SOUTH32 Illawarra Metallurgical Coal




LONGWALLS 709 TO 711 AND 905 BIODIVERISTY MANAGEMENT PLAN

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DOCUMENT REVISION LOG

Persons authorising this Plan

Name	Title	Date
Gary Brassington	Manager Approvals	October 2021

Document Revisions

Revision	Description of Changes	Date
ICH Document		
1.0	Original Document	July 2021
1.1	Administrative updates	October 2021

Persons involved in the review of this Plan

Name	Title	Company	Exp (yrs)
Cody Brady	Principal Approvals	South32	5
Gary Brassington	Manager Approvals	South32	26
Josh Carlon	Coordinator Environment	South32	12
Chris Schultz	Superintendent Environment	South32	25

1. INTRODUCTION

1.1 Project Background

South32 Illawarra Metallurgical Coal (IMC) operates the Bulli Seam Operations (BSO) Appin Mine, extracting hard coking coal used for steel production.

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

This Biodiversity Management Plan (BMP) supports the Longwalls 709 to 711 and 905 Extraction Plan for mining of coal in Appin Areas (AA) 7 and 9 mining domains. The relationship between this BMP and the other components of the Extraction Plan is shown in Figure 1 of the Extraction Plan.

1.2 Scope

This BMP has been prepared in accordance with the BSO Approval (MP 08_0150) Condition 5 (i), Schedule 3 as follows:

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

The Study Area for the Extraction Plan (Figure 1) is defined in accordance with MSEC (2021) as the surface area predicted to be affected by the proposed mining of Longwalls 709 to 711 and 905 and encompasses the areas bounded by the following limits:

- A 35° angle of draw line from the maximum depth of cover, which equates to a horizontal distance varying between 530 m and 750 m around the limits of the proposed extraction areas for Longwalls 709 to 711 and 905; and
- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, resulting from the extraction of the proposed Longwalls 709 to 711 and 905.

Additionally, features potentially sensitive to far field movements, which includes horizontal, valley closure and upsidence movements that may be outside the 20 mm subsidence zone or 35° angle of draw line have been assessed including:

- Watercourses (including the Nepean River), within the predicted limits of 20 mm total upsidence and closure;

- Steep slopes; and
- Cliffs.

1.3 Objectives

The objectives of this BMP are to identify the biodiversity within the Longwalls 709 to 711 and 905 Study Area and to manage the potential impact and/or environmental consequences of the proposed mining to terrestrial and aquatic biodiversity.

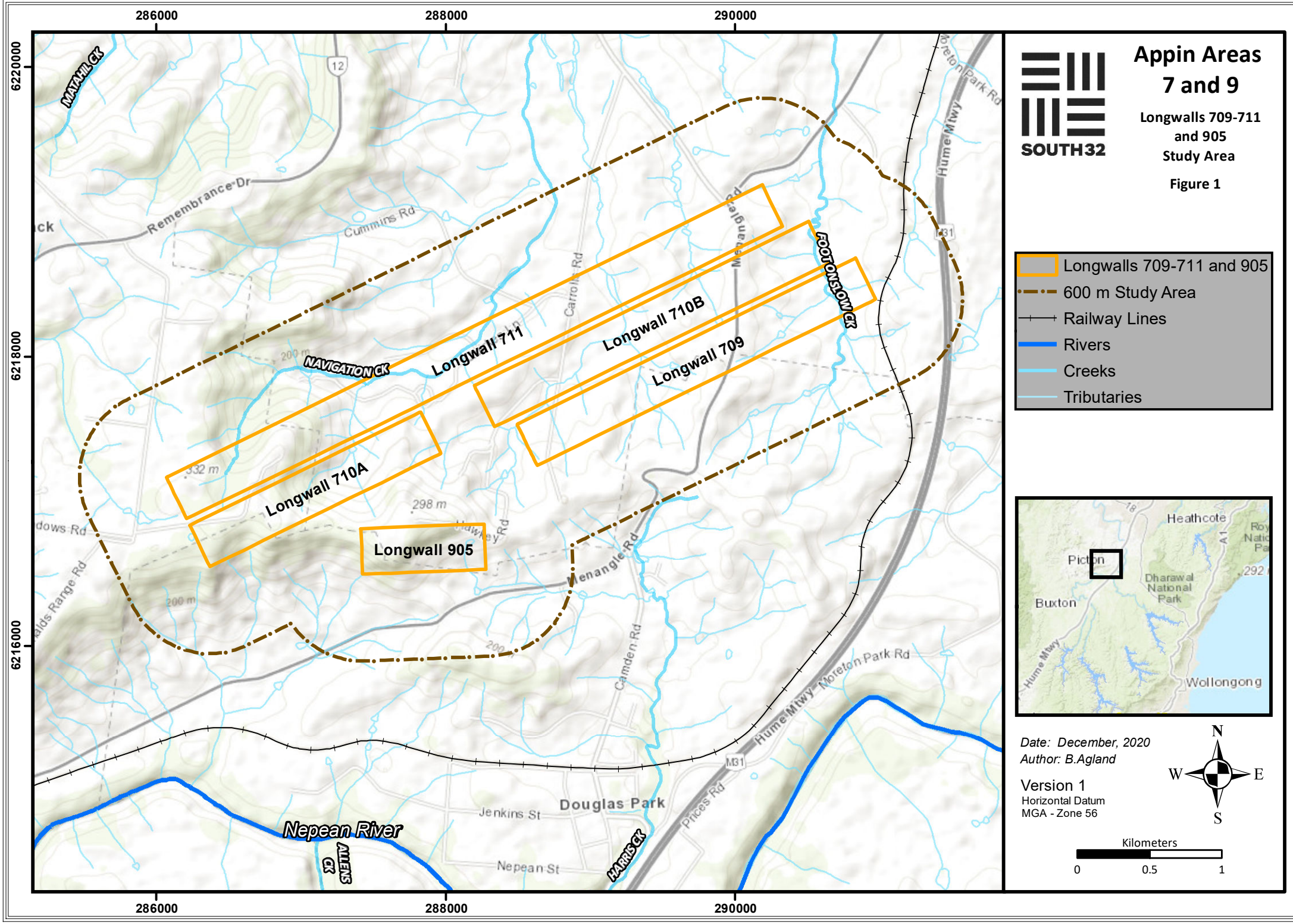
Specific focus will be on threatened species, populations and their habitats; endangered ecological communities; and groundwater dependent ecological communities.

1.4 Consultation

This BMP will be developed in consultation with:

- Biodiversity and Conservation Division (BCD);
- Department of Planning, Infrastructure and Environment (DPIE); and
- DPI Fisheries.

South32 will make the BMP and associated documentation publicly available on the South32 website in accordance with Condition 11, Schedule 6 of the BSO Approval.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Cummins Rd
Carroll Rd
Menangle Rd
Hume Mtwy
Moreton Park Rd
M31
FOOTONSLOW CK
NAVIGATION CK
Longwall 711
Longwall 710B
Longwall 709
Longwall 710A
Longwall 905
200 m
298 m
Hawkey Rd
Camden Rd
Jenkins St
Douglas Park
Nepean River
ALLENS CK
Nepean St
HARRIS CK
Prices Rd
Appin Areas 7 and 9
Longwalls 709-711 and 905 Study Area
Figure 1
Longwalls 709-711 and 905
600 m Study Area
Railway Lines
Rivers
Creeks
Tributaries
Heathcote
Picton
Buxton
Dharawal National Park
Wollongong
Date: December, 2020
Author: B.Agland
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2. STATUTORY REQUIREMENTS

Extraction of coal from Longwalls 709 to 711 and 905 will be in accordance with the conditions set out in the BSO Approval, applicable legislation as detailed in Section 2.2 and the requirements of relevant licences and permits, including conditions attached to mining leases.

2.1 BSO Approval

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

This BMP also addresses the requirements detailed in Condition 6 Schedule 3 and Condition 2, Schedule 6 of the BSO Approval as shown in Table 1.

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

Table 1 Management Plan Requirements

Project Approval Conditions	Relevant BMP Section
Condition 6, Schedule 3 The Proponent shall ensure that the management plans required under Condition 5 (g)-(l) above include: a) an assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval; b) a detailed description of the measures that would be implemented to remediate predicted impacts.	Section 4 Section 7
Condition 2, Schedule 6 The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include: (a) detailed baseline data; (b) a description of: - the relevant statutory requirements (including any relevant approval, licence or lease conditions); - any relevant limits or performance measures/criteria;	Section 3 Section 2 Section 5

- the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;	Section 5 to 8
(c) a description of the measures that would be implemented to comply with the relevant statutory, limits, requirements or performance measures/criteria;	Section 5 to 8
(d) a program to monitor and report on the: - impacts and environmental performance of the project; - effectiveness of any management measures (see c above);	Section 6
(e) a contingency plan to manage any predicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	Section 8
(f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Section 10
(g) a protocol for managing and reporting any: - incidents; - complaints; - non-compliances with statutory requirements; and - exceedances of the impact assessment criteria and/or performance criteria; and	Section 9
(h) a protocol for periodic review of the plan.	Section 10

2.2 Legislation and Guidelines

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

- *Biodiversity Conservation Act, 2016* (BC Act).
- *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act).
- *Fisheries Management Act, 1994* (FM Act).

