid removal of hollow-bearing trees and mature trees, and all areas of impact to actively rehabilitated following decommissioning associated with the service boreholes. The activity is unlikely to lead to adversely affect habitat important population to the survival of the species given over 620 ha of similar habitat within Shale Sandstone Transition Forest would not be impacted by the Project.		Unlikely
5. disrupt the breeding cycle of an important population		
Habitat within the Study Area is thought to be an important breeding area and corridor for the Greater Glider, using tall, moist eucalypt forests with older trees and an abundance of hollows, preferring a variety of *Eucalyptus* species throughout its suitable habitat. The clearing associated with the additional service boreholes and transmission line would avoid mature and hollow bearing trees which the species may utilise. It is highly unlikely that the removal of areas to a maximum of 1.5 ha would disrupt the breeding cycle of the species. The area constitutes a very small proportion of the overall habitat for the population.		Unlikely
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;		
The Project may impact on potential habitat for Greater Gliders but as mentioned previously the lack of species sightings within the impact zone and the removal of such a small area of potential habitat is not likely to contribute to decline of the species.		Unlikely
7. result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;		
The Project is not likely to result in the introduction of invasive species that may become established in habitat for the species.		Unlikely
8. introduce disease that may cause the species to decline, or		
The main diseases affecting Greater Glider is in the feed trees of Eucalypt species. *Phytophthora* a root fungus that is known to impact on the health of eucalypts. Whilst there is some potential for works plant and machinery to transport and disperse soil pathogens throughout the Study Area, this risk will be managed through the use of vehicle wash down procedures.		Unlikely
9. Interfere substantially with the recovery of the species.		
The Project does not interfere with any recovery plan as there is no adopted or made Recovery Plan for this species.		Unlikely
Conclusion: The Project is unlikely to result in a significant impact on the Greater Glider		

Appendix 8. Coastal Upland Swamp Impact Assessment

Introduction

Coastal Upland Swamps are highly dynamic and variable ecosystems that depend on a range of factors (such as water availability, flow and permeability) that interact to form the specific structure, size and vegetation composition of the community. Subsidence associated with longwall mining has the potential to interrupt such natural interactions due to changes to hydrological processes through tensile cracking, movement of joint and bedding planes, and buckling. There is some concern that these subsidence impacts on Coastal Upland Swamps may result in desiccation, erosion, scouring, changes in floristic composition, loss of important fauna habitat and, ultimately, loss of the swamp and its broader water filtering function.

Predicting and quantifying longwall subsidence related impacts on Coastal Upland Swamps presents a range of challenges, due to the unique nature of each swamp, limitations in the ability to predict strains at point locations, and the dynamic nature of the ecosystem.

Impacts to Coastal Upland Swamps to date that have been observed and those that are widely reported as being mine subsidence related, have been stark and readily observable. Three Coastal Upland Swamps (Swamp 37 [Drillhole Swamp], Swamp 18/19 and Flatrock Swamp) that are represented as being impacted heavily by mine subsidence were also acknowledged to be impacted by activities that were unrelated to subsidence (Table 54). The difference in opinion amongst experts as to the cause of observed changes to the Coastal Upland Swamps is attributed to the unique interactions each swamp has within its natural setting.

South32, Metropolitan Coal and Wollongong Coal have conducted biodiversity, hydrology and water chemistry monitoring of Coastal Upland Swamps within mining areas, and in control swamps (not subject to mining), since approximately 2003. The monitoring programs incorporate a Before-After Control-Impact (BACI) experimental design to determine whether subsidence associated with longwall mining results in changes to floristics and swamp size. The current monitoring programs typically involve fixed vegetation transects, photo monitoring, groundwater monitoring and vegetation condition observations at mined (impact) and non-mined (control) sites. In recent years, the data collected has been analysed, along with groundwater data, to assist in determining trends in vegetation transition.

From the monitoring programs, impacts to vegetation as a result of subsidence are determined by monitoring the following:

- Changes in Total Species Richness (TSR) or species composition following mining at or near an impact site that does not occur at a control site;
- Changes in TSR or species composition following changes in groundwater levels;
- Observational evidence in relation to vegetation dieback and decline in condition; and
- The size of Coastal Upland Swamps or the wetter sub-vegetation communities such as Tea-tree Thicket and Cyperoid Heath communities.

However, detecting change in Coastal Upland Swamp vegetation and habitat change from subsidence is confronted with many limitations and variables, and as such, results have not been conclusive to date. This is largely attributed to the time over which change may be observed in vegetation as a result of subsidence, influences of the surrounding landscape, current limitations of monitoring (in particular current LiDAR and aerial interpretation models), and the unique nature of each swamp and its subsidence impacts.

In determining the potential for impacts associated the Project, MSEC (2019) has predicted a number of potential subsidence impacts that may be experienced in Coastal Upland Swamps within the Study Area. In order to assess how this may impact upon the extent, floristic composition and habitat with the Coastal Upland Swamps, the results of the existing monitoring campaigns, coupled with relevant studies and discussion of historic erosion events have been used to understand the likely impacts to Coastal Upland Swamps.

Key monitoring programs undertaken at Dendrobium

South32, Metropolitan Coal and Wollongong Coal have conducted biodiversity, hydrology and water chemistry monitoring of Coastal Upland Swamps within mining areas, and in control swamps, since approximately 2003. The biodiversity monitoring has been designed to determine whether the predicted impacts to Coastal Upland Swamps have been exceeded, and any remediation actions required.

The monitoring programs for South32, Metropolitan Coal and Wollongong Coal incorporate a BACI experimental design to determine whether subsidence associated with longwall mining results in changes to floristics and swamp size. The current monitoring programs typically involve fixed vegetation transects, photo monitoring, groundwater monitoring and vegetation condition observations at mined (impact) and not-mined (control) sites. In recent years, the data collected has been analysed, along with groundwater data, to assist in determining trends in vegetation transition.

From the monitoring programs, impacts to vegetation as a result of subsidence may be determined by monitoring the following:

- Changes in Total Species Richness (TSR) or species composition following mining at or near an impact site that does not occur at a control site;
- Changes in TSR or species composition following changes in groundwater levels;
- Observational evidence in relation to vegetation dieback and decline in condition; and
- The size of Coastal Upland Swamps or the wetter sub-vegetation communities such as Tea-tree Thicket and Cyperoid Heath communities. The Dendrobium Terrestrial Ecology Monitoring Program which commenced in 2003.

An overview of the monitoring sites and associated Coastal Upland Swamps within Dendrobium Areas 3A and 3B that were monitored since 2003 is provided in Table 53.

Data and statistical analyses for the seasonal monitoring program is presented in detail in annual monitoring reports, however in summary, the vegetation monitoring techniques that were employed at thirteen Coastal Upland Swamps included:

- Vegetation survey once in autumn and once in spring each year;
- Airborne Laser Scanning (ALS), to collect LiDAR data, at the beginning of each year (typically between February and April); and
- Photo monitoring; once in autumn and once in spring at all flora monitoring locations.

The seasonal data was compared on an annual basis, and analysed using varying methods, with the focus on detecting trends in TSR, species composition, swamp size and, more recently, trends in relation to shallow groundwater recession. The latest report included an assessment of the 2016 monitoring data, with analysis against the previous 11.5 years of data collected during the monitoring (Biosis 2017).

Table 53. Monitored Coastal Upland Swamps at Dendrobium

Impact Swamp	Year monitoring commenced	Period of Monitoring	Within 400 m of longwall	Mined beneath	Control Swamp
	Dendrobium Area 3A				
Swamp 15B (S15B	2003	Ongoing	18/09/2010	25/08/2012	S15A(1) (Swamp 15A(1)) S33 (Swamp 33) S22 (Swamp 22)
S15A (2) (Swamp 15A(2))	2009	Ongoing	20/10/2012	All monitoring points beyond goaf	S15A(1) (Swamp 15A(1)) S33 (Swamp 33) S22 (Swamp 22)
	Dendrobium Area 3B				
S1A (Swamp 1A)	2012	Ongoing	23/02/2013	11/04/2013	S86 (Swamp 86) S87 (Swamp 87) S88 (Swamp 88) S15A(1) (Swamp 15A(1))
S1B (Swamp 1B)	2005-2009, then 2012-present	Ongoing	08/02/2013	13/02/2013	S86 (Swamp 86) S87 (Swamp 87) S15A(1) (Swamp 15A(1)) S22 (Swamp 22) S33 (Swamp 33)
S5 (Swamp 5)	2012	Ongoing	18/05/2013	25/07/2013	S86 (Swamp 86) S87 (Swamp 87) S88 (Swamp 88) S15A(1) (Swamp 15A(1))
S11	2003	Ongoing	21/05/2016	Beyond goaf. Predicted Longwall 14.	S15A(1) (Swamp 15A(1)) S22 (Swamp 22) S33 (Swamp 33)
S13 (Swamp 13)	2013 (spring only)	Ongoing	10/07/2017	Predicted Longwall 14 Predicted Longwall 15	S86 (Swamp 86) S87 (Swamp 87) S88 (Swamp 88) S15A(1) (Swamp 15A(1))
S14	2017	Ongoing	Predicted Longwall 17 Predicted Longwall 16 Predicted Longwall 15	Mined beneath: Predicted Longwall 17 Predicted Longwall 16 Predicted Longwall 15	S86 (Swamp 86) S87 (Swamp 87) S88 (Swamp 88) S15A(1) (Swamp 15A(1))
S23	2017	Ongoing	Predicted Longwall 15	Mined beneath: Predicted Longwall 15	S86 (Swamp 86) S87 (Swamp 87) S88 (Swamp 88) S15A(1) (Swamp 15A(1))

Predicted Impacts to Coastal Upland Swamps in the Study Area

Key conclusions from MSEC (2019) in relation to potential impacts to Coastal Upland Swamps within the Study Area include the following:

- It is unlikely that there would be large-scale adverse changes in the levels of ponding or scouring of the swamps.
- The swamps that are located outside of the extents of the proposed longwalls are predicted to generally experience tensile strains less than 0.5 mm/m and compressive strains less than 2 mm/m due to the proposed mining. It is unlikely, therefore, that the bedrock beneath these swamps would experience significant fracturing.

- The swamps that are located directly above the proposed longwalls are predicted to experience tensile strains greater than 0.5 mm/m and compressive strains greater than 2 mm/m. It is expected, therefore, that fracturing would occur in the bedrock beneath these swamps.
- Based on evidence in the NSW Coalfields, minor and isolated fracturing has been observed up to 400 m from longwalls; however, these have occurred within large river valleys and have not resulted in adverse impacts. Hence, it is possible that minor and isolated fracturing could occur in the bedrock beneath the swamps located outside the extents of the proposed longwalls but it is unlikely to result in adverse surface impacts on these swamps.
- The valley infill swamps have layers of organic soil that overlie the shallow natural surface soils and underlying bedrock along the alignments of the drainage lines. In most cases, cracking would generally not be visible at the surface within these swamps, except where the depths of bedrock are shallow or exposed.
- The headwater swamps have soil layers which overly the bedrock on the valley sides. It is expected that the potential for fracturing in these locations would be less when compared to the bases of the valleys, where higher compressive strains occur due to the valley-related movements, and due to the higher depths of cover along the valley sides.
- The dilated strata beneath the drainage lines, upstream of the swamps, could result in the diversion of some surface water flows beneath parts of the valley infill swamps. It is noted, however, that the drainage lines upstream of the swamps are generally ephemeral and, therefore, surface water flows occur during and shortly after rainfall events. On the basis that there is no connective fracturing to any deeper storage, it is likely that any diverted surface water will re-emerge at the surface further downstream. This would occur at the limit of the mining-induced fracturing along the downstream drainage lines.

The impact predictions provided in MSEC (2019) indicate that those Coastal Upland Swamps above longwalls are more susceptible to the effects of subsidence, compared to Coastal Upland Swamps located further away, and that it is unlikely that there would be large-scale adverse changes in the levels of ponding or scouring of the swamps.

Of the 46 Coastal Upland Swamp recorded within the Study Area, 25 are located above longwalls, or occur within 60 m from the proposed longwalls. Using the MSEC (2019) predictions, fracturing could occur within the bedrock beneath these Coastal Upland Swamps. The remaining Coastal Upland Swamps are predicted by MSEC (2019) to be unlikely to experience significant fracturing.

The fracturing of bedrock has the potential to result in hydrological regime changes. These indirect impacts associated with the fracturing/cracking are tied to the water regime of Coastal Upland Swamps which is described in the Scientific Determination as (Booth 2006; NSW PAC 2009):

i) water drains into cracks in the bedrock that open beneath or upslope of the swamp as a result of simple tensile strains or complex buckling and shear that enhances connectivity of fractures; and

ii) tilting of the surface results in re-distribution of overland flows, loss of water from swamp margins and/or concentration and channelisation of runoff.

Given the dependence of Coastal Upland Swamps on the presence and persistence of water, the following key impacts have the potential to occur to Coastal Upland Swamps that are subject to hydrological changes as a result of subsidence:

1. Reduction in groundwater levels or desaturation of the Coastal Upland Swamp sediments.
2. Transition of the Coastal Upland Swamp to a drier vegetation type.
3. Desaturation of soil particles exposing the swamp to peat desiccation.
4. Exposure to bushfire intensity due to loss of inundation.
5. Scour and erosion event.

Each of these potential impacts in relation to the Study Area are explored in the following sections.

Reduction in Groundwater Levels or Desaturation of Coastal Upland Swamps

Subsidence from longwall mining may cause the water table to drop from the near surface to below the sandstone base, under the swamp sediments (Young 2017). This in turn impacts upon the natural recharge and discharge system of the Coastal Upland Swamp. This process is described in Young (2017) as involving the following:

- Water table within the swamp rises to near surface from rainfall event;
- Water is lost from the swamp through evapotranspiration, and during high rainfall the runoff can exceed the storage capacity of the sediments so that water flows out at the swamp exit;
- After a swamp is mined under and where there is an impact on the groundwater levels, the water table drops rapidly, and even after heavy rain, rises only briefly before sinking again to below the bedrock base; and
- The swamps inundate occasionally but much less frequently and for a much shorter period than prior to mining.

The OEH (2016) *Addendum to NSW Biodiversity Offsets Policy for Major Projects, Upland Swamps impacted by Longwall Mining Subsidence* requires that offsets be developed where greater than negligible environmental consequences for Coastal Upland Swamps are predicted.

Negligible environmental consequences as per OEH (2016) is considered to mean one or more of the following:

- negligible change to the shallow groundwater regime of a swamp compared with control swamps
- negligible change to the composition or distribution of swamp dependent vegetation communities and threatened species.

Greater than negligible environmental consequences include one or more of the following:

- a shallow groundwater level within swamp sediments lower than the baseline level at any monitoring site within a swamp (in comparison to control swamps)
- a rate of shallow groundwater level reduction post-mining that exceeds the rate of shallow groundwater level reduction during the baseline period at any monitoring site (measured as average mm per day during the recession curve).

If it is predicted that Coastal Upland Swamps are likely to experience greater than negligible environmental consequences as a result of mining subsidence, conditions of consent will require that, on the approval of an extraction plan, a proponent must demonstrate a legal ability to secure offsets for the swamps).

Negligible environmental consequences is focused on groundwater as the best and most certain indicator of whether there will be an impact on the ecological community, as swamps are water-dependent ecosystems. If the shallow groundwater regime within swamp sediments is impacted during, or within 12 months after, mining operations, it is likely that the groundwater-dependent vegetation community and threatened species that comprise the swamp community will also be lost over time.

Piezometers have been installed throughout Coastal Upland Swamps as part of the existing mining monitoring programs, which provide an indicator for changes to the groundwater regime of a Coastal Upland Swamp. Under a natural regime, many swamps demonstrate a relatively constant rate of water level decline following rainfall, which can be mainly attributed to evapotranspiration and possibly some drainage to the underlying sandstone (Advisian 2016). A subsidence impacted swamp would typically exhibit a sharp drop in water level from the piezometer, following a recharge event.

Recent historic analysis completed by Watershed (2019) of Dendrobium Coastal Upland Swamps and swamp piezometers following longwall mining was undertaken to determine the distance at which piezometers have indicated an impact[6] to water table and recession rates. During the analysis, a total of 75 sites were assessed i.e. shallow piezometers located within the updated Coastal Upland Swamp mapping. Of the sites, 30 were considered to show a degree of impact, including 10 which showed effects as water levels falling below pre-mining baseline, while 29 showed increased recession rates. Based on assessments of water levels and recession rates around past mining in Areas 2, 3A and 3B, it was concluded by Watershed (2019) that hydrographs from swamp piezometers within 60 m are likely to exhibit a mining effect and almost certain to exhibit a mining effect when directly mined under, be that through a reduction in the water table to below pre-mining levels and/or increased recession (drainage) rate. Effects on swamp water tables were not reported at distances greater than 60 m from a longwall panel.