2.3 Relevant Leases and Licences

The following licences or permits may be applicable to South32's operations in AA7 and 9:

- Mining Leases as per Table 2.
- Environment Protection Licence (EPL) 2504 which applies to BSO, including Appin and West Cliff Mines. A copy of the licence can be accessed at the EPA website via the following link http://www.epa.nsw.gov.au/prpoeo/index.htm
- BSO Mining Operation Plan (MOP) 1/10/2020 to 30/09/2024 (V1.3).
- All relevant Occupational Health, Safety, Environment and Community approvals.

- Any additional leases, licences and approvals resulting from the BSO Approval.

Table 2 Appin Mine Leases, Licences and Other Reference Documents

Mining Lease - Document Number	Start	Finish
CCL 767	29 Oct 1991	08 Jul 2029
CL 388	22 Jan 1992	22 Jan 2034
ML 1382	20 Dec 1995	20 Dec 2037
ML 1433	24 Jul 1998	23 Jul 2019[1]
ML 1678	27 Sep 2012	26 Sep 2033

[1] Application for the renewal of Mining Lease 1433 which was lodged with the NSW Department of Planning and Environment – Division of Resources and Geoscience (Division) on 18 July 2018.

3. BASELINE ASSESSMENT

A baseline Aquatic Biodiversity Assessment (Bioanalysis, 2009) and Terrestrial Flora and Fauna Assessment (Flora Search, 2009; Biosphere 2009) were undertaken in support of the BSO Environmental Assessment (EA). The Study Area for these assessments included the Longwalls 709 to 711 and 905 Study Area.

Supplementary field surveys for Aquatic Biodiversity (Cardno, 2021 - Appendix A) and Terrestrial Biodiversity (Niche, 2021 - Appendix B) were undertaken for the purposes of this Extraction Plan.

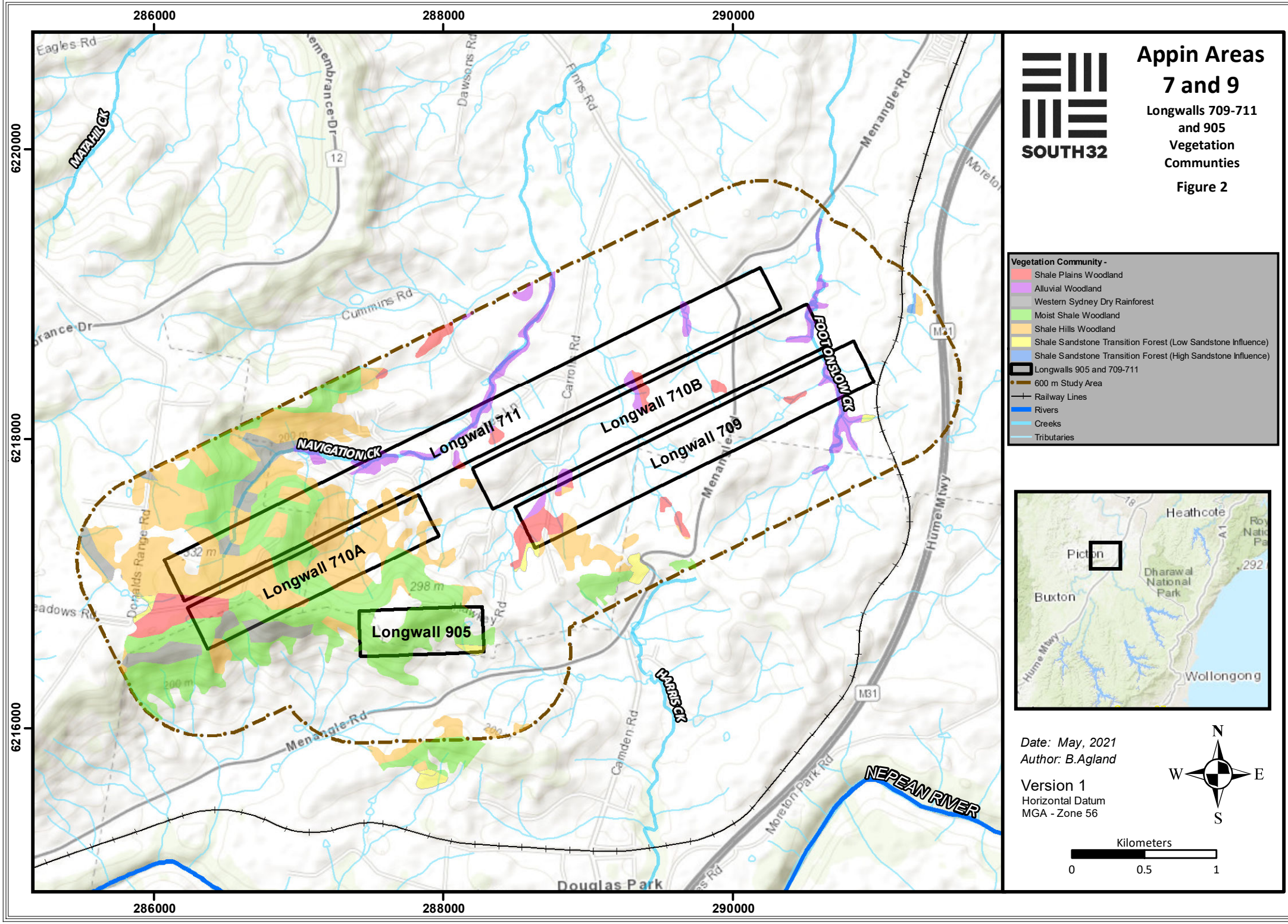
3.1 Terrestrial Biodiversity

AA7 and 9 is known to support four Threatened Ecological Communities (TEC), known habitat for three threatened fauna species, and provides potential habitat for eight threatened flora species as well as 24 threatened fauna species.

3.1.1 Vegetation Communities

The natural environment of the Longwalls 709 to 711 and 905 Study Area contains flora and fauna habitats, which include remnant stands of open woodland, riparian scrub in drainage lines, closed grassland and fringing aquatic vegetation near constructed dams in grazed paddocks (Figure 2).

Six Plant Community Types (PCTs) have been mapped as occurring within the Study Area by DPIE (2013) and Niche (2021). Several TECs were also identified in the Longwalls 709 to 711 and 905 Study Area. Table 3 describes the communities present and their conservation status. Further descriptions of the vegetation communities are detailed in Niche (2021).