In regards to the Coastal Upland Swamps of the Study Area, it is therefore likely that swamps located above longwalls and within 60 m of longwall workings (25 are located directly above or within 60 m of proposed longwalls), may experience some degree of groundwater impact. The severity of impact is uncertain, however based on the historic impacts recorded at Dendrobium, Metropolitan and Russell Vale Colliery, it seems likely that groundwater recession rates may increase following rainfall events, and current levels of waterlogging may become periodic.

6 As discussed in Watershed (2019) "in other studies at Dendrobium, the definition of 'impact' is consistent with the SIMMCP regarding how an impact or environmental consequence of mining is classified:

1) A shallow groundwater level within swamp sediments lower than the baseline level at any monitoring site within a swamp (in comparison to control swamps).

2) A rate of shallow groundwater level reduction post-mining that exceeds the rate of shallow groundwater level reduction during the baseline period at any monitoring site (measured as average mm per day during the recession curve).

In some instances, both the above modes of impact may be observed at a single site, and in others, just one might be identified from the water level record".

Transition of the Coastal Upland Swamp to a Drier Vegetation Type

Most vegetation studies of Coastal Upland Swamps have reported spatial heterogeneity in floristic composition and structure (Keith and Myerscough 1993; Keith 2004). Species richness and composition of Coastal Upland Swamps are highly correlated with the soil moisture gradient that transitions from the drier margins to a waterlogged core (Keith and Myerscough 1993). The hydrological conditions are maintained due to precipitation and water supply exceeding the rate of evapotranspiration and runoff (Keith et al. 2006), with some sections of some Coastal Upland Swamps supporting a perched water table that maintains species diversity and vegetation communities reliant on semi-permanent to permanent waterlogging. As such, vegetation communities with Coastal Upland Swamps are reflected by moisture and nutrient gradient in the underlying soil, resulting in boundaries that may be discrete or subtly transitional.

Coastal Upland swamp vegetation is likely to be relatively resilient to short-term changes in groundwater level and soil moisture, demonstrated by the persistence of the swamp vegetation communities during extended periods of drought. However, it is reasonable to suggest that changes to swamp hydrology that are extensive and persistent may result in changes in the floristics and structure of the community. The thresholds that influence such a vegetation transition is unknown.

The extent to which subsidence may impact the vegetation or flora within a Coastal Upland Swamp is likely to depend on the extent of groundwater changes in the swamp, and the resilience of a particular vegetation type to such change. The groundwater connectivity in swamps is related to the inundation, soil parameters and water quality, which in turn all influence vegetation composition.

Keith and Myerscough (1993) described the following five vegetation communities that grow within Coastal Upland Swamps:

- Banksia Thickets (Map Unit 42): develops on the edge of larger swamps, often occupying the highest parts of swamp topographical sequences. Its soils are predominantly drier and sandy, yet they have intermediate levels of total phosphorus, conductivity and exchangeable cations. Its higher levels of organic matter might be explained by a greater rate of litterfall, rather than by a slower rate of decay due to poor aeration (Keith and Myerscough 1993). *Banksia ericifolia* subsp. *ericifolia* and *Hakea teretifolia* are the dominant diagnostic species of this assemblage.
- Tea-tree Thicket (Map Unit 43): occupies major seepage zones of large swamps, which typically have deep, highly organic waterlogged soils. In general, levels of soil nutrients are highest in Tea-tree Thicket compared to the other Coastal Upland Swamp vegetation. Keith and Myerscough (1993) note that waterlogging is continuous and peat development is greatest in Tea-tree Thicket. Young (1986) showed that the soils, termed 'organic fines', have a high silt/ clay content in their mineral fraction, as well as a high organic carbon content. Their high nutrient status may therefore be explained by a large input of nutrient ions from runoff and downwash, and by the abundance of clay and organic particles which provide a large number of exchange sites for mineral cations. Tea-tree Thicket has a tall to short, relatively dense shrub stratum with *Leptospermum juniperinum, Leptospermum grandifolium, Melaleuca squarrosa, Baeckea linifolia* and *Banksia robur*, and a tall, very dense stratum of ferns; Gleichenia spp., and sedges *Gahnia sieberiana* and *Baumea teretifolia*.
- Sedgeland-Heath Complex (Map Unit 44): comprises of three communities, Cyperoid Heath, Restioid Heath and Sedgeland, have been described by Keith (1994):

- Cyperoid Heath prefers the wetter locations on organic sandy soils (Young 1986) within the Coastal Upland Swamp complex, though it is replaced by Tea-tree Thicket in drainage lines. Sedges from the Cyperaceae family, including *Gymnoschoenus sphaerocephalus* and *Lepidosperma limicola*, dominate Cyperoid Heath. Low shrubs of *Banksia robur* and *Leptospermum juniperinum* occur patchily.
- Restioid Heath occupies relatively drier sites within the swamp complex, with sedges from the Restionaceae family forming the dominant ground cover. Species include *Leptocarpus tenax*, *Empodisma minus* and *Lepyrodia scariosa*. A low spreading shrub layer of *Banksia oblongifolia* and *Hakea teretifolia* is common. Restioid heath occupies higher parts of the topographical sequence where soils are periodically dry, preventing the accumulation of large amounts of peat. This, and their low clay content, provide few exchange sites for mineral nutrients which are leached downslope, perhaps to be adsorbed in soils with higher clay and organic fractions.
- Sedgeland occurs on the perimeter of larger Coastal Upland Swamps or on gently sloping 'hanging swamps' in the headwaters of sandstone gully lines. Similar to Restioid Heath, Sedgeland occupies higher parts of the topographical sequence where soils are periodically dry, preventing the accumulation of large amounts of peat. A thick, low cover of sedge species spreads across the extent of the community. Species such as *Leptocarpus tenax*, *Schoenus brevifolius, Schoenus paludosum* and *Lepyrodia scariosa* are frequently recorded. A number of sparsely scattered low shrubs such as *Sprengelia incarnata, Epacris obtusifolia* and *Symphionema paludosum* are also found.

- Eucalypt Fringing Woodland (Map Unit 45): is a transitional area between the Coastal Upland Swamp vegetation and the sandstone woodlands. Essentially this fringing swamp community shares species from both the Restioid Heath Complex and the Sandstone Woodlands with a sparse cover of Eucalypts, usually those from the Scribbly Gum complex, Eucalyptus racemosa/haemastoma.

A further vegetation unit, referred to as Coastal Upland Swamps: Mallee-Heath (Map Unit MU 46) is not described by Keith and Myerscough (1993), however it is described as part of the Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments mapping project (NPWS 2003). The vegetation unit is distributed on drier gradients with the Coastal Upland Swamp Complex in the Avon and Nepean Catchments, and only occasionally in the north near Maddens Plains. *Eucalyptus stricta* occurs in dense clumps amongst a low cover of shrubs such as *Banksia ericifolia* subsp. *ericifolia*, *B. paludosa* subsp. *paludosa*, *Allocasuarina nana*, *Petrophile sessilis* and *Leptospermum attenuatum* with ground cover typical of Restioid Heath.

Changes to groundwater may result in changes to vegetation structure and composition within a swamp. A decrease in species distribution or abundance, or extent of sub-communities, that are reliant on semi-permanent to permanent waterlogging (such as Tea-tree Thicket and Cyperoid Heath) within a swamp that has experienced lower water levels following mining, may indicate a vegetative impact from mining. Similarly, an increase in drier vegetation types within swamps that have experienced lower water levels following mining, such as Banksia Thicket or Eucalypt Fringing Woodland, may also serve as an indicator of mining impacts. The extent to which subsidence may impact vegetation or flora within a Coastal Upland Swamp is likely to depend on the extent of groundwater change in the swamp, and the resilience of a particular vegetation type to such change.

The Coastal Upland Swamps within the Study Area comprise predominately drier vegetation types including: approximately 49% of Eucalypt Fringing Woodland, 32% of Restioid heath, and 5% of Banksia Thicket. Wetter vegetation communities consisted of 10% of Teatree Thicket, 0.4% Sedgeland Complex and 3.5% Cyperoid Heath. Thus, given 86% of the vegetation within the Coastal Upland Swamps of the Study Area are the drier communities, may indicate that for the most part, the swamps are already in a transitioning state to a woodland community, or are less reliant on waterlogging.

The existing monitoring programs are largely centred on this notion, through pre and post mining comparisons between impacted swamps and control swamps. However despite changes in groundwater in some mined swamps, there is no conclusive evidence (or even suggestive correlations) from the monitoring reports to date that indicate that a significant vegetation response has occurred in response to mining. Recorded hydrological and vegetative changes have also been attributed to landscape influences such as increased rainfall, increased temperatures and more-frequent fire.

A review completed by Biosis (2017) of the data collected during the previous 11.5 years of the Dendrobium Area 2, 7.5 years in Dendrobium Area 3A and 4.5 years in Dendrobium Area 3B monitoring did not provide a strong link with subsidence and vegetation response. Key conclusions from Biosis (2017) included:

- Swamp size and the extent of groundwater dependent swamp sub-communities, mapped using LiDAR data, showed a universal decrease across control and impacted swamps.
- All Coastal Upland Swamps (impact and control) continue to show a trending decline in Total Species Richness (TSR).
- Statistically significant yearly and, occasionally, seasonal trends in species composition were detected at most sites, regardless of mining area or treatment. Such widespread trends are indicative of natural turnover of species within Coastal Upland Swamps in response to seasonal and annual variability in climate, competition, disturbance and edaphic factors, including nutrient availability.
- Species composition was found to be changing (increasing or decreasing at sites) every year at both control and impact sites, and this change is statistically significant at most sites.
- Photo monitoring did not detect any conclusive differences between impact and control sites.
- Swamp 15B and Swamp 1A show a small, but statistically significant, decline in TSR following mining.

Similarly, key conclusions were echoed in the latest Wollongong Coal monitoring report (Biosis 2017) and conclusions provided in the Metropolitan Coal Annual monitoring summary reports (Trevor Brown & Associates 2016; Peabody 2013; 2014; 2015).

Wollongong Coal monitoring report (Biosis 2017) key conclusions include:

- TSR is higher in mined swamps compared with un-mined swamps
- The extent of Coastal Upland Swamps in the Study Area remained constant between 1951 and 1984. A decline in swamp size occurring between 1984 and 2012 is coincident with a decline in rainfall over the same period
- No direct relationship between subsidence and vegetation change within Coastal Upland Swamps has been shown.

Metropolitan Coal annual monitoring summary reports (Trevor Brown & Associates 2016; Peabody 2013; 2014; 2015) key conclusions include:

- No statistically significant differences in the variation of species composition and abundance within or between plots were found
- Analysis of quadrat/transect data indicates that the vegetation in Coastal Upland Swamps overlying the longwalls has not experienced changes significantly different to changes in control swamps
- Monitoring of Coastal Upland Swamp vegetation has reported some random senescence of individual plants in both control and impact sites
- Fluctuations in vegetation condition have also been recorded across all sites

- Dieback was observed in both mined and unmined swamps, but also in areas well outside the current survey area.

Whilst no strong links to subsidence and vegetation response have been presented in the available monitoring reports, the time between the impact and vegetative response may not be immediate and not yet detected in monitoring data. Given the persistence of Coastal Upland Swamps throughout periods of drought, it is likely that the swamps are relatively resilient to short term changes in groundwater level and soil moisture.

Given the Coastal Upland Swamps of the Study Area are made of up of 86 % of drier subvegetation communities (Eucalypt Fringing Woodland, Banksia Thicket and Restriod Heath), it is also possible that these communities are more resilient to hydrological changes, given they are not as dependent on waterlogged peat compared to wetter subvegetation communities (Teatree Thicket, and Cyperoid Heath). However to date, no studies have been completed to support this.

Within recent years, LiDAR and historic aerial mapping of Coastal Upland Swamps has been incorporated in both Dendrobium and Wollongong Coal monitoring programs, to determine if Coastal Upland Swamp boundaries have been changing since longwall mining. The LiDAR and historic aerial mapping analysis completed by Biosis (2015, 2016, 2017) indicates that there has been a decline in the size of Coastal Upland Swamps and sub-vegetation communities within the Dendrobium and Russell Vale mining domains. This decline in size of swamps was attributed to the inward contraction of the swamp perimeter, leading to an encroachment of Eucalypt Fringing Woodland. The historical mapping of Coastal Upland Swamps for Dendrobium and Russell Vale showed that a decline in the size of Coastal Upland Swamps has occurred regardless of mining status, although impacted swamps showed a greater decline on average.

Monitoring at Russell Vale indicated that the size of Coastal Upland Swamps remained stable between 1951 and 1984, with a significant decline occurring between 1984 and 2012 (Biosis 2015). The decline in swamp size was attributed to rainfall, given a strong relationship between declines in Coastal Upland Swamps and a decline in monthly rainfall since the mid-1980s.

LiDAR monitoring at Dendrobium Mine indicates that the size of Coastal Upland Swamps at all control and impact swamps in the Dendrobium 3A and 3B areas in 2014, 2015 and 2016 was smaller than the extent measured in the baseline year of 2012. There was a substantial decline in swamp extent from 2012 to 2014, followed by a small increase in swamp extent in 2015, relative to the 2014 extent, and a subsequent decline again in 2016 (Biosis 2017a). Similarly, the change in the extent of Coastal Upland Swamp sub-communities typically decreased substantially from 2012 to 2014, then increased or remained stable from 2014 to 2015, and subsequently decreased again between 2015 and 2016.

Whilst there are a number of limitations associated with the LiDAR and historic mapping analysis (Biosis 2015; 2016; 2017), the result presented in the reports is a similar outcome to the vegetation monitoring; namely that to date, there is no conclusive evidence relating a decrease in swamp extent to the effects of mining.

It seems likely that any large-scale vegetative response to Coastal Upland Swamps within the Study Area, is not likely to be immediately detected and may take several years to be revealed. However, regardless of this, as detailed in the Scientific Determination, longwall mining has the potential to decrease the size of a Coastal Upland Swamp over time. Impacted Coastal Upland Swamps within the Study Area therefore may exhibit such a vegetation change.

Desaturation of Soil Particles Exposing the Swamp to Peat Desiccation

A reduction in the water table from subsidence may result in changes to the cohesion of the soils within aCoastal Upland Swamp. The organic matter within the soil may undergo a hydrophobic reaction, which in turn results in the organic matter, which binds the sand grains, becoming loose and resulting in sediments that are highly erodible (Young 2017, DPE 2015).

Long-term studies into the loss of organic sediment and soil cohesion have not been looked at in detail in relation to Coastal Upland Swamps in the Southern Coalfield, however soil moisture monitoring has recently been included in South32's Dendrobium Mine monitoring program to assist in determining any trends in regards to this.

To date, soil moisture levels of a number of swamps within Dendrobium Area 3B (Swamp 1a, 1b, 5 and 11) have been reported to have soil level moisture below baseline records following mining (DPE 2015).

It is likely that given the correlation between groundwater and soil moisture, should Coastal Upland Swamps in the Study Area exhibit changes to groundwater recession due to subsidence, they would be likely to have some decline in moisture in parts of the swamp.

The long-term impacts of changed moisture regimes within Coastal Upland Swamps in relation to the drying of the soil is unclear due to the lack of data and studies in this regard. However as a worst case scenario, as noted in Young (2017), eroding sediments may result in a knickpoint forming, or may ultimately facilitate an erosion and gully event in a Coastal Upland Swamp. However, as discussed in later in this section, such catastrophic erosion and gully events have only been observed in three Coastal Upland Swamps (of the more than 500 subject to subsidence) and MSEC (2019) predict that it is unlikely that there would be large-scale adverse changes in the levels of ponding or scouring of the swamps.

Exposure to Bushfire Intensity due to Loss of Inundation

It is unclear the extent to which Coastal Upland Swamps within the Study Area would have a change in waterlogging as a result of subsidence. However, it is possible that should a decrease in waterlogging occur, it may expose the Coastal Upland Swamp to higher intensive burns resulting in peat desiccation.

Such a potential impact is further exacerbated by climate change, which is predicted to be warmer and drier, with a greater proportion of rain falling during summer, which is likely to result in an increase in frequency of fire (Scientific Committee 2012, Hennessy *et al*. 2004, DECC 2008).