SOUTH32

Appin Areas 7 and 9

Longwalls 709-711 and 905 Vegetation Communties

Figure 2

Date: May, 2021
Author: B.Agland

Version 1
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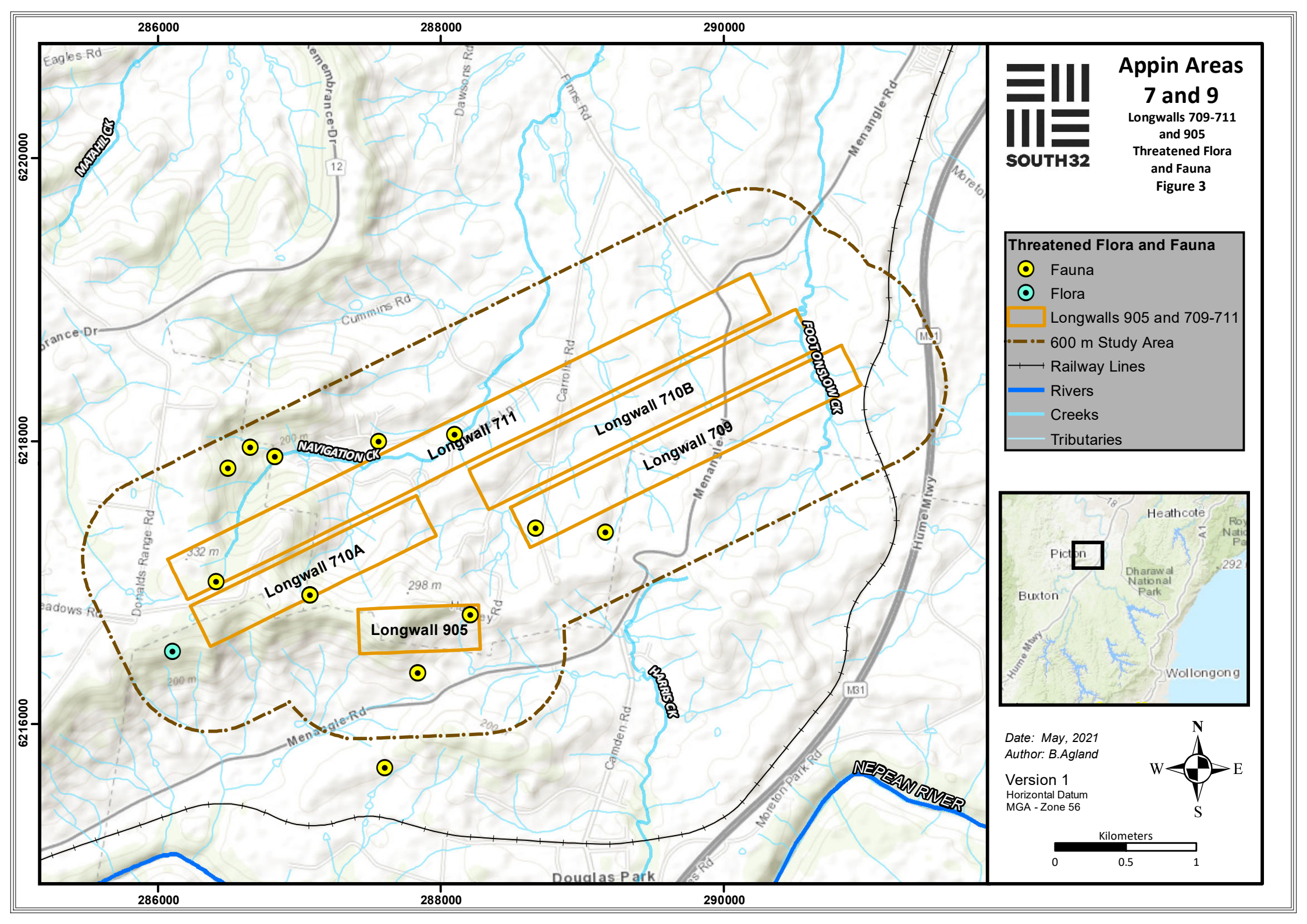
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Flinns Rd
Menangle Rd
Cummins Rd
Carrolls Rd
Donalds Range Rd
Camden Rd
Moreton Park Rd
Douglas Park
M31
Hume Mtwy
NATAKIL CK
NAVIGATION CK
FOOTONSLOW CK
HARRISCK
NEPEAN RIVER
Longwall 711
Longwall 710B
Longwall 709
Longwall 710A
Longwall 905
332 m
298 m
200 m
Appin Areas 7 and 9
Longwalls 709-711 and 905
Threatened Flora and Fauna
Figure 3
SOUTH32
Threatened Flora and Fauna
Fauna
Flora
Longwalls 905 and 709-711
600 m Study Area
Railway Lines
Rivers
Creeks
Tributaries
Heathcote
Picton
Buxton
Dharawal National Park
Wollongong
Date: May, 2021
Author: B.Agland
Version 1
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Table 3 Longwall 709 to 711 and 905 Study Area Vegetation Communities

Plant Community Type Niche Mapping (2021)	BC Act Status	EPBC Act Status
830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	E	CE
835 Forest Red Gum – Rough barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	E	CE
849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	CE	CE
850 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	CE	CE
877 Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion	E	CE
1395 Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	CE	CE

Notes: Endangered = E, Critically Endangered = CE.

3.1.2 Threatened Flora

No threatened flora species were recorded in the supplementary surveys (Niche, 2021). Figure 3 shows known occurrences of threatened species previously recorded in the locality.

Twenty-two threatened plant species listed on the EPBC Act and/or BC Act have been previously recorded or have potential habitat within a 10 km radius of the Study Area. Of the 22 threatened species, nine species have a moderate to high likelihood of occurrence in the Study Area:

- *Cynanchum elegans;*
- *Eucalyptus benthamii;*
- *Epacris purpurascens var. purpurascens;*
- *Grevillea parviflora subsp. Parviflora;*
- *Persoonia bargoensis;*
- *Pultenaea pedunculata;*
- *Pomaderris brunnea;*
- *Pimelea spicata;* and

- *Pterostylis Saxicola.*

A detailed list of threatened flora species with a likelihood of occurring within the Study Area is provided in Niche (2021).

3.1.3 Threatened Fauna

No threatened fauna species were recorded in the supplementary surveys (Niche, 2021). **Figure 3** shows known occurrences of threatened species in the locality.

Fifty-five threatened species listed on the EPBC Act and/or BC Act have been previously recorded or have potential habitat within a 10 km radius of the Study Area. Of the 55, 28 of these species were determined to have a moderate or high likelihood of occurrence within the Study Area:

- Frogs: *Heleioporus australiacus* (Giant Burrowing Frog), *Litoria Littlejohni* (Littlejohn's Tree Frog).
- Birds: *Callocephalon fimbriatum* (Gang-gang Cockatoo), *Calyptorhynchus lathami* (Glossy Black-Cockatoo), *Chthonicola sagittata* (Speckled Warbler), *Circus assimilis* (Spotted Harrier), *Climacteris picumnus victoriae* (Brown Treecreeper (eastern subspecies)), *Daphoenositta chrysoptera* (Varied Sittella), *Glossopsitta pusilla* (Little Lorikeet), *Haliaeetus leucogaster* (White-bellied Sea-Eagle), *Hieraaetus morphnoides* (Little Eagle), *Lathamus discolour* (Swift Parrot), *Melanodryas cucullate cucullata (Hooded Robin (south-eastern form)), Melithreptus gularis* (Black-chinned Honeyeater), *Ninox connivens* (Barking Owl), *Ninox strenua* (Powerful Owl), *Petroica boodang* (Scarlet Robin), *Rostratula australis* (Australian Painted-snipe) and *Stagonopleura guttata* (Diamond Firetail).
- Mammals: *Chalinolobus dwyeri* (Large-eared Pied-bat), *Dasyurus maculatus* (Spotted-tailed Quoll), *Micronomus norfolkensis* (Eastern Coastal Free-tailed Bat), *Miniopterus australis* (Little Bent-winged Bat), *Miniopterus orianae oceanensis* (Large Bent-winged Bat), *Myotis macropus* (Southern myotis), *Phascolarctos cinereus* (Koala) and *Pteropus poliocephalus* (Grey-headed Flying-fox).
- Invertebrates: *Meridolum corneovirens* (Cumberland Plain Land Snail).

3.1.4 Areas of Outstanding Biodiversity Value

No Areas of Outstanding Biodiversity Value (AOBV) have been declared for any ecological values within the Study Area. No AOBV will be impacted by the proposal (Niche, 2021).

3.2 Aquatic Biodiversity

3.2.1 Nepean River

The Nepean River is located outside this area and is not expected to experience further impacts related to subsidence. However, as a precautionary measure, the adjacent section from existing aquatic ecology monitoring Site 8 upstream to Site X8 is assessed in Cardno (2021) (Figure 4). The water in this section of the Nepean River is derived from the discharges of the Cataract, Cordeaux, Avon and Nepean Dams and catchment runoff with low flows controlled by Maldon Weir, which is situated approximately 5 km south-west of the proposed longwalls. The lower section includes the 1 m high causeway at Douglas Park.

The channel above and below this causeway consists of a continuous pool, approximately 50 m wide and 3.5 m deep, with low flows except during flood events. Overall, aquatic habitat of the sites on the Nepean River are generally in good condition, although the AUSRIVAS modelling does not fully reflect this observation, indicating impaired habitat and / or water quality.

A full description of the Study Area can be found in Cardno (2021).

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

3.2.2 Other Creeks and Drainage Lines

Navigation Creek

A 2.2 km third order section of Navigation Creek flows through improved pastures within the Study Area, with 1.1 km of this creek located directly above Longwall 711 and 1.9 km within 400 m. This reach was classified as moderate aquatic habitat (Class 2 i.e. containing some small semi-permanent refuge pools which are unlikely to persist through prolonged drought) (The Ecology Lab 2008). At the time of inspection (which followed recent rainfall) the pools at Site N1 were connected by shallow flow, though pool connectivity would not be expected to persist during dry periods (Cardno 2021).

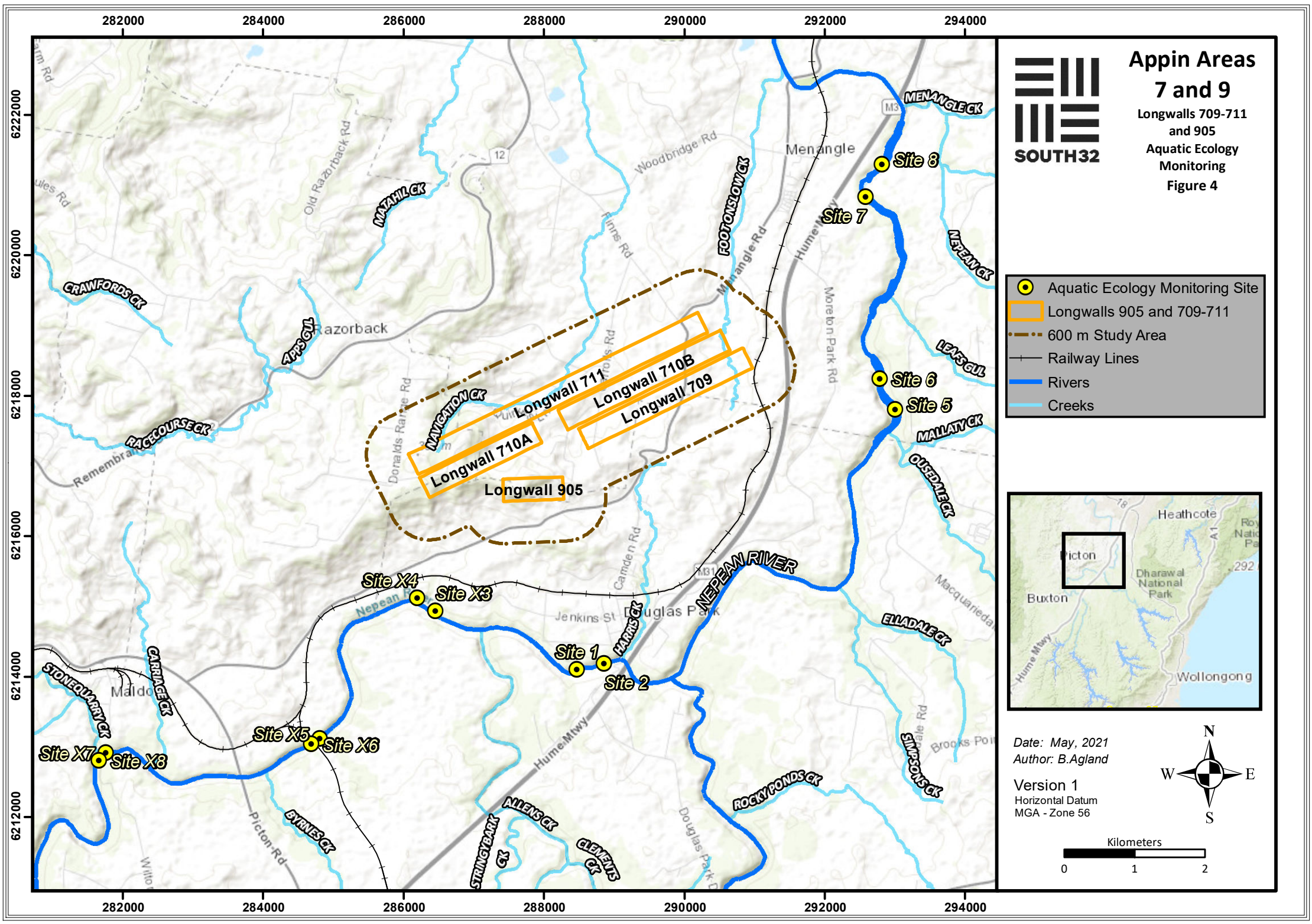
One unnamed third-order tributary of Navigation Creek Tributary 1 is located within the Study Area east of the main channel of Navigation Creek and west of Foot Onslow Creek. A 2.3 km section is located in the Study Area, with 1.6 km located directly above Longwalls 710B and 711 and 2.0 km within 400 m. This watercourse provided very little aquatic habitat, apart from several farm dams along or adjacent to the channel, and pools formed where road culverts have had a dam effect (The Ecology Lab 2008). The watercourse provided minimal aquatic habitat (containing some small semi-permanent refuge pools which are unlikely to persist through prolonged drought). During visits by IMCEFT in August 2020, no flow and in-stream wood debris or large rocks were observed.

Foot Onslow Creek

A 2.3 km section of Foot Onslow Creek is located in the Study Area, with 0.8 km of this located directly above Longwalls 709 and 710B and 1.2 km within 400 m. This section of the creek provides moderate aquatic habitat and contains a number of relatively large, deep pools that would be expected to persist through prolonged dry periods (Plate 3a to d of The Ecology Lab 2008a). At the time of inspection, there was no flow connectivity and standing pools were separated by sections of dry creek bed (Cardno 2021).

Harris Creek

A 150 m section of Harris Creek is located in the Study Area, though none is located directly above the longwalls or within 400 m. The downstream section of this creek was visited at the Mountbatten Road crossing by The Ecology Lab (2008). There were a few scattered permanent pools providing habitat in these lower sections, and there was some flow connectivity at the time of inspection, however it is expected that connectivity would not be maintained during extended dry periods. The upper section flows through pasture, forming a gully with limited aquatic habitat. Stock had access to these upper reaches and there was extensive stock induced erosion of the banks and channel. Several farm dams are scattered along the channel interrupting downstream flow (Cardno 2021).


Appin Areas 7 and 9
Longwalls 709-711 and 905 Aquatic Ecology Monitoring
Figure 4
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Aquatic Ecology Monitoring Site
Longwalls 905 and 709-711
600 m Study Area
Railway Lines
Rivers
Creeks
Longwall 711
Longwall 710B
Longwall 709
Longwall 710A
Longwall 905
Site 8
Site 7
Site 6
Site 5
Site 1
Site 2
Site X3
Site X4
Site X5
Site X6
Site X7
Site X8
NEPEAN RIVER
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NEPEAN CK
FOOTONSLOW CK
MATAHIL CK
CRAWFORDS CK
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ALLENS CK
STRINGYBARK CK
CLEMENTS CK
BYRNES CK
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CARRIAGE CK
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Camden Rd
Picton Rd
Hume Mtwy
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Wollongong
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Author: B.Agland
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3.2.3 Aquatic Vegetation

A number of aquatic macrophytes are present within the Nepean River. These were surveyed most recently in November 2019 as part of the ongoing monitoring in AA 7 and 9 (Cardno 2019). They generally grow on the shallower riverbed reaches (confined to a maximum river depth of approximately 3.5 m) where soft sediment is present. In 2019, 10 species of aquatic macrophytes were recorded across the six sites sampled for AA7 and 9 (Figure 4):

- *Potamogeton tricarinatus* (Floating pondweed);
- *Vallisneria sp.* (Ribbonweed);
- *Hydrilla verticillate* (Hydrilla);
- *Elodea canadensisi* (Eelodea);
- *Eleocharis sphacelate* (Tall spikerush);
- *Potamogeton perfoliatus* (Clasped pondweed);
- *Rorippa nasturtium-aquaticum* (Watercress);
- *Alternanthera philoxeroides* (Alligator weed);
- *Typha sp.* (Cumbungi); and
- *Potamogeton crispus* (Curly Pondweed).

The species composition at each AA7 monitoring site was identical to that observed in the most recent previous survey in 2018. The exceptions were the presence of tall spikerush, which was not observed previously, and clasped pondweed, which was observed in 2016 (Cardno 2017).

Five species were identified at AA9 sites in 2019. These were hydrilla, curly pondweed, floating pondweed, alligator weed, and watercress. All have been identified previously at these sites and all except watercress have been identified at AA7 sites. The species composition at AA9 sites in 2019 was very similar to that in the most recent previous survey in AA9 in 2017 (Cardno 2018). The only difference was the absence of watercress from where it was present in 2017.

The extent and species composition of aquatic macrophytes at these sites is highly dependent on flow variability, with high flows scouring away river sediments, and thus associated plants, and providing new areas for colonisation following high flows (Cardno 2019). This appears to be the explanation for the apparent reduction in the extent of ribbonweed observed in November 2016 compared with previous surveys. Since this time, including in November 2019, the extent of ribbonweed and tall spikerush has increased as these plants have colonised nearby areas of unvegetated sediment exposed following high flows (Cardno 2021).

3.2.4 Aquatic Macroinvertebrates

Between September 2003 and November 2019, Cardno has undertaken 14 surveys of macroinvertebrates in the Nepean River in relation to AA7 and 9. In total, 97 taxa were identified from 112 samples collected (Cardno 2021).

During September 2003 to 2019, the number of taxa per sample has ranged from 13 to 34, the OE50 Taxa Score has ranged from 0.47 (Band C - severely impaired relative to reference condition) to 1.20 (Band A - equivalent to reference condition) and the SIGNAL2 Score ranged from 3.0 (indicative of severe water pollution) to 4.7 (indicative of moderate water pollution). The mean number of taxa per site was relatively comparable among sites, though there was a slight trend for fewer taxa at upstream sites X3 to X8 compared with most sites farther downstream. This likely reflects the variable habitat conditions between these sections of the Nepean River (Cardno 2021).