It is suggested by Keith et al (2006) that an increased fire frequency of around 15 years may not be compatible with the persistence of Coastal Upland Swamp vegetation. An increased fire regime from climate change may result in a decline of resprouting shrubs and sedges, which may lead to more prolonged exposure of soils after fires, especially if fires consume all ground fuels. This is because resprouting plants restore groundcover more rapidly than new seedlings. Prolonged or enhanced soil exposure could lead to accelerated decay of organic matter and/or accelerated erosion of surface soils, particularly if heavy rainfall events occur in the early post-fire years (Keith et al 2006). Erosion and reductions in the organic content of swamp soils are likely to increase the turbidity and mineral content of discharge waters and reduce the water retention capacity of the swamps (Young 1986). Subsidence may have a role in exacerbating the process through drying soils as a result of a changed groundwater regime, however as noted previously, soil monitoring studies are limited.

Erosion Events and Swamp Dewatering

Within the Southern Coalfield, a number of Coastal Upland Swamps have been impacted by a range of man-made and natural occurrences, and subsidence related mechanisms, which have been reported widely (e.g. Tomkins and Humphreys 2006, Krogh 2007, Krogh 2012, DP 2008, Commonwealth of Australia 2014, Pells and Pells 2015, Bower 2015, Advisian 2016). Many of the investigations over the past few decades have focused on those swamps that have experienced episodes of erosion and gullying, notably:

- Swamp 37 (Drillhole Swamp) – which occurs within Avon catchment within the Wongawilli Colliery leases
- Flatrock Swamp in the Woronora catchment at Darkes Forest, within Metropolitan Coal's mining lease
- Swamp 18/19 in Avon catchment within the Elouera Colliery lease.

Investigations into these Coastal Upland Swamps present contrasting views on the role of subsidence in the erosion and gullying events that occurred in the swamps, owing to other factors such as the occurrence of rainfall, bushfires, natural erosional phasing of the Coastal Upland Swamps, and direct man-made impacts, which have been summarised in Table 54.

It is apparent based on the conclusions in the investigations that the limited monitoring data prior to initiation of the erosion events, coupled with the lack of understanding of swamp thresholds and resistance to change, has led to great uncertainty in the role subsidence played in the erosion events.

In relation to the Project, MSEC (2019) states that for the Coastal Upland Swamps in the Study Area it is unlikely there will 'be large-scale adverse changes in the levels of ponding or scouring of the swamps based on the predicted vertical subsidence and tilt'. Given over 500 swamps have been directly mined beneath using varying methods (Richardson and Ryan 2007), with only three exhibiting gully and erosion events, it seems unlikely that such events would be experienced within the Study Area.

Table 54. Historic impacts to Drillhole Swamp, Flatrock Swamp, and Swamp 18/19

Coastal Upland Swamp	Type of impact	Details regarding impact event
Drillhole Swamp, located on Flying Fox Creek No 1 in the headwaters of the Avon catchment	Cracks in bedrock downstream of Drillhole Swamp Physical disturbance from MWSDB enquiry Gully erosion event	Experienced a gully erosion event in 1978 which eroded a large portion of the Coastal Upland Swamp. The gully event has been attributed by some studies to a subsidence event that occurred as a result of bord and pillar extraction mining methods in the 1960s and 1970s (Kapp 1980), which was noticed in 1971 by cracking in the bedrock downstream of the swamp (Tomkins and Humphrey 2006). An investigation by the Metropolitan Water, Sewerage and Drainage Board (MWSDB) in the early 1970s, as part of the Coal Mining Under Stored Water Inquiry (the Reynolds Inquiry), is known to have caused a significant disturbance to the swamp surface, which could reasonably be attributed to being a major knickpoint for the erosion event. The disturbance to the Coastal Upland Swamp by the MWSDB investigation included the construction of an access track across the centre of the swamp, clearing of a section of the swamp to bedrock, mounding of the spoil along the swamp margins and construction of a small dam on a creek upstream of the swamp, as well as drilling activities into bedrock) (Reynolds 1978, Tomkins and Humphrey 2006). A significant rainfall event occurred in March 1978 which resulted in the collapse of the small dam upstream of the swamp, and triggered erosion of a gully which cut through the swamp (Tomkins and Humphrey 2006). Young (2017) notes that 502 mm of rain fell over three days (19-21 March 1978) which was the fifth highest rainfall event in the area between 1967 and 2005. Young (2017) estimates that 8,250m^3 of sediment was eroded from the swamp in this event. Young (2017) notes that the mining beneath the swamp had resulted in multi-seam extraction resulting in 2.4 m of subsidence and reduced water table (8 m below the surface and 3-4 m below the bedrock in the swamp). Young (2017) concludes, in her view, that while the dam failure was the trigger for the erosion event, the long period of drying prior to the event left the swamp sediment highly erodible.

Coastal Upland Swamp	Type of impact	Details regarding impact event
Swamp 18/19 located on Native Dog Creek in the headwaters of the Avon catchment	Gully erosion Swamp dewatering Construction of the incomplete Maldon Dombarton railway across the upper reaches of the swamp, including infilling the valley and diversion of the stream into a culvert system.	A major gully in the swamp was discovered on 19 August 2002 following bushfire events in 2001 to 2002. Subsidence: Subsidence related cracks in bedrock were first noticed in the creek downstream of the swamp in late 2001 (Tomkins and Humphrey 2006). Evidence found that bedrock beneath the swamp had cracked and water had drained to within the bedrock layer (Gibbins 2003 cited in Tomkins and Humphrey 2006). The gully that formed in 2002 has been attributed by some to dewatering of the swamp by mining and burning of the swamp surface during the fires, followed by an intense storm. Bushfire events: Swamp 18/19 has experienced two major wildfires and a hazard reduction burn since 1964. The 2001-02 wildfire caused extensive damage to the swamp vegetation in all but the upper part of the swamp and the side swamps. EarthTech (2003) concluded that Swamp 18/19 is subject to periodic erosion events related to disturbance such as fire and subsequent significant flow events, however could not establish links between mining and an increased risk of wildfires, and mining subsidence and gully erosion (Tomkins and Humphrey 2006). Biosis Research (2001) discusses that the 2001-02 fires likely resulted in high severity burning of the near surface layers along with the fractured nature of the peat units indicates that dewatering had taken place and the surface of the swamp was dry by late 2001. It is possible that subsidence accelerated dewatering of Swamp 18/19 during the late 1990's which enhanced burning during the 2001-02 wildfires. Alternatively, the gully erosion through the lower part of the swamp prior to 1990 could have drained the swamp sufficiently to cause a similar effect. Existing gully events Tomkins and Humphrey (2006) showed that gully erosion of the lower extension of the swamp had commenced before 1951 and had reached the main body of Swamp 18/19 by 1990. This was well before known underground coal mining and before the 1968 and 2001-02 wildfires. Thus, the gully had been active for over 50 years prior to the erosion event following the 2001-02 fire.
Flatrock Swamp is located on Waratah Rivulet in the headwaters of the Woronora catchment	Gully erosion Swamp dewatering	Flatrock Swamp has had a history of gully erosion pre and post mining. Metropolitan Colliery and Sydney Catchment Authority first noticed cracks in the bedrock in Waratah Rivulet at the end of 2003, however no cracks were observed in Flatrock Swamp. Fracturing below the lower end of Flatrock Swamp may have resulted in possible changes to swamp bed gradients and flow paths (Mills and Huuskes 2004). Tomkins and Humphrey (2006) notes that mine related subsidence may be a contributing factor to the main gully erosion since longwall mining commenced under the lower part of the swamp in September 2002 and surface cracking was noticed in late 2003. However, subsidence does not explain the erosion of the lower part of the swamp between 1990 and 2002, unless the impacts from mining under the upper part of the swamp (~ 1970's) extended over a greater area at the surface. In 2002, several changes to the swamp were evident; many of the pools in existence in 1947 in the lower part of the swamp had become linked by gully erosion to form a continuous pool (Tomkins and Humphrey 2006). Historic gully events Tomkins and Humphrey (2006) notes that the gully appears to have formed through the development of channels and connection of pre-existing pools which progressively formed over time, commencing between 1982 and 1990, extending to 2002, and finally connecting throughout the length of the swamp by 2005. The erosion of the main section of the gully occurred progressively in response to several minor to moderate rainfall events which occurred between February 2002 and November 2004. The rainfall events led to failure of litter dams on the bare slopes which increased runoff velocities beyond those of vegetated slopes. The burnt and desiccated peat in the swamp may have facilitated the formation of knickpoints.

Conclusion

Impacts to Coastal Upland Swamps to date that have been observed and those that are widely reported as being mine subsidence related have been stark and readily observable. For reasons discussed above, all of the swamps (Swamp 37 or Drillhole Swamp), Swamp 18/19 and Flatrock Swamp) that are represented as being impacted heavily by mine subsidence were at the very least also impacted by activities that were unrelated to subsidence. The long term more subtle changes in vegetation extent and composition, considered by some commentators as likely to occur as a result of dewatering and drying, have not as yet been definitively recorded, despite some 16 years of monitoring.

The Coastal Upland Swamps of the Study Area which are to be mined beneath are likely to exhibit degrees of subsidence related impacts as predicted by MSEC (2019), readily detected in the swamp piezometer monitoring for the Project. It is apparent based on the monitoring to date, that any vegetative response is not likely to be detected within the immediate term, and analysis clouded by many natural variables.

Regardless of the monitoring results to date, there is still a risk that the Project would change the natural cycle of Coastal Upland Swamps within the Study Area. Whilst it is unlikely that a scour and erosion event would occur, it is possible that a change in swamp hydrological function from subsidence exposes a Coastal Upland Swamps above a longwall to a range of indirect impacts.

Appendix 9. Coastal Upland Swamps Offset Liability

Introduction

The OEH (2016) *Addendum to NSW Biodiversity Offsets Policy for Major Projects, Upland Swamps impacted by Longwall Mining Subsidence* sets a precautionary approach to biodiversity offsetting the uncertain impacts toward Coastal Upland Swamps from longwall mining.

The Addendum requires that offsets be developed where greater than negligible environmental consequences for Coastal Upland Swamps are predicted.

Negligible environmental consequences are defined in OEH (2016) is considered to mean one or more of the following:

- negligible change to the shallow groundwater regime of a swamp compared with control swamps
- negligible change to the composition or distribution of swamp dependent vegetation communities and threatened species.

Greater than negligible environmental consequences include one or more of the following:

- a shallow groundwater level within swamp sediments lower than the baseline level at any monitoring site within a swamp (in comparison to control swamps)
- a rate of shallow groundwater level reduction post-mining that exceeds the rate of shallow groundwater level reduction during the baseline period at any monitoring site (measured as average mm per day during the recession curve)" (OEH 2016).

As discussed in the OEH (2016) "if it is predicted that upland swamps are likely to experience greater than negligible environmental consequences as a result of mining subsidence, conditions of consent will require that, on the approval of an extraction plan, a proponent must demonstrate a legal ability to secure offsets for the swamps to be mined under in that extraction plan, as calculated using the FBA".

Predictions for the Project

Hydrological monitoring is determined in the OEH (2016) Addendum to be the most important measure for early detection of subsidence related impacts to Coastal Upland Swamps. Based on the groundwater response, the Project is likely to have a greater than negligible environmental consequence to a portion of Coastal Upland Swamps located in the Study Area. This is supported by the results of the current groundwater monitoring in Dendrobium Area 3 which indicate that groundwater recession changes are detected following mining in piezometers within occur following mining to Coastal Upland Swamps located above (and within 60 m of) the longwall.

Historic analysis completed by Watershed (2019) of Dendrobium Coastal Upland Swamps and swamp piezometers following longwall mining was undertaken to determine the distance at which a piezometer results show a greater than negligible environmental consequence, according to the definitions quoted above. A total of 75 sites were assessed in the analysis i.e. shallow piezometers located within the updated Coastal Upland Swamp mapping. Of the sites, 30 were considered to show a degree of impact, including 10 which showed effects as water levels falling below pre-mining baseline, while 29 showed increased recession rates. Swamp piezometers within 60 m of longwall secondary extraction are likely to exhibit a mining effect and almost certain to exhibit a mining effect when directly mined under, be that through a reduction in the water table to below pre-mining levels and/or increased recession (drainage) rate. Effects on swamp water tables were not reported (i.e. effects were considered nil or negligible) at distances greater than 60 m from a longwall panel (Watershed, 2019). As such, a similar distance could reasonably be expected with the current Project (Watershed, 2019).

From a vegetative response perspective, no conclusive findings have been presented to date in the Dendrobium Terrestrial Ecology Monitoring Program (commenced in 2003) to suggest that subsidence alone has resulted in substantial changes to vegetation within Coastal Upland Swamps. Similarly, monitoring results available from the Metropolitan Coal (Peabody 2013; 2014; 2015; Trevor Brown & Associates 2016) and Wollongong Coal (Biosis 2015; Biosis 2017) monitoring programs also have not presented any findings identifying any substantial vegetation response due to changes in groundwater.

Regardless of the vegetation monitoring, given actions in the OEH (2016) Addendum are driven by hydrological response, a greater than negligible environmental consequence for Coastal Upland Swamps within 60 m of longwalls, is predicted for the Project for the purpose of developing an offset strategy.

Approach to the Coastal Upland Swamp Offset Liability

The OEH (2016) Addendum requires that the loss of the Coastal Upland Swamp should be assumed e.g. the total area of the Coastal Upland Swamp has essentially been cleared and devoid of ecosystem function. This is summed up in the Addendum as follows -

> '*It is recognised that the impact of altering the hydrological regime within Coastal Upland Swamps is not equivalent to removing all vegetation. However, this impact is likely to result in total loss of the upland swamp ecological community in the long-term as a result of loss of critical ecosystem function. When predicting the offset liability it is the loss of the upland swamp ecological community, including the threatened species that reply on that community, which must be calculated to determine the offset liability*'.

Whist South32 acknowledges that a groundwater change may be experienced in Coastal Upland Swamps in the Study Area, there is strong evidence that indicates native vegetation and fauna habitat would still persist following mining, in fact there is little evidence to the contrary, and as such propose that this be taken into consideration when determining the biodiversity offset liability associated with Coastal Upland Swamps.

Given that the FBA provides the ability to amend 'site values' scores to reflect an impact, South32 proposes to amend the default 'site value' scores in the BBCC to reflect a transition vegetation type, rather than assuming the area of Coastal Upland Swamp would be completed cleared and devoid of fauna habitat, as would be the case for an open cut mine in the same location.

The proposed scoring is presented in Table 55, with justification provided in detail below.

Table 55. Proposed BBCC 'site value' scores

	Current score (0-3)	Score with development assuming the persistence of native vegetation and habitat (0-3)	Justification for change in score
HN560 Needlebush - banksia wet heath on sandstone plateau of the Sydney Basin Bioregion			
Native plant species:	3	2	Native richness may decline due to shading of overstorey and midstorey due to transition to Eucalypt Fringing Woodland. The impacts of shading from transition Coastal Upland Swamp subvegetation types is discussed in Keith (2007) As such, the score has been reduced by one score rather than a scenario assuming the complete loss of native plant species.
Native over-storey cover:	1	1	Score already at 1. It therefore cannot be increased, however it is worth noting that the overstorey is likely to increase due to regeneration of canopy species as a Coastal Upland Swamp becomes drier.
Native mid-storey cover:	3	3	The shrub layer score is at the maximum permissible as midstorey is likely to increase due to transitions to a drier vegetation community. Drier vegetation types include Banksia thicket which has a greater percentage of mid-storey cover compared to wetter vegetation communities.
Native ground cover (grasses):	1	1	Grasses should increase as swamp becomes drier and transitions to Eucalypt Fringing Woodland.
Native ground cover (shrubs):	3	3	Shrubs will increase as swamps become drier. Drier vegetation types include Restioid Heath and Banksia thicket which has a greater percentage of shrub cover compared to wetter vegetation communities.
Native ground cover (other):	2	1	Native ground-cover (other) may decrease due to transitioning vegetation types, however will not be completely lost. As such, the score has been reduced by one.
Exotic plant cover:	3	3	This will not change given area does not contain weeds.
Number of trees with hollows:	0	0	No change in score permissible.
Overstorey regeneration:	3	3	There will be regeneration in overstorey. No change expected
Total length of fallen logs:	0	0	No change in score permissible.
Current Site Value Score (out of 100)		67.39	
Future Site Value Score		55.80	
Decrease in Site Value Score		11.59	
HN662 Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin			
Native plant species:	3	2	Native richness may decline due to shading of overstorey and midstorey due to transition to Eucalypt Fringing Woodland. The impacts of shading from transition Coastal Upland Swamp subvegetation types is discussed in Keith (2007) As such, the score has been reduced by one score rather than a scenario assuming the complete loss of native plant species.
Native over-storey cover:	3	3	Score already at 3. It therefore cannot be increased, however it is worth noting that the overstorey is likely to increase due to regeneration of canopy species as a Coastal Upland Swamp becomes drier.
Native mid-storey cover:	0	0	The shrub layer score has been increased to the maximum permissible as midstorey is likely to increase due to transitions to a drier vegetation community. Drier vegetation types include Banksia thicket which has a greater percentage of mid-storey cover compared to wetter vegetation communities.
Native ground cover (grasses):	3	3	Grasses should increase as swamp becomes drier and transitions to Eucalyptus Fringing Woodland.
Native ground cover (shrubs):	3	3	Shrubs will increase as swamps become drier. Drier vegetation types include Restioid Heath and Banksia thicket which has a greater percentage of shrub cover compared to wetter vegetation communities.
Native ground cover (other):	2	1	Native ground-cover (other) may decrease due to transitioning vegetation types, however will not be completely lost. As such, the score has been reduced by one.