The aquatic macroinvertebrate fauna in this section of the Nepean River appears to have experienced some degree of environmental stress prior to, and hence independent of, mining, and continues to do so (Cardno 2021).

3.2.5 Fish

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

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

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

Movement of fish into the upstream reaches of the Nepean River is restricted by Maldon Weir. Maldon Weir is the upstream limit of migration for Australian bass and other species that require estuarine areas to spawn (Sammut and Erskine, 1995). Further detail about where each of these fish species has been observed is provided in Cardno (2021).

3.2.6 Threatened Species

In desktop searches four threatened species were found to be present in the locality of, or have potential habitat within the Study Area. Table 4 provides a summary of the likelihood of identified threatened species to be present in the Study Area.

Table 4 Likelihood of Occurrence Threatened Aquatic Species in the Study Area (Cardno 2021)

Species and Listing	Likelihood of Occurrence
Macquarie Perch (endangered under FM Act and EPBC Act)	Not expected to occur in the Study Area due to the limited aquatic habitat provided by ephemeral first, second and third order drainage lines present.
Adams Emerald Dragonfly (endangered under FM Act)	Not expected to occur in drainage lines within the Study Area. No records within, or adjacent to the Study Area despite extensive sampling, though suitable microhabitat appears to exist adjacent to the Study Area in the Nepean River.
Sydney Hawk Dragonfly (endangered under FM Act)	Not expected to occur in drainage lines in the Study The only records of this species are from 1979 and 1980 in the Nepean River upstream of the Study Area near Sites X7 and X8 and further upstream near Nepean Dam.
Australian Grayling (endangered under FM Act and vulnerable under EPBC Act)	Does not occur in the Study Area. Present in coastal rivers of southern NSW outside of the Study Area.

4. PREDICTED IMPACTS

In accordance with the findings of the Southern Coalfield Inquiry (2008) and Independent Expert Panel for Mining in the Catchment (2019a), subsidence impacts are defined as:

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

4.1 Subsidence Effects

Terrestrial ecological features could experience the full range of predicted subsidence movements depending on their location in the Longwalls 709 to 711 and 905 Study Area.

4.2 Subsidence Impacts

Predicted subsidence impacts for natural features within the Longwalls 709 to 711 and 905 Study Area are outlined in MSEC (2021). A summary of the predictions that could have environmental consequences for terrestrial biodiversity are provided in Table 5.

Table 5 Predicted Impacts to Natural Surface Features as a Result of Subsidence for Longwalls 709 to 711 (MSEC, 2021)

Natural Surface Feature	Predicted Impacts Due to Subsidence
Nepean River	The Nepean River is located a minimum distance of 1.5 km from the longwalls. The Nepean River would experience vertical subsidence, upsidence and closure of less than 20 mm. It is considered unlikely, therefore, that the Nepean River would experience adverse physical impacts due to the mining-induced movements from Longwalls 709, 710A, 710B, 711 and 905. Further gas release zones could develop due to the mining of the proposed longwalls.
Drainage Lines	There would be no reversals of stream grade in third order watercourses (Foot Onslow Creek, Harris Creek, Navigation Creek and Navigation Creek Tributary 1) or in first and second order watercourses due to the proposed mining. Large-scale adverse changes in the levels of ponding or scouring of the banks along the creeks and tributaries within the Study Area due to the mining induced tilt are, thus, unlikely. It is possible that localised increased ponding could develop in some locations, where the natural grades are small, and upstream of the chain pillars and the edges of the mining area. The potential impacts of increased ponding and scouring of the

	drainage lines are, therefore, expected to be minor and localised. Impacts resulting from changes in surface water flows due to mining-induced tilt are expected to be small in comparison with those which occur during natural flooding conditions. Fracturing of the uppermost bedrock could occur along watercourses that are located directly above or adjacent to the proposed longwalls (including Navigation Creek, Foot Onslow Creek and a small section of Harris Creek). Surface water flow diversions could occur in these watercourses. Fracturing can also occur outside the mining area, with minor and isolated fracturing occurring at distances up to approximately 400 m outside the 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. It is unlikely, however, that there would be a net loss of water from the catchment.
Cliffs, Rocky Outcrops and Steep Slopes	Impacts on cliff lines, rock outcrops and other rocky habitats within the Study Area are likely to be minor, as observed in previous mining areas. No large-scale cliff collapses or slope failures are predicted, though tension cracks may appear in steep slopes, which could result in erosion without rehabilitation. It is expected that the rock outcrops located directly above the proposed longwalls would experience fracturing and, where the rock is marginally stable, this could then result in instabilities.

4.3 Environmental Consequences

Table 6 compares the potential consequences as determined in the BSO EA to the residual impact determined by Niche (2021) for the Longwalls 709 to 711 and 905 Study Area. Potential impacts as assessed by Niche (2021) are consistent and are generally less than those outlined within the BSO EA.

When compared to the broader BSO EA area there are fewer sensitive vegetation communities in the locality and substantial areas of cleared vegetation. The proposed extraction does not require significant vegetation clearing.

Table 6 Predicted Impacts to Natural Surface Features as a Result of Subsidence for Longwalls 709 to 711 and 905 (MSEC, 2021)

Potential Impact Assessed	Level of Impact according to FloraSearch (2009), Biosphere (2009) and BSO EA	Level of Impacts Based on Current Survey
Vegetation	Slope and ridge-top vegetation: • Small, isolated impacts to vegetation due to cracking. Riparian vegetation: • Small, localised impacts to vegetation due to ponding, flooding, scouring or gas release. Gently undulating lands • Negligible impacts due to surface cracking.	Vegetation communities which are not dependent on groundwater are unlikely to be impacted by subsidence due to underground mining. This accounts for most of the woodland and forest communities in the Study Area. Groundwater dependant and riparian vegetation may experience some floristic changes in response to altered groundwater conditions or the release of strata gas, as a result of subsidence. Impacts to riparian vegetation associated with the proposal are predicted to be minor in occurrence, being localised if they occurred. Predicted impacts of the proposal on vegetation and TECs are consistent with the predicted impacts from the BSO EA.
Fauna Habitats	Slope and ridge-top habitats: • Potential for small animals to become trapped in cracks. Impacts expected to be minor. • Rare impacts to fauna due to rockfall. Riparian habitats: • Negligible impacts to fauna and fauna habitat. Gently undulating lands: • Minor impacts due to surface cracking. Water habitats:	Consistent with the predicted impacts from the BSO EA.

	• Impacts to water habitat unlikely to result in impacts to fauna.	
Threatened Flora	No significant impacts on threatened flora species predicted.	Impacts of the BSO Project on threatened flora were previously assessed within the BSO Project EA (BHPBIC 2009). Predicted impacts as a result of the current proposal are likely to be minimal. Therefore, the predicted impacts for the current proposal are consistent with the impact predictions of the BSO EA.
Threatened Fauna	No significant impacts on threatened fauna species predicted.	Impacts of the BSO Project on threatened fauna were previously assessed within the BSO Project EA (BHPBIC 2009). Predicted impacts as a result of the current proposal are likely to be minimal. Therefore, the predicted impacts for the current proposal are consistent with the impact predictions of the BSO EA.
Koala Habitat	As described above for other fauna habitats, the predicted effects of subsidence on Koala habitat are likely to be minimal and are not considered to have any real effect on the species.	Subsidence impacts to the Koala are low as the proposal is unlikely to affect the trees that this species utilises and forages in. Impact not likely to be significant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Spread of amphibian Chytrid Fungus and Impacts on Frog Species	Collection and handling of frogs or the inadvertent transport of the infected material between frog habitat by persons, vehicles or equipment may promote the spread of the disease.	Not likely to be exacerbated by the current proposal.
Infection of Native Plants by *Phytophthora cinnamomi*	Project-related activities have the potential to introduce or spread the infection of native plants by *P. cinnamomi.*	Not likely to be exacerbated by the current proposal.
Weeds	The Project has the potential to increase the spread of weeds through vegetation clearing activities, dispersal of seed or soil material containing	Not likely to be exacerbated by the current proposal.

	seed via continued movement of vehicles across the Project area and through rehabilitation or restoration activities.	

4.4 Aquatic Biodiversity

4.4.1 Subsidence Effects

MSEC (2009) undertook an initial assessment of predicted subsidence in the Longwalls 709 to 711 and 905 Study Area to support the BSO EA. These predictions were revised by MSEC (2021) to account for a revised mine plan for Longwalls 709 to 711 and 905. The maximum predicted subsidence, upsidence and closure are outlined in Table 7.