	Current score (0-3)	Score with development assuming the persistence of native vegetation and habitat (0-3)	Justification for change in score
Exotic plant cover:	3	3	This will not change given area does not contain weeds.
Number of trees with hollows:	0	0	No change in score permissible.
Overstorey regeneration:	3	3	There will be regeneration in overstorey. No change expected
Total length of fallen logs:	0	0	No change in score permissible.
Current Site Value Score (out of 100)		99.07	
Future Site Value Score		83.33	
Decrease in Site Value Score		15.74	

The justification to support this approach is based on the following:

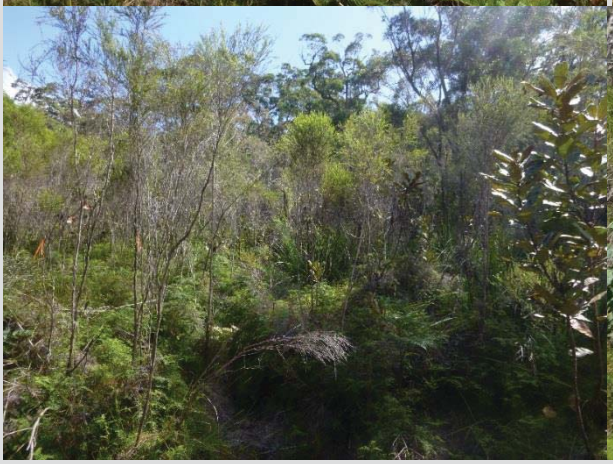
1. ***Coastal Upland Swamp vegetation would transition into a drier vegetation community***

To date, monitoring has not detected any substantial changes in sub vegetation communities that can be attributed to subsidence (Appendix 8). Given over 500 swamps have been directly mined beneath using varying methods (Richardson and Ryan 2007) with swamp vegetation still persisting (in some cases for 9 years (Swamp 15b)), demonstrates that there is some degree of resilience to subsidence. Photographs obtained from the Coastal Upland Swamp monitoring have been provided in Table 56 which demonstrates the persistence of swamp vegetation since 2010.

At a worst case vegetation transition, Coastal Upland Swamps are likely to take on the appearance and function of a drier woodland community, similar to that of Coastal Upland Swamp: Eucalypt Fringing Woodland, which also shares the same PCT as the Coastal Upland Swamp TEC (HN560 Needlebush - banksia wet heath on sandstone plateau); or Exposed Sandstone Scribbly Gum Woodland (HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin).

As such, at a worst-case scenario, whilst the ecosystem itself has changed (from swamp to woodland), vegetation is still persistent, and as such site value scores provided in Table 55 reflect a reasonable transition through the site scores.

Table 56. Swamp 15b photo monitoring results

Swamp 15b Photo monitoring site /date	Monitoring photographs
S15b_SO1 18/11/2010	 
11/4/2019	 

S15b_SO2 18/11/2010		
11/4/2019		
S15b_SO3 18/11/2010		
11/4/2019		

S15b_SO4 18/11/2010 (Left), 17/01/2011 (Right)	 
11/4/2019	 
S15b_SO5 17/01/2011	 
11/4/2019	 

S15b_SO6 11/02/2011 (Left), 18/11/2010 (Right)	
11/4/2019	

2. *The Predicted threatened species in the BBCC for Coastal Upland Swamps and HN566 are similar*

As discussed above, it is likely that a Coastal Upland Swamp that has been completely changed in hydrological function would resemble that of a drier community, similar to HN566 Red Bloodwood - scribbly gum heathy woodland.

Whilst it is acknowledged that Coastal Upland Swamps are important for number of threatened flora and fauna, including: Giant Burrowing Frog, Littlejohn's Tree Frog, Giant Dragonfly, and *Pultenaea aristata*, the Predicted threatened fauna as determined by the BBCC for Coastal Upland Swamps are similar to that of the woodland community (HN566). The only difference being the Spotted Harrier is not predicted to occur in HN566. As such, predicted threatened biodiversity habitat would essentially not be lost if a transition to a drier community takes place and as such, it may be reasonable to attribute the site value score in the BBCC to more a meaningful score than simply a complete loss in habitat as suggested in the Addendum.

Table 57. Predicted threatened species in Coastal Upland Swamp units (HN560 & HN562)

Common name	Species	TS offset multiplier	Predicted to occur in Coastal Upland Swamp (HN560 & HN562)	Predicted in Exposed Sandstone Scribbly Gum Woodland (HN566)
Eastern Freetail-bat	*Mormopterus norfolkensis*	2.2	Y	Y
Gang-gang Cockatoo	*Callocephalon fimbriatum*	2.0	Y	Y
Greater Broad-nosed Bat	*Scoteanax rueppellii*	2.2	Y	Y
Little Eagle	*Hieraaetus morphnoides*	1.4	Y	Y
Little Lorikeet	*Glossopsitta pusilla*	1.8	Y	Y
New Holland Mouse	*Pseudomys novaehollandiae*	3.0	Y	Y
Scarlet Robin	*Petroica boodang*	1.3	Y	Y
Spotted Harrier	*Circus assimilis*	1.4	Y	N
Spotted-tailed Quoll	*Dasyurus maculatus*	3.0	Y	Y
Swift Parrot	*Lathamus discolor*	1.3	Y	Y
Eastern false pipestrelle	*Falsistrellus tasmaniensis*	2.2	N	Y
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	1.8	N	Y
Varied Sittella	*Daphoenositta chrysoptera*	1.3	N	Y

3. Candidate threatened species of Coastal Upland Swamps are offset separately

Threatened biodiversity that are listed on the EPBC Act or are regarded as 'species credit' species are offset accordingly if detected within habitat types impacted by subsidence. As such, whilst at a worst-case scenario, a Coastal Upland Swamp transitions to a woodland, through the process of an impact assessment, those threatened biodiversity reliant upon the swamp system are offset separately to the Addendum. As such, given the predicted species detailed above are assumed to be present in a woodland transition, and threatened biodiversity with evidence of using the Coastal Upland Swamp are offset separately, the site values scores in the BBCC have been amended to reflect the habitat potential still present.

4. Evidence to support impacts directly above and within 60 metres from proposed longwalls

As discussed previously, historic analysis completed by Watershed (2019) of Dendrobium Coastal Upland Swamps and swamp piezometers following longwall mining has indicated that effects on swamps (that could be classified as "greater than negligible environmental consequence") do not occur at distances greater than 60 m from a longwall panel. Based on the analysis completed by Watershed (2019), of a total of 75 sites assessed in the analysis, 30 were considered to show a degree of impact. Of the piezometers impacted, 10 showed effects of water levels falling below pre-mining baseline, while 29 showed increased recession rates (Table 58).

Based on assessments of water levels and recession rates around past mining in Areas 2, 3A and 3B, swamp piezometers within 60 m are likely to exhibit a mining effect and almost certain to exhibit a mining effect when directly mined under, be that through a reduction in the water table to below pre-mining levels and/or increased recession (drainage) rate (Table 58). Effects on swamp water tables were not reported (i.e. effects were considered nil or negligible) at distances greater than 60 m from a longwall panel. As such, a similar distance could reasonably be expected with the current Project.

Table 58. Frequency of impacts by distance: swamp piezometers (Watershed 2019)

Distance from longwall panel(m)	No. of swamp piezometers affected	
	Impact on baseline	Impact on recession rate
0 (impact occurred above mined goaf)	22	6
0-10 m	1	1
10-20 m	1	1
20-30 m	1	0
30-40 m	1	0
40-50 m	2	1
50-60 m	1	1
60-100 m	0	0
100-150 m	0	0
150-200 m	0	0
200-400 m	0	0
Total affected	29	10

Conclusion

Whist South32 acknowledges that a groundwater change may be experienced in Coastal Upland Swamps in the Study Area, there is strong evidence to suggest that any groundwater impact would not occur at a distance greater than 60 m from the proposed longwalls. There is also strong evidence that at worst case, native vegetation (including the listed threatened ecological community) and fauna habitat would still persist following mining. As such, Niche has generated the required number of ecosystem credits for Coastal Upland Swamps based on the site value scores presented in Table 55 . The results of which have been provided in section 10.2 of this assessment.

Appendix 10. Credit Profile

Biodiversity credit report

This report identifies the number and type of biodiversity credits required for a major project.

Date of report: 2/05/2019 Time: 5:28:01PM Calculator version: v4.0

Major Project details

Proposal ID:	0112/2018/4943MP
Proposal name:	3365 Dendrobium 1
Proposal address:	
Proponent name:	South 32 - Illawarra Coal
Proponent address:	
Proponent phone:	
Assessor name:	Luke Baker
Assessor address:	
Assessor phone:	
Assessor accreditation:	0112

Summary of ecosystem credits required

Plant Community type	Area (ha)	Credits created
Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	1.50	120.38
Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion	16.30	227.00
Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin	4.57	78.00
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	25.80	1,022.00
Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	0.20	6.00
Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion	1.00	80.00
Total	49.37	1,533

Credit profiles

1. Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion, (HN597)

Number of ecosystem credits created	6
IBRA sub-region	Sydney Cataract - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion, (HN597) Blackbutt - Narrow-leaved White Mahogany shrubby tall open forest of coastal ranges, northern Sydney Basin Bioregion, (HN505) Sydney Blue Gum - Blackbutt - Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin Bioregion, (HN596) Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion, (HN647) Deane's Gum - Mountain Grey Gum - Turpentine tall moist forest on shale, Sydney Basin Bioregion, (HN636)	Sydney Cataract - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

2. Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion, (HN556)

Number of ecosystem credits created	120
IBRA sub-region	Sydney Cataract - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion, (HN556) Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion, (HN513) Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion, (HN604)	Sydney Cataract - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

3. Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (HN566)

Number of ecosystem credits created	1,022
IBRA sub-region	Sydney Cataract - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (HN566) Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion, (HN587) Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion, (HN586) Spotted Gum - Grey Ironbark open forest in the Pittwater and Wagstaffe area, Sydney Basin Bioregion, (HN642) Sydney Peppermint - White Stringybark - Smooth-barked Apple forest on shale outcrops, Sydney Basin Bioregion, (HN644)	Sydney Cataract - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

4. Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion, (HN651)

Number of ecosystem credits created	80
IBRA sub-region	Sydney Cataract - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion, (HN651)	Sydney Cataract - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

5. Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion, (HN560)

Number of ecosystem credits created	227
IBRA sub-region	Sydney Cataract - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion, (HN560) Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion, (HN563) Baeckea linifolia - Grevillea acanthifolia subsp. acanthifolia shrub/sedge swamp on sandstone, Sydney Basin Bioregion, (HN633)	Sydney Cataract - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

6. Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin, (HN662)

Number of ecosystem credits created	78
IBRA sub-region	Sydney Cataract - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin, (HN662)	Sydney Cataract - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

Summary of species credits required

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Broad-headed Snake	Hoplocephalus bungaroides	0.28	9
Giant Burrowing Frog	Heleioporus australiacus	32.74	426
Koala	Phascolarctos cinereus	1.50	39
Littlejohn's Tree Frog	Litoria littlejohni	32.74	851
Red-crowned Toadlet	Pseudophryne australis	7.21	94
Giant Dragonfly	Petalura gigantea	13.93	1,073

Appendix 11. Koala Plan of Management

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Koala Plan of Management

Dendrobium Mine – Plan for the Future: Coal for Steelmaking

Prepared for Illawarra Coal | 8 May 2019

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Executive summary

The Dendrobium Mine is an existing underground coking coal mine located in the Southern Coalfield of New South Wales. The Dendrobium Mine was approved in 2001 and has operated since that time under approvals from both the NSW Government (under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act)) and the Commonwealth Government (under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)).

Illawarra Coal Holdings Pty Ltd (Illawarra Coal), a wholly owned subsidiary of South32 Limited (South32) is seeking to continue operations at the site through approval consent to gain access to two future mining areas within Consolidated Coal Lease (CCL) 768 known as Area 5 and Area 6.

The Project area lies within the Metropolitan Special Area, declared in 1880 to protect the land of the Upper Nepean catchment, currently managed by WaterNSW (Office of Environment and Heritage 2017). The Project locality is generally comprised of rich and diverse intact native vegetation cover as a result of protection to maintain water quality in the Upper Nepean storages (Office of Environment and Heritage 2017).

Koalas have been recorded within the Project area during field surveys completed by Niche for the Project (Niche 2019).

The aims of this Koala Plan of Management (KPoM) are to:

1. Manage the local Koala population, for the life of the Project, in a manner such that a significant population decline does not occur
2. Identify appropriate management strategies in order to achieve aim (1).

The Koala is the largest arboreal marsupial in south-eastern Australia, with a widespread distribution throughout the eastern-Australian mainland, extending from north Queensland, through NSW, Victoria to south-east South Australia (DECC 2008). The Koala is listed as 'Vulnerable' under the NSW *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth EPBC Act.

The Koala has been recorded at six locations within the Project area by Niche and is known to occur within the broader locality of the Project area; including across most of the Upper Nepean State Conservation Area, and south of the Nepean and Avon dams. There are 6,935 discrete records of the Koala within a 50 kilometre radius of the Project area (OEH Atlas of NSW Wildlife, 2018).

Koala habitat mapping was performed for the Project area based on the SEPP 44 definitions of 'core' and 'potential' Koala habitat. Results indicated that approximately three per cent of the Project area comprises core habitat for Koalas based on evidence of a resident Koala population (recent records). Potential Koala habitat is estimated to cover approximately 20 per cent of the Project area based on the likely occurrence of feed tree species within the vegetation communities of the Project area.

Based on the Koala habitat mapping, the Project area supports approximately 125 hectares of core Koala habitat and 816 hectares of potential Koala habitat which make up 23 per cent of the overall Project area. Clearing for the ventilation shafts will be localised (total of 18.8 ha of vegetation removal) and not include areas mapped as core Koala habitat. The clearing for the proposed Dendrobium carpark is 0.2 ha, and does not include areas of core Koala habitat.

Additional clearing impacts for service boreholes and electricity transmission lines (9.5 ha) will occur and are predicted to include clearing of a maximum of 1.5 hectares of Shale Sandstone Transition Forest which is considered core Koala habitat (actual location to be determined during the exploration phase of the Project).

Principal threats to the Koala, relevant to the Project, include habitat loss and fragmentation. There is some potential for increased risk of road kill, predation by dogs or foxes and increased wildfire.

This Plan includes the following measures to avoid and mitigate potential impacts to the Koala and its habitat as a result of the Project:

1. Minimising clearing in areas of core or potential Koala habitat
2. Rehabilitation of the service borehole sites and electricity transmission line corridors
3. Reducing the risk of Koala injury and death (including pre-clearing surveys, establishment of speed limits on all tracks and roads and fauna (including Koala-specific) inductions for all personnel
4. Koala injury monitoring and management.

Glossary and list of abbreviations

Term or abbreviation	Definition
Area 5	Dendrobium Area 5
Area 6	Dendrobium Area 6
BC Act	NSW *Biodiversity Conservation Act 2016*
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
KPoM	Koala Plan of Management
MNES	Matters of National Environmental Significance listed under the EPBC Act
OEH	Office of Environment and Heritage
Project area	The Project area includes the proposed mining and surface infrastructure areas as illustrated in Figure 1
TEC	Threatened Ecological Community as listed on the BC Act and or EPBC Act. Collective term to describe vulnerable, endangered and critically endangered ecological communities.

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1. Introduction

1.1 The Project

The Dendrobium Mine is an existing underground coking coal mine located in the Southern Coalfield of New South Wales. The Dendrobium Mine was approved in 2001 and has operated since that time under approvals from both the NSW Government (under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act)) and the Commonwealth Government (under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)).

Illawarra Coal Holdings Pty Ltd (Illawarra Coal), a wholly owned subsidiary of South32 Limited (South32) is seeking to continue operations at the site through approval consent to gain access to two future mining areas within Consolidated Coal Lease (CCL) 768 known as Area 5 and Area 6 (hereafter referred to as the 'Project'). The Project constitutes a State Significant Development (SSD) and requires an Environmental Impact Statement (EIS).

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Illawarra Coal to prepare a Koala Plan of Management (KPoM) due to the known occurrence of Koalas within the Project area as detailed in Niche (2019).

1.1.1 Project area

The Project and Project area refers to the proposed mining area (Area 5 and Area 6 collectively) as well as surface infrastructure areas detailed below and shown in Figure 1.

Mining Area

The Project involves the development and underground mining of two new mining domains called Area 5 and Area 6. The area potentially subject to subsidence effects associated with Area 5 and Area 6 are approximately 2,958 hectares and 1,075 hectares, respectively. The extent of Area 5 and Area 6 are shown in Figure 1.

Surface Infrastructure

The Project is expected to include development/installation of up to four ventilation shafts (Figure 1) which have been assessed as part of the biodiversity assessment report for the Project (Niche 2019). The total disturbance area of the ventilation shaft sites is 18.8 hectares (Figure 1).

The surface infrastructure will also include the proposed Dendrobium Pit Top carpark (the carpark), which is off Cordeaux Road, Kembla Heights. The carpark is a component of the Project area but is not shown on the mining area figure (Figure 1) due to its distance from Area 5 and Area 6. The carpark is located approximately 12 kilometres south-east of Area 5 and Area 6 and as shown in Figure 2. It would result in an additional disturbance area of 0.2 hectares.

Additional clearing impacts for borehole sites and electricity transmission lines are required, including clearing of up to 1.5 hectares of Sandstone Transition Forest (the actual location of which is to be determined during the exploration phase of the Project).

Clearing of all vegetation within the surface infrastructure areas (namely the ventilation shaft sites, car park and borehole sites and transmission lines) has been assumed for the purpose of this plan.

1.2 Aims and objectives

1.2.1 Aims

The aims of this KPoM are to:

1. Manage the local Koala population, for the life of the Project, in a manner such that a significant population decline does not occur
2. Identify appropriate management strategies in order to achieve aim (1).

The successful achievement of the above aims would be determined through consideration of koala habitat during final planning of surface infrastructure areas, active rehabilitation of vegetation, employee education, avoiding injury through traffic controls and management of any injured Koalas as described in Section 6.7.

1.2.2 Objectives

The objective of this KPoM is to adequately address the requirements of SEPP 44, in particular clause 17 of the policy. Clause 17 states that such plans are to be prepared with reference to the Director Generals guidelines. Guidelines provided by the NSW Department of Planning in 1995 to provide interpretation of SEPP 44, state in Section 2.2.2 that an individual KPoM should consider the information listed in Table 1 (Department of Planning 1995).

Table 1. SEPP 44 KPoM Requirements (Department of Planning 1995)

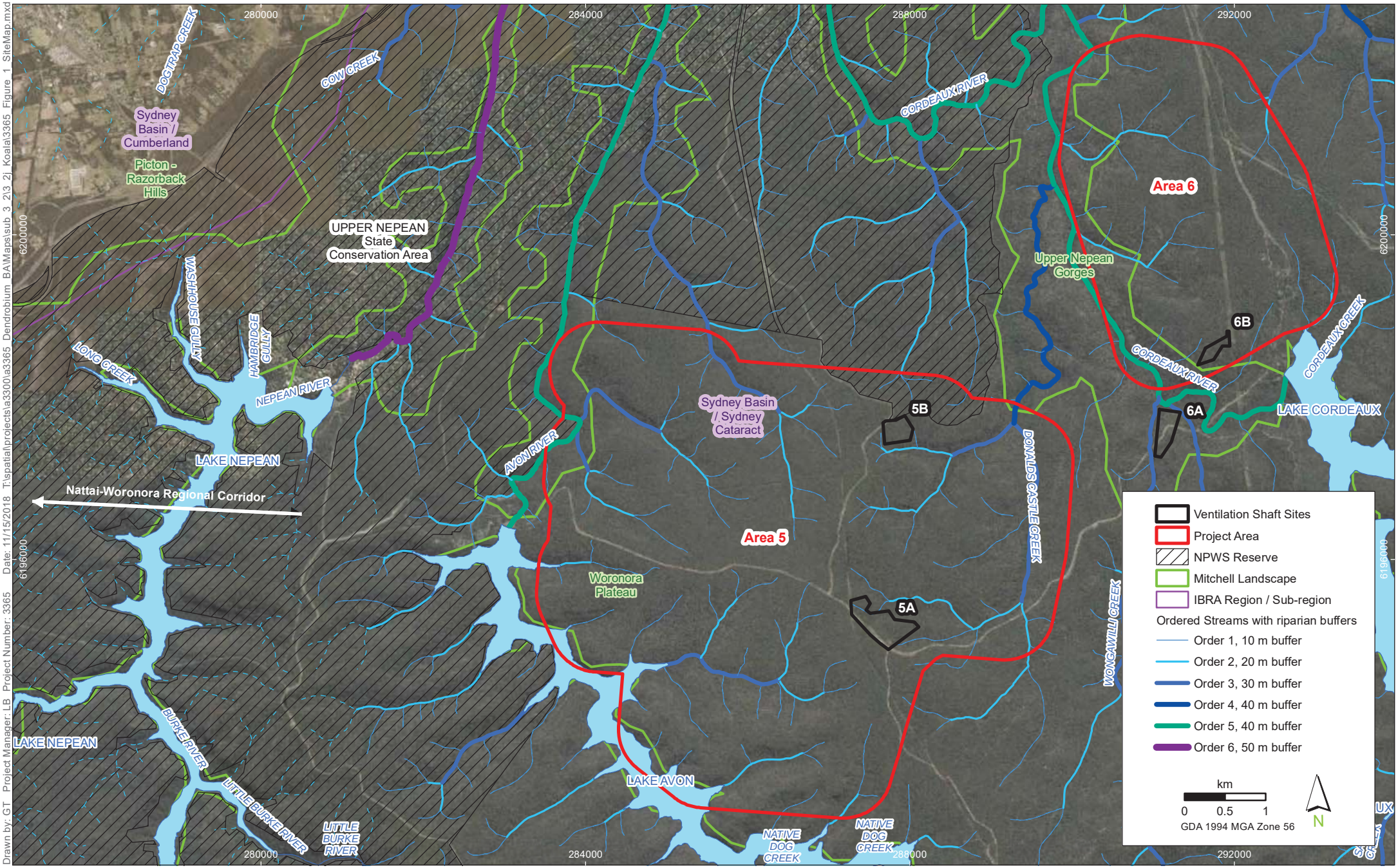
Landscape feature		Relevant Section in this KPoM or how addressed
I.	An estimate of population size.	3.2, 4.2
II.	Identification of preferred feed tree species for the locality and the extent of resource available.	4.3
III.	An assessment of the regional distribution of Koalas and the extent of alternative habitat available to compensate for that to be affected by the actions.	4.2
IV.	Identifications of linkages of core Koala habitat to other adjacent areas of habitat and movement of Koalas between areas of habitat. Provision of strategies to enhance and manage these corridors.	3.3
V.	Identification of major threatening processes such as disease, clearance of habitat, road kill and dog attack which impact on the population. Provision of methods for reducing these impacts	5
VI.	Provision of detailed proposals for amelioration of impacts on Koala populations from any anticipated development within zones of core Koala habitat.	6.3 Plan to be amended once areas of impact area known.
VII.	Identification of any opportunities to increase size or improve condition of existing core habitat, this should include land adjacent to areas of identified core Koala habitat	Via offsetting of impacts to any habitat as per project Biodiversity Assessment Report (Niche 2019).
VIII.	The plan should state clearly what it aims to achieve (for example maintaining or expanding the current population size or habitat area).	1.2.1
IX.	The plan should state the criteria against which achievement of these objectives is to be measured (for example, a specified population size in a specific time frame or the abatement of threats to the population).	7.1

X.	The plan should also have provisions for continuing monitoring, review and reporting. This should include an identification of who will undertake further work and how it will be funded.	7

Due to the limited extent of impacts proposed for the Project (given that the ventilation shafts have been located to avoid impacts to core habitat for the Koala and impacts will be localised and marginal compared to the extensive widespread habitat throughout the locality), this KPOM will focus on maintaining the local population of Koalas and minimising impacts through implementation of:

- Pre-clearing protocols
- Education programs
- Driving restrictions and reporting of sightings/ vehicle strikes
- Rehabilitation of any impacts to core habitat (i.e. borehole sites and transmission lines).

The KPOM will be wholly implemented and funded by South32 for the life of the Project including any specified timeframe required for rehabilitation of cleared areas.



Site Map

Dendrobium Mine – Plan for the Future: Coal for Steelmaking - Koala Plan of Management

FIGURE 1

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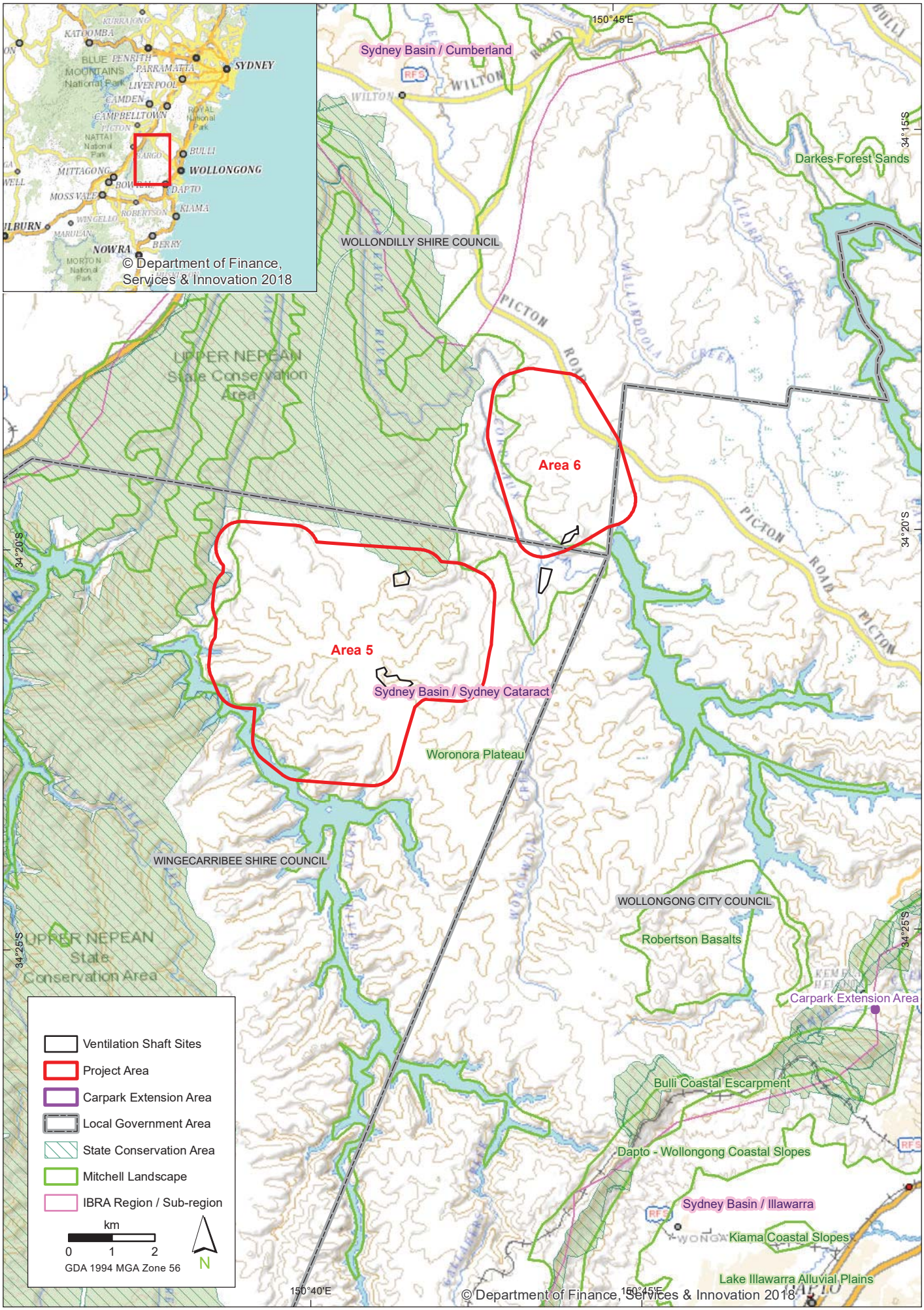


Location Map

Dendrobium Mine – Plan for the Future: Coal for Steelmaking - Koala Plan of Management

Source: Illawarra Coal and Niche

FIGURE 2

2. Regional and local context

2.1 Description of Project area and surrounds

The Project area is located within the Sydney Basin bioregion, with the majority of the Project area within the Woronora Plateau. The general landscape features of the Project area and surrounds are provided in Table 2 and Figure 1.

Table 2. Landscape features

Landscape feature	Description
Local government area(s)	Wollongong City Council, Wingecarribee Shire Council, Wollondilly Shire Council.
IBRA bioregion	Sydney Basin
IBRA subregion	Area 5, Area 6 and Ventilation Shaft Sites: Sydney Cataract Carpark: Illawarra
Mitchell Landscape	Area 5 and Area 6: Woronora Plateau (majority of Project area), Upper Nepean Gorges Carpark: Bulli Coastal Escarpment
Rivers, streams and estuaries	The Avon River lies to the west of Area 5. Cordeaux River is located on the western boundary of Area 6. Donald's Castle Creek and Wongawilli Creek are also situated on the perimeter of the Project area.
Wetlands	There are no Coastal Wetlands in the Project Area, in accordance with SEPP (Coastal Management) 2018 (previously known as SEPP 14 Coastal Wetlands).

The Project area lies within the Metropolitan Special Area, declared in 1880 to protect the land of the Upper Nepean catchment, currently managed by WaterNSW (Office of Environment and Heritage 2017). The Project locality is generally comprised of rich and diverse intact native vegetation cover as a result of protection to maintain water quality in the Upper Nepean storages (Office of Environment and Heritage 2017).

The Project area is bordered to the north and west by the Upper Nepean State Conservation Area, which covers an area of 25,869 hectares between Wilton in the north, Mittagong in the west and Robertson in the south (Office of Environment and Heritage 2017).

2.1.1 Vegetation

The broader locality is dominated by Sandstone-derived vegetation communities, consistent with the underlying geology. The species assemblages are responsive to the gradual changes in rainfall, elevation and underlying geology of the area, with rarer vegetation communities often present where shale and basalt is present (Office of Environment and Heritage 2017).

Upland swamps are extensive on the Woronora Plateau, primarily occurring in the higher rainfall areas to the south of the Project area, on periodically waterlogged soils associated with quaternary alluvial deposits and humic matter (Office of Environment and Heritage 2017).

2.1.2 Topography and drainage

The Project area is located within the Upper Nepean catchment which covers almost 900 square kilometres of mostly pristine bushland on the Illawarra Plateau west of Wollongong (WaterNSW 2018). The catchment lies at the southern end of the Illawarra Plateau, which stretches from Robertson north to Heathcote National Park, and is bordered by the Illawarra Escarpment in the east, Campbelltown in the north-west and the villages of Bargo and Yerrinbool in the south-west (WaterNSW 2018).

The broader locality supports diverse topography and landscape features, including river gorges, exposed scarps and closed valleys, associated with the Illawarra Escarpment and associated river systems (including the Nepean, Avon, Cordeaux, Burke and Little Burke rivers) (Office of Environment and Heritage 2017). The general landform follows the geological feature known as the Nepean Ramp, the gentle slope aligned on a north-west to south-east axis (Office of Environment and Heritage 2017).

2.1.3 Geology and soils

The Woronora Plateau is dominated by Triassic Hawkesbury sandstone, with the underlying Narrabeen Group (sandstone, siltstone and shale) exposed in the river gorges (Office of Environment and Heritage 2017). In places, the Hawkesbury sandstone is overlain by thin lenses of Wianamatta Group shales (Office of Environment and Heritage 2017).

Soils derived from Hawkesbury sandstone cover the majority of the Upper Nepean region (Office of Environment and Heritage 2017). These soils are typically thin, acidic and sandy and are highly susceptible to erosion if disturbed (Office of Environment and Heritage 2017).