Table 7 Maximum Predicted Subsidence Effects for Rivers, Creeks and Tributaries located within the Study Area (MSEC 2021)

Name	Maximum predicted total subsidence (mm)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Nepean River (not within Study Area)	<20	<20	<20
Foot Onslow Creek	1400	300	250
Harris Creek	500	350	300
Navigation Creek	950	350	475
Navigation Creek Tributary 1	1350	550	800

4.4.2 Subsidence Impacts

Nepean River

The centreline of the Nepean River is located 1.5 km south of the commencing (i.e. western) end of Longwall 710A and 1.6 km east of the finishing (i.e. eastern) end of Longwall 709, at its closest points to the proposed longwalls. No fracturing is predicted to occur in the Nepean River, thus there would be no reductions in the availability and connectivity of aquatic habitat. Longwall extraction is not anticipated to have any significant impacts on surface water quality as a result of mining the proposed longwalls (SLR 2021b). Mining of previous longwalls within AA7 and 9 has not led to identification of any detectable ferruginous springs in the walls of the Nepean River. It is therefore considered that there is a low likelihood of ferruginous springs induced by the mining of the proposed Longwalls 709 to 711 and 905 (SLR 2021b). It is possible that gas releases may result in localised changes in water quality, such as reductions in dissolved oxygen, though localised changes are not expected to result in significant impacts to aquatic biota (Cardno 2021).

Drainage Lines

Localised and minor changes in habitat availability and connectivity may occur along the first, second and third order drainage lines due to tilt but these effects will be difficult to detect due the high variability in natural flows within these ephemeral watercourses. The impacts resulting from the changes in surface water flows are expected to be small in comparison with those which occur during natural flooding conditions (Cardno 2021).

Fracturing and flow diversions may occur in drainage lines directly above and up to 400 m away from the proposed longwalls. This may result in the draining of pools in these watercourses, particularly during low flows, resulting in a reduction in the availability of aquatic habitat and the connectivity of remaining habitat. This would be expected to result in associated reductions in the population sizes of aquatic biota (Cardno 2021).

4.4.3 Environmental Consequences

Table 8 compares the potential consequences on aquatic ecology as determined in the BSO EA to the potential consequences determined by Cardno (2021) for the Longwalls 709 to 711 and 905 Study Area.

The assessment of the consequences for aquatic ecology of subsidence that occurs during extraction of Longwalls 709 to 711 and 905 is concluded to be similar to that based on the BSO EA layout.

Table 8 Comparison of Environmental Consequences from BSO EA and Cardno (2021)

Component of Aquatic Ecology	Impacts Predicted in the BSO EA (Bioanalysis 2009)	Potential Impacts Predicted for Current Survey (Cardno 2021)
Nepean River		
Aquatic Habitat	Nepean River - Impacts on flow and pool depth are not expected in the Douglas Park Weir pool.	Same as for BSO EA. It is considered unlikely, that the Nepean River would experience adverse physical impacts due to the mining-induced movements from Longwalls 709 to 711 and 905.
	Some fracturing of bed rock is expected, as well as mobilisation of iron and other minerals and transient gas emissions in the weir pool.	Fracturing not expected to occur in the Nepean River. Further gas release zones could develop due to the mining of the proposed longwalls. Any short term and localised impact on water quality is not expected to significantly affect aquatic biota. Minor localised iron staining may occur, but is unlikely to lead to changes in water quality and should not therefore affect the quality of aquatic habitat.
Riparian Vegetation	Changes in the level of water in streams and gas emissions are unlikely to disturb riparian vegetation to the extent that its ecological role would be significantly adversely impacted.	Substantial localised gas emissions could result in localised die-back of riparian vegetation. Such impacts are considered unlikely and would be transient. No fracturing is predicted to occur in the Nepean River and no associated impacts to riparian vegetation is expected.
Aquatic macrophytes	Nepean River – limited to no detectable changes in composition or distribution.	Increase in the level of the bank or bed of the Nepean River that could reduce the wetted perimeter and lead to stranding and desiccation of aquatic vegetation along the edge of the river is not expected. Localised gas releases may lead to minor changes in the

		composition and extent of macrophyte beds, but these are unlikely to be detected, because of the natural variability of these beds. Impacts to water quality and surface water availability, and thus associated impacts to aquatic habitat and biota, are not expected.
Fish	Potential impacts would be similar in scale to those observed during mining of AA7 (i.e. none detected). Reductions in dissolved oxygen associated with gas emissions are likely to be short-lived and localised and unlikely to have a significant effect, because fish populations are highly mobile.	Same as for BSO EA.
Threatened Species	It is unlikely that a viable population of Macquarie perch is present in the section of the Nepean River adjacent to the Study Area. This is because of a lack of suitable habitat (including natural riffle habitat required for spawning and numerous barriers to fish passage from downstream. Mine subsidence induced impacts resulting from the proposal are not predicted to lead to loss of riffle habitat or large permanent pools within watercourses that provide suitable habitat for Macquarie perch. Changes in water quality are predicted to be localised or transient. It was therefore considered unlikely that the Project would have a significant adverse effect on Macquarie perch. Likewise, impacts to Sydney hawk dragonfly (which was not located in the BSO Part 3A Application layout), were also unlikely.	Same as for BSO EA.
Drainage Lines		

Aquatic habitat	Potential impacts in Foot Onslow and Navigation Creeks are expected to be limited to localised areas of iron staining; possibly fracturing and enhanced leakage from farm dams and pools (where present) and possible low flow diversion in areas of rock outcrop or where bedrock is covered by a thin mantle of alluvium. Potential impacts in Harris Creek include isolated incidents of iron staining, short-term spikes in water quality parameters such as iron, gas emissions, reduced pool levels in dry weather and localised underflow and a reduction in the frequency and persistence of inter-pool flow. If diversion of surface water occurs, drainage of pools may result in a temporary loss of small areas of aquatic habitat.	Fracturing could occur and could result in flow diversions and localised reductions in the availability and connectivity of ephemeral pool habitat. This is unlikely to have a detectable effect on the availability of aquatic habitats beyond the scale of individual pools and watercourses. Impacts to water quality are not expected.
Riparian vegetation	It is considered unlikely that changes in the level of water in streams or the emission of strata gas caused by mine subsidence within this domain would disturb riparian vegetation to the extent that its ecological role would be significantly adversely impacted.	Given the ephemeral nature of these watercourses, and the current disturbed nature of riparian vegetation along drainage lines, it is unlikely that any reduction in flow and water availability would have any significant impact on this vegetation.
Aquatic macrophytes	In Harris Creek, reduced water levels in the downstream reach could lead to exposure and desiccation of macrophytes. These impacts would be short-term and localised and would not persist once water levels are restored.	Impacts on the aquatic flora that may inhabit these ephemeral watercourses are unlikely to be detectable, because of the large variability in natural flows. In any case, the extent of native aquatic plants in these ephemeral drainage lines appears limited.
Aquatic macroinvertebrates	Significant adverse impacts are unlikely given that changes in water quality are expected to be short-lived	Fracturing and flow diversions could occur and could be associated with reductions in the availability and connectivity of aquatic habitat. An impact on the local population size of these and other native

	and localised and macroinvertebrates should recover quickly once water levels return. Given that changes in water quality were predicted to be localised and transient, macroinvertebrates should recover quickly once water levels return following rain events. it is considered unlikely that populations in drainage lines would be significantly affected. Moreover, any potential impacts affecting these areas would be hard to discern, should they occur, because of the degraded nature of the existing aquatic habitat in this area.	aquatic species could be expected. This could be significant at the scale of individual pools and possibly individual watercourses. However, given the ephemeral nature of these watercourses, the predicted localised reductions in habitat availability and connectivity and the abundance of such habitat in the Nepean River Catchment, impacts on population size are expected to be negligible in a regional context.
Fish	If fracturing of bedrock leads to loss of habitat, a few species (e.g. eels) may be able to relocate to nearby pools, but others would perish due to desiccation and/or predation. As losses would be restricted to small, localised areas of habitat, this is unlikely to have a significant effect on fish assemblages within the Study Area.	Same as for BSO EA.
Threatened Species	No threatened species identified in drainage lines.	Same as for BSO EA.

5. PERFORMANCE MEASURES AND INDICATORS

The BSO Approval provides subsidence impact performance measures (Condition 1, Schedule 3). Table 9 below details the conditions relevant to biodiversity within the Study Area.

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

Table 9 Subsidence Impact Performance Measures (Biodiversity)

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

Other relevant performance measures from this section of the BSO Approval to the BMP are outlined in Table 10.

Table 10 Subsidence Impact Performance Measures (Other)

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

	0.5% of the total face area of such cliffs) within any longwall mining domain.
Other cliffs	Minor impacts (that is occasional rock falls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 3% of the total face area of such cliffs within any longwall mining domain).