2.1.4 Climate

The climate is warm in summer (generally between 20-25 degrees Celsius) and mild in winter, with minimum temperatures between 2-5 degrees Celsius (BOM 2018). Annual rainfall for the broader locality ranges from 800 to 1600 millimetres, decreasing with distance from the coast along a distinct gradient from the south-east to north-west (Office of Environment and Heritage 2017).

3. Ecology of the Koala

3.1 Description, status and ecology of the Koala

The Koala is the largest arboreal marsupial in south-eastern Australia, weighing from 6.5 to 12 kilograms (NSW Department of Environment and Climate Change 2008). Its distribution is widespread but very patchy throughout the eastern-Australian mainland, extending from north Queensland, through NSW, Victoria to south-east South Australia (DECC 2008). The Koala is listed as 'Vulnerable' under the NSW *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth EPBC Act.

Phillips and Callaghan (2000) identified that *Eucalyptus punctata* (Grey Gum) and *E. agglomerata* (Blue-leaved Stringybark) were most preferred by Koalas in the forest and woodland in the Campbelltown area, which is approximately 30 kilometres north of the Project area. Their research also noted that the Koalas showed a preferential utilisation of *E. punctata* and *E. agglomerata* on substrates derived from shales, compared with the same species on sandstones, suggesting that their use by Koalas was influenced by differences in nutrient status between substrates (Phillips and Callaghan 2000).

Within the nearby Upper Nepean State Conservation Area, Koalas have been observed using a number of different browse species including *Eucalyptus globoidea* (White Stringybark*), E. sieberi* (Silvertop Ash*),* Grey Gum, *E. piperita* (Sydney Peppermint), *Corymbia gummifera* (Red Bloodwood) and Blue-leaved Stringybark (Office of Environment and Heritage 2017). Koala observations within the Upper Nepean State Conservation Area appear to be consistent with research on Koalas in nearby populations undertaken by Phillips and Callaghan (2000) which showed a preference towards trees associated with richer soils (Office of Environment and Heritage 2017).

The Koala does not require tree hollows for breeding and, although they appear to prefer larger trees for diurnal shelter, they often forage in young eucalyptus trees with small diameters (Kavanagh et al. 2007, Matthews et al. 2007, Woodward et al. 2008).

The breeding season for the Koala peaks between September and February and animals travel the furthest in this period (Dique et al. 2003). Female Koalas do not always breed every year (Martin and Handasyde 1999). The gestation period for the Koala is approximately 35 days (Martin and Handasyde 1999). Following birth, the young remains in the pouch for approximately six months and on leaving the pouch remain dependent on its mother as 'back young', reaching independence at approximately one year of age (Martin and Handasyde 1999). Dispersal distances for young Koalas generally range from one to 10 kilometres (Gall 1980, Mitchell 1990, Dique et al. 2003), which may vary, depending on the availability of unoccupied habitat. The Koala reaches sexual maturity at approximately two years of age and has a life expectancy of approximately 10 years (Martin and Handasyde 1999).

The home range of the Koala varies in relation to environmental factors, such as site productivity, but also in relation to tree species composition, degree of habitat fragmentation, and population density. The home range of the Koala in semi-arid forests and woodlands is usually much larger (greater than100 hectares) than in temperate forests nearer the coast (less than three hectares), and there is less overlap between the home range of individual animals (Hindell and Lee 1988, Mitchell 1990, Hasegawa 1995, Melzer 1995, White 1999, Ellis et al. 2002).

The Koala population in NSW and Queensland has declined significantly over the past two decades, as a result of frequent fire, habitat removal, predation and vehicle strike (Allen 2009). It is estimated that the NSW Koala population declined by around 10,000 individuals, or approximately 30 percent, between 1990 and 2010 (Allen 2009).

3.2 The Koala population in the Upper Nepean

In NSW, Koalas occur along the coast, extending west to the Darling Riverine Plains and Mulga Lands bioregions in the north of the state; to the Cobar Peneplain bioregion in the centre of the state; and to the Riverina and eastern-most parts of the Murray-Darling Depression bioregions in the south (Department of Environment 2018). The highest densities of the Koala in NSW occur on the North Coast and Central Coast (Department of Environment 2018). In the Sydney Basin bioregion, where the Project area is located, Koalas occur around the Central Coast, Blue Mountains and the fringes of the Cumberland Plain (Department of Environment 2018). The number of Koalas occurring on the Central Coast of NSW are estimated to have been approximately 1,900 individuals in 2010; the population in Campbelltown and the surrounding area are considered to be increasing slowly since the 1980s with approximately 300 animals estimated in 2010 (Department of Environment 2018).

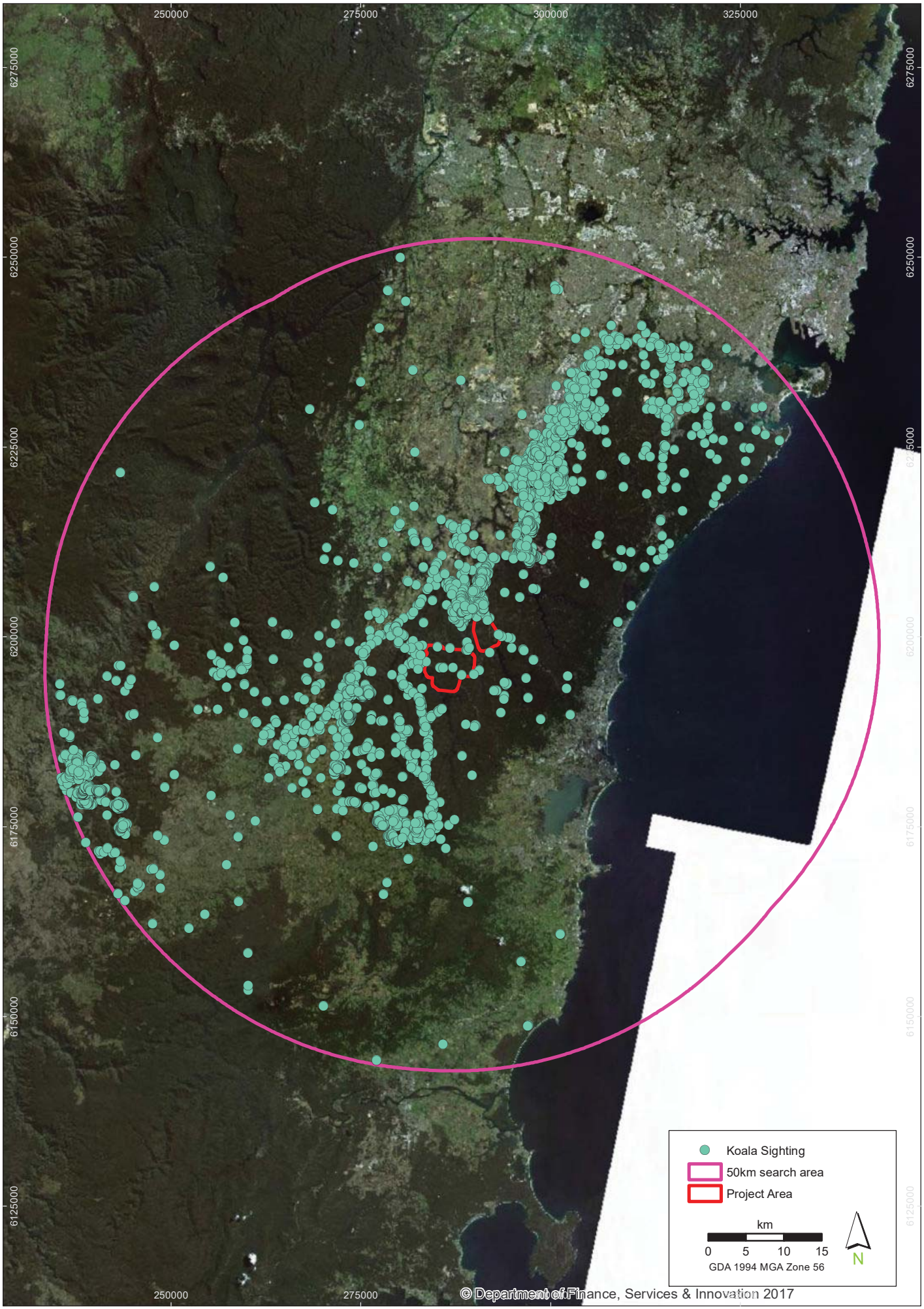
There have been numerous sightings of the Koala distributed over the broader locality of the Project area, including across most of the Upper Nepean State Conservation Area, south of the Nepean and Avon dams (Office of Environment and Heritage 2017). The Koalas residing in the Upper Nepean State Conservation Area are considered to be a distinct population but retain linkages with other known sub-populations in the area, including those in Dharawal National Park to the north, Nattai National Park and Bargo and Bargo River State Conservation Areas to the west, and Morton National Park to the south (Office of Environment and Heritage 2017).

A search of the NSW BioNet Wildlife Database (accessed November 2018, OEH Atlas of NSW Wildlife) within a 50 kilometre radius of the Project revealed a total of 6,935 discrete records of the Koala (Figure 3). Most of these were recent records with 81 per cent observed since 2000. Records are concentrated in the forests and woodland of the greater Campbelltown area and throughout the Upper Nepean State Conservation Area (generally associated with accessible areas along existing roads and tracks).

Phillips and Callaghan (2000) speculated that, in the Campbelltown area, the Koala occurs at low densities as a result of the relatively low habitat quality and its associated carrying capacity, more than other factors. The fact that Koalas within the area showed preferential utilisation of trees on substrates derived from shales, compared with the same tree species present on sandstones, indicated that the low activity levels reported for Koalas in the area may be typical of those to be expected in low-nutrient environments (Phillips and Callaghan 2000). Further, they suggest that the presence of a sparsely distributed food resource may result in relatively large-ranging patterns by resident animals in the population.

3.3 Corridors and habitat connectivity

The Project area is located predominantly within a large remnant corridor of native vegetation that connects Macquarie Pass in the south to the Georges River in the north. The Project area is bordered to the north and west by the Upper Nepean State Conservation Area and large stretches of native vegetation connect along the Illawarra escarpment and continue north to Dharawal National Park and Heathcote National Park (Figure 1). The Project area is located along the Nattai-Woronora regional corridor (Figure 1).



Koala records within 50 km of the Project

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FIGURE 3

Imagery: (c) S32 2015

4. Koala population and its habitat in the Project area

4.1 Vegetation types

A total of 11 Plant Community Types (PCTs) have been identified within the Project area within the biodiversity assessment report for the project (Niche 2019, Figure 4). Vegetation zones identified for the Project area are defined as areas of native vegetation that are the same PCT and have a similar broad condition state. Vegetation zones for the Project area have been identified within the ventilation shaft and car park areas, service boreholes and transmission line corridors (i.e. areas subject to vegetation clearing) and areas that may be susceptible to subsidence impacts (including areas supporting Upland Swamps and riparian vegetation). The vegetation communities within the Project area include the following:

- PCT1292 Water Gum - Coachwood riparian scrub along sandstone streams
- PCT1284 Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains
- PCT1254 Sydney Peppermint - White Stringybark moist shrubby forest on elevated ridges
- PCT1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain (corresponding vegetation community: Shale Sandstone Transition Forest)
- PCT1250 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies
- PCT1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney
- PCT1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux
- PCT881 Hairpin Banksia - *Kunzea ambigua* - *Allocasuarina distyla* heath on coastal sandstone plateaux
- PCT978 Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion
- PCT1804 Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin
- PCT1245 Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes.

Four PCTs occur within the Project area that are subject to vegetation clearance. These are tabled below (Table 3):

Table 3. Plant Community Types impacted (or with a predicted impact) by clearing from the Project.

PCT ID	BVT Code	PCT/BVT Name	Keith Formation	Koala habitat	Condition	Corresponding TEC	Area in Study Area (ha)	Area in areas of Direct Impact (ha)
1083	HN566	Red Bloodwood - scribbly gum heathy woodland on sandstone plateaus, Sydney Basin	Dry Sclerophyll Forests (Shrubby sub-formation)	Other	Moderate_Good	Not listed	2,461.5	25.8[1]
1250	HN651	Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest	Dry Sclerophyll Forests (Shrubby sub-formation)	Other	Moderate_Good	Not listed	430.7	1.0[2]
1395	HN556	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Grassy Woodland	Core	Moderate_Good	Shale Sandstone Transition Forest (BC Act and EPBC Act)	173.5	1.5[3]

PCT ID	BVT Code	PCT/BVT Name	Keith Formation	Koala habitat	Condition	Corresponding TEC	Area in Study Area (ha)	Area in areas of Direct Impact (ha)
1245	ME044	Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	Wet Sclerophyll Forests (Shrubby sub-formation);	Other	Moderate_Good	Not listed	0.2	0.2

1 This area is made up of the ventilation shaft site disturbance footprints (18.8 ha), and 4 ha of disturbance that may be associated with the additional service boreholes, and 3 ha of disturbance associated with the transmission lines.

2 This area is made up of disturbance that may be associated with the transmission lines (1 ha).

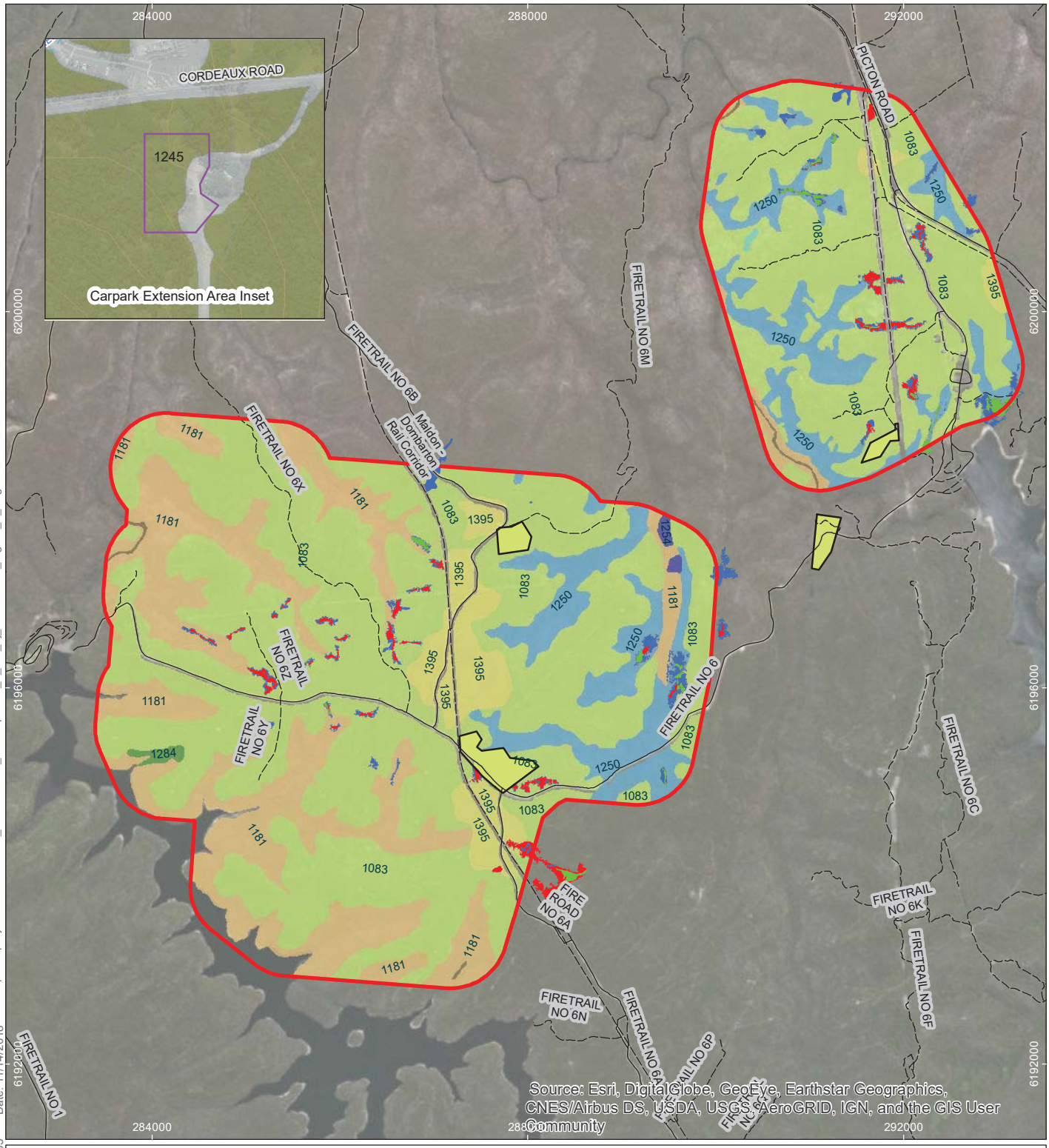
3 This area is made up of the additional service boreholes (1 ha) and transmission lines (0.5ha).

Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion (PCT1395) aligns to a Threatened Ecological Community under both the BC Act and EPBC Act – Shale Sandstone Transition Forest. Impacts to this community and others would be actively regenerated after infrastructure is decommissioned.

The main community to be impacted by clearing is Red Bloodwood - scribbly gum heathy woodland, which is the dominant vegetation community of the sandstone plateaus within the Metropolitan Water Catchment.

Three separate zones were established within the Red Bloodwood - scribbly gum heathy woodland areas to be cleared, reflecting differences in condition or structure. The largest zone to be cleared consists largely of an undisturbed form of the community with typical structure in terms of canopy cover. This zone was considered to be in 'moderate/good' condition.

The native vegetation within the car park consisted of *Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes southern Sydney Basin Bioregion* (PCT 1245). This community at the site was in a highly modified (low) condition; it supported isolated native shrubs, a mix of introduced ground cover and no large native mature trees were present.



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Date: 11/14/2018

Project Number: 3365

Project Manager: LB

Drawn by: MH

Ventilation Shaft Sites

Project Area

Upland swamps (Niche validated)

- 978: Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion (TEC)
- 978: Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin (TEC)
- 1804: Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin (TEC)

Vegetation (Niche validated)

- 1083: Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux, Sydney Basin
- 1245: Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion

Woronora Vegetation (NPWS 2003) PCT equivalent

- 881: Hairpin Banksia - Kunzea ambigua - Allocasuarina distyla heath on coastal sandstone plateaux, Sydney Basin
- 1083: Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux, Sydney Basin
- 1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin
- 1250: Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin
- 1254: Sydney Peppermint - White Stringybark moist shrubby forest on elevated ridges, Sydney Basin Bioregion
- 1284: Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion
- 1292: Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin
- 1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin (TEC)
- 1804: Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin (TEC)

km

0 0.5 1

N

GDA 1994 MGA Zone 56

Vegetation zones

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FIGURE 4

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4.2 Koala population size

Koala presence within the Project area was assessed during the fauna baseline surveys using the following techniques (Niche 2019):

- Spotlighting surveys - 10 hours within proposed ventilation shaft sites in Area 5 and Area 6 and additional spotlighting from vehicles and within areas of Sandstone Transition Forest in Area 5
- Call playback surveys at each proposed ventilation shaft sites over 3 nights (2-3 hours)
- Spot Assessment Technique (SAT) - three SAT plots were conducted within ventilation shaft sites that were within 500m of identified core Koala habitat
- Infrared cameras

The Koala was already known to be present within and adjoining the Project area and considered unlikely to be impacted by subsidence, therefore survey was not performed throughout the mining areas. Three SAT plots were conducted in ventilation shaft site 5A within close proximity to known core Koala habitat, however, no preferred tree species were present within ventilation shaft sites.

The results of the fauna baseline survey included six records of the Koala within the Project area (at two locations in Area 6 and four locations in Area 5) (Figure 5), comprising a total of eight individuals. These results include two direct observations of Koalas, two recordings on camera traps and two instances where Koalas were heard calling across the landscape.

The Koala records were within dry sclerophyll forest and grassy woodland (transition forest) within the central portion of Area 5 and the south-west corner of Area 6. One Koala was heard in the vicinity of the proposed ventilation shaft 5A. While it was not possible to obtain a definitive location for this individual, it was estimated to be approximately 150 metres from the survey team at the time the call was heard. Vegetation within the proposed ventilation shaft sites and the carpark was closely examined during the flora and fauna baseline surveys (Niche 2019) for the presence of Koala feed trees and thus the potential for the areas to support Koala habitat. Given the absence of preferred tree species within any of the ventilation shaft sites and the carpark, these areas are not considered to contain important (potential or core) Koala habitat despite it being acknowledged that Koalas may pass through these areas on occasion.

An estimate of Koala population was not performed during this assessment given the scale of potential impacts is considered relatively minor. Core areas of habitat have been identified where Koala densities are highest. Koalas within the Project area are part of a large Koala population extending from the Southern Highlands to Western Sydney (Figure 3). Potential habitat within the Project area and wider catchment represents a small proportion of the population with a relatively low density of Koalas due to limited areas of preferred feed trees.

4.3 Koala tree preferences and distribution throughout the Project area

Koala habitat mapping was carried out for the Project area based on the SEPP 44 definitions of 'core' and 'potential' Koala habitat as follows:

*"**core Koala habitat**" means an area of land with a resident population of Koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population.*

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

During the field surveys undertaken for the flora and fauna baseline assessments (Niche 2019), no Koala feed trees listed under Schedule 2 of SEPP 44 were recorded within the ventilation shaft and carpark disturbance areas.

To determine the extent of core or potential Koala habitat within the Project area, the vegetation descriptions provided in NPWS (2003) along with observations made during the field survey and Koala records in the Project area were reviewed. Areas were designated as core habitat where multiple recent and/or historical Koala records occurred within the same area (in keeping with the SEPP 44 definition). Potential Koala habitat was determined to include areas with vegetation communities identified as containing Koala feed trees, as identified on Schedule 2 of SEPP44. Areas with multiple Koala records which did not meet the definition of potential habitat were typically along roads, which Koalas (particularly roaming males) are likely to use as movement corridors.

Three Koala feed trees listed under Schedule 2 of SEPP 44 were identified as occurring within vegetation communities mapped within the Project area. These included *E. punctata*, *E. tereticornis* and *E. viminalis* and are identified as key canopy species in five vegetation communities present throughout the Project area. These vegetation communities are described in Table 4. The extent of these communities, and thus potential Koala habitat, and core Koala habitat, within the Project area is shown in Figure 5.

Table 4. Vegetation communities comprising core and potential habitat (Niche 2019)

Vegetation community	Composition and Koala habitat features	Koala habitat
PCT1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain (Shale Sandstone Transitional Forest)	This community features *Eucalyptus punctata* as a regular species and *Eucalyptus tereticornis* as an associated species (NPWS 2003). *E. punctata* was recorded during the field survey as occurring within the community whereas *E. tereticornis* is not present. Whilst no formal vegetation plots were undertaken within this vegetation community, it was noted that *Eucalyptus punctata* would likely occupy at least 15% of the total number of trees in the upper and lower stratum. Additional tree species recognised as supplementary feed species for the Koala such as *Eucalyptus* eugeniodes and *Eucalyptus globoidea* were also present.	Core Potential
PCT1250: Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies	This vegetation community features *Eucalyptus piperita* and *Corymbia gummifera* as a co-dominant species along with *Eucalyptus seiberi* and *E. globoidea*. No feed SEPP 44 tree species are considered dominant or associate species for this community and would not therefore constitute 15% of the total trees in the community. However, at least one Koala was recorded within a section of this vegetation community (south-western part of Area 6) as detailed in Niche (2019), and as such, a portion of this vegetation has been regarded as core Koala habitat.	Core Other
PCT1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney	This vegetation community features *Eucalyptus punctata* as a co-dominant species along with *Corymbia gummifera* and *Eucalyptus piperita*. Its key diagnostic feature as described by NPWS (2003) is the 'open forest dominated by *Eucalyptus punctata*'. As such, given it is known that *E. punctata* is a dominant tree in the community, it is highly likely that *E. punctata* constitutes 15% of the total number of trees in the community. At least one Koala was recorded within a section of this vegetation community (south-western part of Area 6) as detailed in Niche (2019), and as such, a portion of this vegetation has been regarded as core Koala habitat.	Core Potential
PCT1254: Sydney Peppermint - White Stringybark moist shrubby forest on elevated ridges	This vegetation community features *Eucalyptus piperita* and *E. globoidea* as a co-dominant species. There are a wide variety of other species including *Eucalyptus obliqua*, *E. cypellocarpa*, *E. quadrangulata*, *E. elata* and *E. punctata*, *E. smithii* and *E. radiata*. Given no plots were undertaken in this vegetation community, and given the one feed tree is an associate species, it is unclear whether the community would constitute 15% of the total trees in	Potential

	the community. As such, this vegetation unit has been regarded as potential Koala habitat as a precaution.	
PCT1284: Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains	This vegetation community features *Eucalyptus punctata* as a co-dominant species along with *Eucalyptus elata*, *Eucalyptus agglomerata*, and *Eucalyptus piperita*. Its key diagnostic feature as described by NPWS (2003) is the 'tall forest supporting *Eucalyptus elata*, *E. punctata* and E. *agglomerata*'. Given it is known that *E. punctata* is a co-dominant tree in the community, it is likely that *E. punctata* constitutes 15% of the total number trees in the community. A few scattered *E. viminalis* were also recorded in this community towards Donald's Castle Creek in Area 5.	Potential

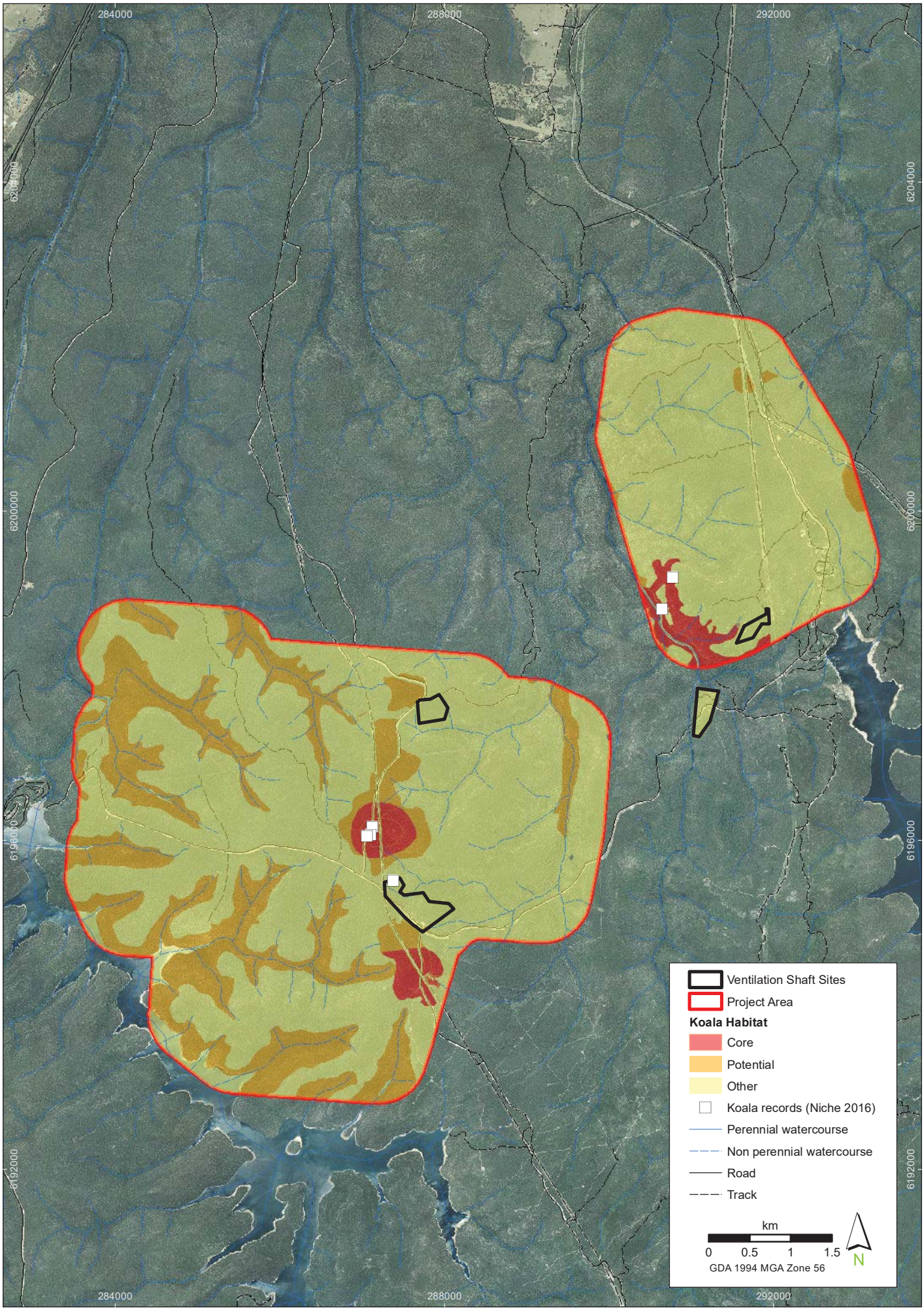
Koala habitat mapping (Figure 5; Table 5) indicates that approximately three per cent of the Project area comprises core Koala habitat (based on historical and recent records and thus evidence of a resident Koala population). Potential Koala habitat is estimated to cover approximately 20 per cent of the Project area (Figure 5; Table 5) based on the likely presence of feed tree species within the vegetation communities of the Project area.

Table 5. Results of Koala habitat mapping for the Project area.

Category	Area (hectares)	Proportion of study area (%)
Core	125	3
Potential	816	20
Other	3,103	77
Total	**4,044**	**100**

Vegetation observations, transects or other vegetation surveys have been performed to inform the Koala habitat mapping throughout parts of the Project area. Since potential impacts from the project are considered limited, however, detailed vegetation mapping was confined to the proposed ventilation shaft sites during the flora and fauna survey (Niche 2019). The findings from the Niche (2019) assessment concludes that the proposed ventilation shaft sites do not support core or potential Koala habitat and is considered accurate according to SEPP 44 definitions.

Koalas may occur anywhere within the Project area given the widespread presence of likely core and potential Koala habitat, however, outside of these mapped habitat areas, such occurrences are more likely to be transient in nature i.e. individuals moving between areas of potential/core habitat. Roads and tracks within the Project area likely facilitate movement of the species (note the records along the track in Area 5, Figure 5) and such pathways occur on the edge of a number of the proposed ventilation shaft sites.



Koala habitat mapping

Dendrobium Mine – Plan for the Future: Coal for Steelmaking - Koala Plan of Management

FIGURE 5

Imagery: (c) S32 2015

5. Threats and management issues

5.1 Overview

The principal threats to the Koala as detailed in the Recovery Plan for the species (DECC 2008) and the National Koala Conservation and Management Strategy 2009-2014 (National Resource Management Ministerial Council 2009) along with other literature, include: habitat loss, fragmentation and degradation, road kills, predation by dogs and foxes, drought, high temperatures, climate change, wildfire, overbrowsing and disease (Kavanagh et al. 2007, Lunney et al. 2012). The majority of these threats are active within the Project area and are discussed in the following sections, with the exception of disease, drought, high temperatures and climate change which are not considered to be directly relevant to the Project.

5.2 Fragmentation, degradation and habitat loss

Based on the Koala habitat mapping, the Project area supports approximately 125 hectares of core Koala habitat and 816 hectares of potential Koala habitat which together make up 23 per cent of the overall Project area. The areas of mapped core and potential Koala habitat are contiguous with large stretches of native vegetation throughout the Project area and the broader landscape.

Potential fragmentation and degradation impacts to Koala habitat associated with the Project are expected to be minimal given the following:

- The effect of subsidence is unlikely to affect woodland vegetation (i.e. Koala habitat) as it is generally associated with impacts to groundwater dependant ecosystems, such as the upland swamp vegetation areas (which did not support preferred Koala feed trees).
- Clearing for the ventilation shafts will be localised (totalling 18.8 hectares) and will avoid mapped core and potential habitat areas.
- No hard barriers to Koala movement would be introduced as a result of the project and existing significant barriers within the local area would not be increased.

Additional clearing impacts for exploration sites and transmission lines are considered to be required for up to 1.5 hectares of Sandstone Transition Forest (actual location of which is to be determined during the Project exploration phase). Areas of Shale Sandstone Transition Forest are considered core or potential Koala habitat, as described in Section 4.2. Measures to minimise potential impacts to Koalas including minimising the disturbance footprint wherever possible and undertaking pre-clearance surveys are detailed in Section 6. Areas of disturbance would be directly rehabilitated following decommissioning.

5.3 Road kills

Potential exists for interactions between mine vehicle traffic and Koalas on the access road to and from the Project area and within it. Roads and vehicle strike have been shown to significantly affect Koala populations (e.g. Lassau et al. 2008). Koala mortality from vehicle strike along Picton Road is known, with approximately 27 Koala road-kill incidents having been reported within the NSW Wildlife Atlas since 2000 (6), representing only a proportion of the overall Koala deaths from vehicle collision along Picton Road and surrounding roads. The density of Koalas within the catchment is relatively low compared with areas supporting a greater proportion of preferred foraging habitat, which typically occur on more fertile shale influenced soils closer to the township of Picton where the greatest densities of Koala and Koala roadkill records occur.

The Project would result in an increase in traffic on a number of roads within the wider Project locality (e.g. Picton Road), however such increases would be minor compared with predicted traffic volumes. The Project contribution to total traffic on Picton Road would remain small, with an increase following the proposed change to primary access (Year 2035) of 0.4 to 2.5% and 0.1 to 0.3% for Picton Road east of Cordeaux Pit Top and Picton Road west of Cordeaux Pit Top, respectively.

Product coal would be continue to be transported via rail from the Dendrobium Pit Top, below the escarpment where Koalas are not known to occur (Figure 6). Roads and fire trails within the catchment would likely experience more frequent traffic movements due to construction and operation of infrastructure for the Project, such as ventilation shaft sites. This presents an increased risk of potential interactions with the Koala, however the expected increased risk is considered relatively low given the existing speed limits for vehicles within the catchment would continue to be enforced, along with additional mitigation measures recommended to reduce the likelihood of lethal interactions between vehicles and the Koala.

One approach to managing vehicle strike is to construct a barrier (e.g. floppy-topped fence) to prevent animals from venturing into the path of a vehicle. While merit exists in isolating the potential for vehicle strike, other unintended impacts, such as introduction of a barriers to movement, are likely to result from this mitigation method for Koalas and other fauna species. As such, fences within the catchment area are not proposed as this is considered to pose a greater threat to Koalas (through fragmentation of habitat or Koala sub-populations) than the low increased risk of impacts from vehicle collisions.

Applying speed limits within the Project site, in conjunction with the use of a code of conduct is a preferred method for managing the increased risk of vehicle strike within the catchment area.

Further discussion of the proposed management measures relating to potential vehicle strike is provided in Section 6.4.

5.4 Predation by dogs and foxes

Dog attacks primarily occur where the Koala uses habitat in urban areas, on small rural holdings close to urban centres and in semi-urban and rapidly urbanising areas (DECC 2008). They also occur in the wider landscape in areas such as national parks, reserves and on a range of rural holdings. The problem is exacerbated when dogs have the opportunity to form pairs or packs, when dogs can roam widely outside their home properties and where large and aggressive breeds are common (DECC 2008). Dog attacks commonly result in stress, injury or death to the Koala (DECC 2008).

The greatest risk of predation by dogs is from feral individuals that may be present throughout the catchment area. This concentration of dogs and foxes is unlikely to be influenced by the Project. Control of vertebrate pest species within the catchment area is conducted routinely by WaterNSW.

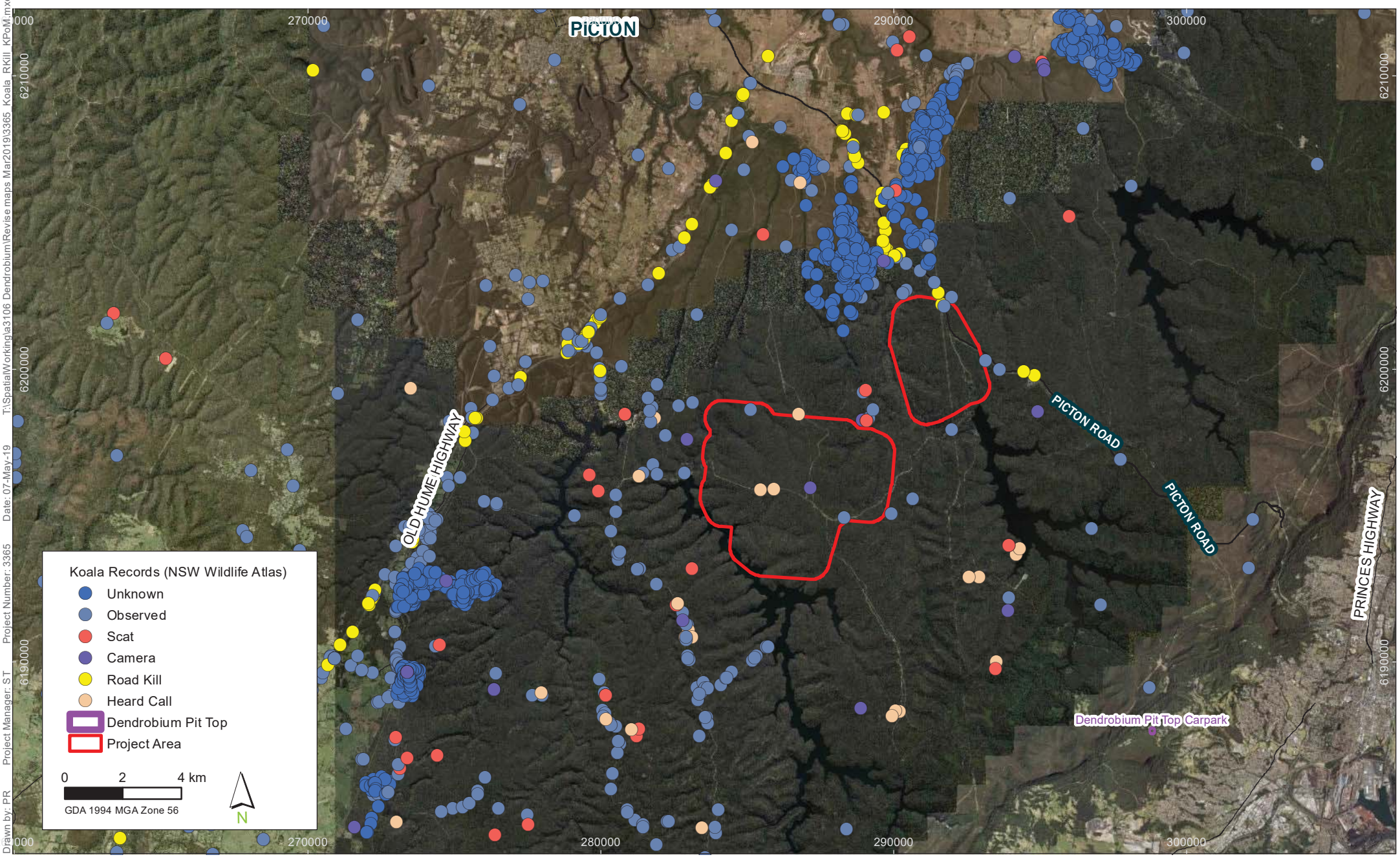
5.5 Wildfire

Fires have been shown to cause extensive direct mortality to the Koala (Lunney et al. 2007). The Upper Nepean State Conservation Area is an area of high bushfire hazard during summer months (SCA & NPWS 1999). According to fire records maintained by WaterNSW, there were extensive fires in the Metropolitan Special Area in 1951–52, 1957–58, 1964–65, 1968–69 and 2001–02 (Office of Environment and Heritage 2017). Large fires often follow extended dry periods. In spring 2013, a 6,533 hectare wildfire burnt most of the Upper Nepean State Conservation Area north of Nepean Dam.

There is the potential for a greater chance of fire ignition sources via increased levels of industrial activity, introduction of electricity infrastructure and increased numbers of people working in and around the forest. In hot, dry, windy conditions, a fire ignition could quickly flare up and expand to significantly impact the Koala population in the wider Project locality. Management measures would be implemented during construction and operation of the Project to minimise increased risk of accidental fires occurring. Bushfire management measures are detailed in Section 6.5.

5.6 Over-browsing

Over-browsing of preferred food trees by the Koala is a well-known phenomenon (DECC 2008), often reported from areas in Victoria and South Australia where high-density populations occur, but it has rarely been reported in NSW. Reasons for over-browsing remain unclear, but are likely to relate to habitat availability and condition. Over-browsing is unlikely to become an issue within and adjoining the Project area due to the relatively minor disturbance areas and the extent of intact bushland over the locality that is protected by WaterNSW.



Koala records including recorded roadkill

Dendrobium Mine - Plan for the Future: Coal for Steelmaking - Biodiversity Assessment

FIGURE 6

6. Impact avoidance, mitigation and management measures

6.1 Overview

The impact minimisation strategy for the Project will follow the hierarchy (in order of preference) to avoid, mitigate and offset potential impacts to the Koala and its habitat. The following sections provide details of the proposed ameliorative measures designed to address the threats identified in Section 4. These proposed measures include:

1. Minimising clearing in Koala habitat (Section 6.2)
2. Rehabilitation of borehole sites (Section 6.3)
3. Reducing the risk of Koala injury and death (Section 6.4)
4. Bushfire control strategies (Section 6.5)

6.2 Minimising clearing in Koala habitat

Vegetation within the proposed ventilation sites and carpark does not support core or potential Koala habitat (as per the SEPP 44 definitions). The clearing of native vegetation for the ventilation shafts and carpark will be limited to localised clearing (18.8 hectares and 0.2 hectares, respectively) that avoids mapped core and potential habitat areas.

Additional clearing for exploration sites and electricity transmission lines are considered to be required for up to 1.5 hectares of Shale Sandstone Transition Forest (the actual location of which is to be determined during the exploration phase of the Project), which is considered mapped core or potential Koala habitat. Exploration sites will be located to minimise clearance of vegetation and avoid clearance of core Koala habitat, in particular mature Koala feed trees as far as practical.

Should clearing be required within areas mapped as core or potential habitat, measures to reduce the risk of Koala injury and death (as described below) will be implemented and active rehabilitation of the impact areas undertaken upon decommissioning.

6.3 Rehabilitation and revegetation activities

All areas to be cleared for the exploration sites would be rehabilitated using brushmatting, and if required, tubestock planting. Clearing would be undertaken using a trittering machine, or similar, where the rootball of the plant is left intact to aid in natural rehabilitation.

Monitoring of rehabilitation areas would seek to ensure the regeneration of any identified Koala feed tree species at similar densities as per prior to clearing or within adjacent areas of the same community. A schedule of required feed tree species and densities would be developed for each area prior to clearing and included within this KPoM.

6.4 Reducing the risk of Koala injury and death

6.4.1 Habitat clearing protocols

Pre-clearing surveys would be conducted by a suitably experienced and qualified person to determine if any Koalas are present. If a Koala is found, it would be left to move away from the clearance area of its own accord with the following measures implemented to encourage the Koala to move away in a stepwise fashion:

1. Clearance of understory vegetation 24 hours prior to clearance of midstorey and canopy trees
2. Gentle shaking of the host tree with appropriate machinery if the Koala has not moved within 24 hours followed by a further 24 hours hold period before clearing

3. Capture and relocation of the individual by a suitably experienced and qualified person.

The requirement for local relocation of animals is considered unlikely and is not preferred. Koalas would be released within adjacent known or potential habitat.

6.4.2 Reducing vehicle strikes

Implementation of Koala protection procedures will occur for all mine employees and contractors to minimise the likelihood of a Koala being harmed by mining operations. An impact avoidance culture would involve applying the following mandatory procedures:

- Obey speed limits (including 40 km/hr speed limit within the WaterNSW catchment landholdings and 20km/hr around construction areas).
- Report any individual Koala observations within the Project area during operational hours to the South32 Environmental Team as soon as practicable.
- Distribute Koala sighting information to all relevant personnel as soon as practicable to minimise likelihood for vehicle strike.
- Include Koala signage where it is identified that vehicles will be moving through areas of Core Koala habitat with increased frequency.
- Limit vehicle operation in twilight and night hours.
- Include information on the Koala during mine site inductions, including what to do if somebody finds an injured or dead animal.
- Ensure that if a vehicle strike occurs, that the vehicle is to be stopped immediately and the animal is to be checked to determine if it is dead or injured. The incident is to be reported immediately to the South32 Environmental Team and a qualified wildlife carer contacted to take care of the animal. Procedures should be reviewed after any vehicle collision or near miss.

The Environmental Team is to establish and maintain a register documenting all Koala sightings, near misses and vehicle strike. Information contained on this register is to be included in the reporting of the Koala monitoring program specified in this plan.

In the event of a vehicle strike, the Environmental Team is to immediately contact a suitably experienced wildlife carer and/or veterinarian to assess the need for animal care and determine the organisation which would be most available to assist. Contact details of a suitable vet and wildlife carer would be provided in the relevant Environmental Management Plan for the Project.

6.4.3 Minimising pest species

Illawarra Coal would implement appropriate waste management measures and maintain a clean, rubbish-free environment to discourage scavenging and reduce the potential for further colonisation of these areas by non-endemic fauna (e.g. feral dogs, foxes) and minimise predation threats to the Koala.

6.5 Bushfire control strategies

Illawarra Coal would develop a Bushfire Management Plan and maintain regular engagement with the Rural Fire Service. Management measures to reduce the risk of bushfire and bushfire protection measures may include the bunding of storage facilities which contain flammable material, implementation of housekeeping activities such as keeping the site tidy and removing fire hazards where practicable, having fire fighting equipment and spill kits located on-site, and training of staff in the proper use of fire fighting equipment and spill kits.

6.6 Protecting Koala habitat and enforcing implementation of the KPoM

Project Approval (if granted) would commit Illawarra Coal to the implementation of the KPoM (and/or its revision) for the life of the Project. Conditions of consent are enforceable and in this respect represent an

appropriate mechanism to protect retained Koala habitat whilst the Project is in operation. Koala ameliorative measures have been detailed in this KPoM. These measures are auditable and as such provide an ongoing compliance mechanism.

6.7 Key performance indicators

The ameliorative measures listed above would be implemented during the life of the Project.

Key performance indicators against which success would be measured include:

- Koala habitat to be impacted for the borehole sites would be rehabilitated until the lower benchmark of the PCT has been achieved
- All Koala injuries/fatalities as a result of the Project, including on access roads, are reported, managed as required by the KPoM and documented.

7. Monitoring and reporting

7.1 Monitoring

7.1.1 Road-kill monitoring

Reporting of the Koala monitoring program should occur annually. The reporting should summarise the data on any Koala-vehicle strikes recorded by the Environment Team, including any Koalas killed, injured or euthanized, or injured and released. Incidental sightings of the Koala should also be included in the reporting. The goal of this management plan is for zero Koala deaths from road strike within the catchment area as a result of the Project.

This reporting will provide scope for the implementation of adaptive management actions, should they be required.

7.1.2 Progress of the habitat rehabilitation

All areas rehabilitated will be inspected by South32 to ensure that the vegetation composition and structure meets the requirements of WaterNSW. Rehabilitation sites would be monitored at regular intervals as directed by WaterNSW with final sign off achieved when vegetation is generally self-sustaining to the satisfaction of regulators.

Reporting on the rehabilitation progress and identification of any amelioration required would be undertaken annually.

7.2 Employee education

An employee education program will be implemented for relevant Illawarra Coal staff and contractors to ensure that they are aware of their responsibilities with respect to protection of Koalas and their habitat, obeying speed limits and incident/near miss reporting.

Monitoring and reporting on the employee education program would be undertaken as part of general reporting and auditing procedures for the mine induction program and health, safety and environment procedures.

7.3 Consultation

South 32 conducted consultation with Wollondilly Council environmental representatives (April 2019) specifically to identify any overlap with existing KPoMs and seek input as to the content of the current KPoM. No existing KPoMs affect the Project. It has been communicated that OEH are currently revising Koala mapping within the locality and that Wollondilly Council are seeking to develop and implement a whole of Local Government Area KPoM.

Consultation with Wollondilly Council and OEH should occur prior to works and as appropriate throughout the life of the project so that the current KPoM can be reviewed if required to achieve consistency of Koala management within the region.

8. Conclusion

While the Project area is known to support habitat for a Koala population that occurs across the broader locality, the Project will impact a limited extent of Koala habitat. The Project will require clearance of up to 18.8 ha of vegetation for the ventilation shafts, 0.2 ha for the carpark, 5 ha for borehole sites and 4.5 ha for the transmission lines. The ventilation shafts and carpark have been located to avoid impacts to core habitat for the Koala and impacts will be localised and marginal compared to the extensive widespread habitat throughout the locality. The borehole sites and electricity transmission line corridors are anticipated to require clearing of up to 1.5 ha of Shale Sandstone Transition Forest, which may impact on core or potential Koala habitat. Any clearing within areas mapped as core or potential habitat would include measures to reduce the risk of Koala injury and death. Rehabilitation of the impact areas will be undertaken to ensure regeneration of Koala feed trees.

The management of impacts to the Koala detailed in this KPoM focus on maintaining the local population of Koalas and minimising impacts through implementation of:

- Pre-clearing protocols
- Education programs
- Driving restrictions and reporting of sightings and management of any vehicle strikes
- Rehabilitation of any impacts to core or potential Koala habitat (i.e. exploration sites and transmission line corridors).

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