Note. Not all of the above mentioned features are present in the Longwall 709 to 711 and 905 Study Area as the subsidence impact performance measures in Schedule 3 relate to the entire BSO Area.

In order to mitigate the potential subsidence impacts and environmental consequences from the mining of Longwalls 709 to 711 and 905, monitoring and recording will be undertaken prior to mining, throughout the extraction and at the completion of subsidence (refer Section 6).

Where subsidence impacts are recorded, consideration would be given to implementing appropriate management, remediation and/or mitigation measures in consultation with relevant landowners, BCD, DPI Fisheries and other relevant stakeholders (refer Section 7).

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

6. MONITORING AND REPORTING

6.1 Monitoring Program

Subsidence parameters (i.e. subsidence, tilt, tensile strain, compressive strain, valley closure and closure strain) will be measured in accordance with the Longwalls 709 to 711 and 905 Subsidence Monitoring Program provided in Appendix B of the Extraction Plan.

The monitoring program outlined below will be implemented to monitor the impacts of subsidence effects to biodiversity within the Longwalls 709 to 711 and 905 Study Area. As subsidence effects are predicted to be small in magnitude, the monitoring program outlined below reflects the magnitude of these expected impacts.

6.1.1 Aquatic Biodiversity

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

Monitoring will occur along the Nepean River and build on the current monitoring program in place for Appin Longwalls 701 to 708 and Longwalls 901 to 904, as detailed in Appendix B of the Extraction Plan. Existing impact sites applicable to monitoring potential impacts associated with Longwalls 709 to 711 and 905 on the Nepean River are Sites 5, 6, X3 and X4 (i.e. those closest to the proposed longwalls). Sites 1, 2, 7, 8, X5, X6, X7 and X8 would provide control data (Figure 4).

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

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

Detailed recommendations for monitoring including laboratory methods and data analysis are provided by Cardno (2021).

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

Additional aquatic ecology studies would be triggered by events such as significant changes in water quality and availability of aquatic habitats. Trigger values for aquatic ecology monitoring parameters are outlined in Table 11.

6.1.2 Terrestrial Biodiversity

The monitoring program for mining related subsidence effects on terrestrial biodiversity reflects the predicted small magnitude of subsidence effects on biodiversity values for the Longwalls 709 to 711 and 905 Study Area.

Monitoring will focus on detecting changes to vegetation communities and fauna habitats present within the Longwalls 709 to 711 and 905 Study Area and will have coverage across the Study Area.

Groundwater dependant and riparian vegetation may experience some floristic changes in response to changed groundwater conditions, as a result of subsidence. Subsidence effects are more likely to result in impacts to natural features through loss of surface water flows and the impacts to groundwater dependant ecological features (PAC, 2010). Groundwater dependant vegetation communities present within the Study Area, as shown in Figure 2, include PCT830 (*Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion*) and PCT835 (*Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion*). Other vegetation communities are less likely to be impacted as a result of subsidence effects, hence less monitoring of these communities will be undertaken.

Visual inspections of vegetation communities within the Longwalls 709 to 711 and 905 Study Area will be undertaken as part of routine landscape and water monitoring programs. A targeted inspection by a qualified ecologist will follow should changes to vegetation health be observed.

Inspections of vegetation condition will assess the following:

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

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

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

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

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

The reports will:

- Detail any impact detected;

- Provide a proposed assessment methodology for further study; and
- BCD will be consulted in relation to assessment methodology.

IMC will implement remediation measures (Section 7.1) where significant impacts to vegetation communities or fauna habitat are caused by subsidence effects.

6.2 Reporting

Results from the monitoring program will be reported annually in the Annual Review. This report will:

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

Monitoring results will be reviewed monthly by the IMC Subsidence Management Committee. However, if the findings of monitoring are deemed to warrant an immediate response, the Principal Approvals will initiate the requirements of the Trigger Action Response Plan (TARP) (Table 11).

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

7. MANAGEMENT AND MITIGATION MEASURES

7.1 Terrestrial Biodiversity

7.1.1 Mitigation Strategies

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

- Mitigation measures within Sections 5.8.3 and 5.9.3 of the BSO EA;
- Implementation of monitoring program (Section 6.1);
- Implementation of offset measures (Sections 7.3 and 8);
- Prepare and implement TARPs (Section 7.3);
- Vegetation clearance mitigation measures (if applicable);
- Implementation of weed control measures;
- Implementation of measures for the management of Chytrid/Phytophthora e.g. restricting vehicle movements and access, limiting soil disturbance, encouraging natural regeneration, hygiene of staff and equipment;
- Manage fire (if applicable);
- Manage dust (if applicable);
- Minimise fauna traps e.g. mitigate cracking where access is available;
- Implement speed limits on fire roads and tracks;
- Manage noise (if applicable);
- Manage artificial lighting (if applicable);
- No introduced fauna e.g. no pets;
- Report pest species and include pest awareness in induction/awareness sessions;
- Any remediation works will take appropriate measures to minimise other impacts;
- Vehicular access will be restricted to recognised tracks and disturbed areas where possible to avoid and minimise impacts to native vegetation and fauna habitat;
- Should access to areas of native vegetation be required, access on foot will be preferred to vehicular access;
- If vegetation clearing is required a suitably qualified ecologist will be engaged to determine the vegetation/fauna habitat characteristics of the area to determine the potential impacts and recommended measures to reduce these impacts.

7.1.2 Management Measures

As detailed in Section 6.1.2, where significant impacts are observed and are a result of subsidence effects, IMC will implement a remediation program where access to the site is available.

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

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

Assisted regeneration will include weed management measures, as well as fencing off affected areas to prevent grazing (where agreed with the landowner and the relevant statutory authority). Where assisted regeneration is not meeting expected outcomes, replanting of ground cover, shrub and tree species will be implemented. All replanting will be undertaken using species characteristic of the vegetation community, with planting undertaken with local provenance species where available.

7.2 Aquatic Biodiversity

7.2.1 Mitigation Strategies

The potential impacts of Longwalls 709 to 711 and 905 on aquatic habitats and biota in the Nepean River will be minimised by:

- Adopting a mine layout that does not involve mining under the river.
- Identifying triggers that would prompt surveys to assess any impacts on aquatic habitats and their biota identified during and after extraction of the longwalls.
- Identifying physical and water quality impacts that occur during the extraction of Longwalls 709 to 711 and 905 through ongoing monitoring and timely implementation of appropriate CMAs.

7.2.2 Management Measures

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

Specific management measures for aquatic biodiversity will be employed where more than negligible impacts resulting from subsidence occur. Management measures include implementation of monitoring and reporting as well as the involvement of relevant stakeholders, agencies and specialists to investigate and report on the changes that are identified and any specific mitigation measures required.

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

- Should impacts on aquatic biodiversity occur which are considered to be outside of the performance measures of the BSO Approval, IMC would review future longwalls.

The review would consider measures including decreases in longwall width and length.

- Implementing stream remediation measures, such as backfilling or grouting in areas where fracturing of controlling rock bars and/or stream bed leads to diversion of stream flow and drainage of pools.
- Implementing appropriate control measures, such as installation of sediment fences down slope of areas where subsidence has led to erosion, and stabilisation of areas prone to erosion and soil slumping using rock, brush matting or vegetation, to limit the potential for deposition of eroded sediment into watercourses.

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

7.3 Trigger Action Response Plan

The AA7 and 9 Biodiversity TARP is shown in Table 11.

Table 11 AA7 and 9 BMP Trigger Action Response Plan

Monitoring	Trigger	Action
Aquatic Ecology		
Impact Sites: 5, 6, X3 and X4 **Control Sites:** 1, 2, 7, 8, X5, X6, X7 and X8	***Level 1**** • Reduction in aquatic habitat resulting from the mining over 1 season	• Continue monitoring program • Submit an Impact Report to BCD, DPIE, DPI Fisheries and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AR
	Level 2* • Reduction in aquatic habitat resulting from the mining over 2 seasons	• *Actions as stated for Level 1* • Report trigger to key stakeholders • Review monitoring program • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. impacts to aquatic habitat with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Level 3* • Reduction in aquatic habitat resulting from the mining for >2 consecutive seasons or complete loss of habitat	• *Actions as stated for Level 2* • Notify BCD, DPIE, DPI Fisheries, relevant resource managers and technical specialists and seek advice on any CMA required. • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include: – Grouting of fractures which result in flow diversion – Completion of works following approvals • Completion of works following approvals, including monitoring and reporting on success • Review the TARP and Management Plan in consultation with key stakeholders *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e.*

		impacts to aquatic habitat with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts
	Exceeding Prediction • Mining results in more than negligible environmental consequences for a threatened species, threatened population or endangered ecological communities	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful
Terrestrial Ecology		
Visual inspections as part of landscape and water monitoring programs in active mining areas[#]	***Level 1**** • Impacts detectable via observational monitoring (e.g. canopy thinning, thinning of shrub layer, minor loss of ground cover) to a single vegetation strata • Subsidence impacts (such as surface cracking, rock falls) resulting in small areas of disturbance that will mitigate without CMA	• Continue monitoring program • Submit an Impact Report to BCD, DPIE and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AR
	Level 2* • Impacts detectable via observational monitoring (e.g. canopy thinning with dead branches present, thinning of the shrub layer with dead branches, loss of ground cover in multiple areas) to multiple vegetation strata • Subsidence impacts (such as surface cracking, rock falls) resulting in small areas of disturbance that will not mitigate without CMA	• *Actions as stated for Level 1* • Report trigger to key stakeholders • Review monitoring program • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. impacts to terrestrial habitat with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Level 3* • Impacts (e.g. canopy thinning with dead branches present, thinning of the shrub layer with dead branches, loss of ground cover in multiple areas) to multiple vegetation strata caused by subsidence effects	• *Actions as stated for Level 2* • Notify BCD, DPIE, relevant resource managers and technical specialists and seek advice on any CMA required. • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include:

	• Subsidence impacts (such as surface cracking, rock falls) resulting in large areas of disturbance that will not mitigate without CMA • Negligible environmental consequences to threatened species, populations or EEC Reduction in aquatic habitat resulting from the mining for >2 consecutive seasons or complete loss of habitat	– Erosion prevention works – Establishment of vegetation • Completion of works following approvals, including monitoring and reporting on success • Review the TARP and Management Plan in consultation with key stakeholders *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. impacts to terrestrial habitat with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Exceeding Prediction • Mining results in more than negligible environmental consequences for a threatened species, threatened population or endangered ecological communities	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful

* These may be revised in consultation with DPIE and other key stakeholders following analysis of natural variability within the pre-mining baseline data.
# Monitoring subject to access agreement from landowners.

8. CONTINGENCY RESPONSE PLAN

In the event that performance measures detailed in Section 5 of this BMP are exceeded, or are likely to be exceeded, South32 will implement a contingency plan to manage any unpredicted impacts and their consequences.

This would involve:

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

South32 will consult with appropriate specialists and relevant agencies in order to devise an appropriate response in respect to any identified exceedance.

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

If the contingency measures implemented by South32 fail to remediate the impact or the Secretary determines that it is not reasonable or feasible to remediate the impact, South32 will provide a suitable offset to compensate for the impact to the satisfaction of the Secretary in accordance with the BSO Approval Condition 2, Schedule 3.

9. COMPLAINTS AND COMPLIANCE MANAGEMENT

9.1 Incidents

IMC will notify DPIE and any other relevant agencies of any incident associated with the BSO as soon as practicable after IMC becomes aware of the incident. IMC will provide DPIE and any relevant agencies with a detailed report on the incident within seven days of confirmation of any event.

9.2 Complaints and Dispute Resolution

IMC has a 24 hour, free community call line (1800 102 210) and email address (illawarracommunity@south32.net) through which all complaints and general enquiries regarding environmental or community issues associated with IMC's operations can be reported.

All complaints received in relation to Appin Mine are managed in accordance with the Handling Community Complaints, Enquiries and Disputes Procedure.

Upon receipt of a community complaint, preliminary investigations will commence as soon as practicable to determine the likely cause of the complaint using information such as activities being undertaken on site at the time or area of the complaint.

An initial response will be provided to the complainant within 24 hours of the complaint being made, with a follow up response being provided as soon as practicable once a more detailed investigation is complete.

A summary of all complaints received during the reporting year will be provided as part of the Annual Review. A log of complaints is also maintained on the South32 website at:

https://www.south32.net/our-business/australia/illawarra-metallurgical-coal/documents.

9.3 Non-Compliance, Corrective Action and Preventative Action

Events, non-compliances, corrective actions and preventative actions are managed in accordance with the Reporting and Investigation Standard and Environmental Compliance/Conformance Assessment and Reporting Procedure. These procedures, which relate to all IMC operations, detail the processes to be utilised with respect to event and hazard reporting, investigation and corrective action identification. The key elements of the process include:

- identification of events, non-conformances and/or non-compliances:
- recording of the event, non-conformance and/or non-compliance in the event management system G360;
- investigation/evaluation of the event, non-conformance and/or non-compliance to determine specific corrective and preventative actions;
- assigning corrective and preventative actions to responsible persons in G360; and
- review of corrective actions to ensure the status and effectiveness of the actions.

Exceedances or non-compliances with biodiversity related criteria will be reported to relevant agencies via the Annual Review or notified in accordance with Section 8.

10. PLAN ADMINISTRATION

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

10.1 Roles and Responsibilities

Statutory obligations applicable to this Plan are identified and managed via an online compliance management system (TICKIT). The online system can be accessed from the link below:

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

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

Parties responsible for environmental management in AA7 and 9 and the implementation of the Plan include:

Manager Approvals

- Ensure that the requisite personnel and equipment are provided to enable this Plan to be implemented effectively.
- Authorise the Plan and any amendments thereto.

Principal Approvals

- Document any changes to the Plan, recognising the potential for those changes to affect other aspects of the Plan.
- Provide regular updates to IMC on the results of the Plan.
- Arrange information forums for key stakeholders as required.
- Prepare any report in accordance with the Plan. Maintain records required by the Plan.
- Organise and participate in assessment meetings called to review mining impacts.
- Within 24 hours, respond to any queries or complaints made by members of the public in relation to aspects of this Plan.
- Organise audits and reviews of the Plan.
- Address any identified non-conformances, assess improvement ideas submitted and implement if considered appropriate.
- Arrange for the implementation of any agreed actions, responses or remedial measures.
- Check surveys required by this Plan are conducted and record details of instances where circumstances prevent these from taking place.

Environmental Field Team Coordinator

- Instruct suitable person(s) in the required standards for inspections, recording and reporting and be satisfied that these standards are maintained.

- Investigate significant subsidence impacts.
- Identify and report any non-conformances with the Plan.
- Participate in any other assessment meetings called to review subsidence impacts in the area affected by mining.

Survey Coordinator

- Collate survey data and present in an acceptable form for review at assessment meetings.
- Bring to the attention of the Principal Approvals any findings indicating an immediate response may be warranted.
- Bring to the attention of the Principal Approvals any non-conformances identified with the Plan provisions or ideas aimed at improving the Plan.

Technical Experts

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

Person(s) Performing Inspections

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

10.2 Resources Required

The Manager Approvals provides resources sufficient to support this Plan.

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

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

10.3 Training

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

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

All training records are maintained by the IMC Training Department.

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

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

10.4 Review and Update

In accordance with Condition 5 of Schedule 6 of the BSO Approval, the BMP will be reviewed, and if necessary revised, within three months, of:

- the submission of an Annual Review;
- the submission of an incident report;
- the submission of an Independent Environmental Audit (IEA) report; or
- any modification to the conditions of the BSO Approval (unless the conditions require otherwise).

If significant deficiencies in this BMP are identified in the interim period, the Plan will be modified as required. This process has been designed to ensure that documentation continues to meet current requirements, including changes in technology and operational practice, and expectations of stakeholders.

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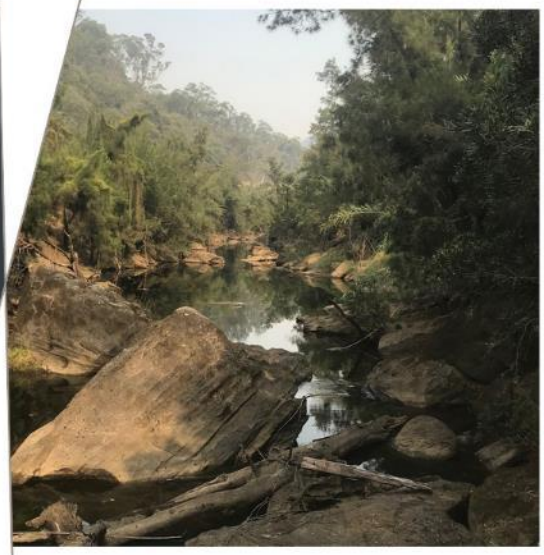
12. APPENDICIES

Appendix A - Cardno, 2020 *Appin Areas 7 and 9 Longwalls 709, 710A, 710B, &11 and 905 Aquatic Flora and Fauna Assessment*

Aquatic Flora and Fauna Assessment

Appin Area 7&9 Longwalls 709, 710A, 710B, 711 and 905

59919104



Prepared for

South32– Illawarra Metallurgical Coal

14 May 2021

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Executive Summary

Introduction

South32 – Illawarra Metallurgical Coal (South32) plans to extract coal from Longwalls 709, 710A, 710B, 711 and 905 in Appin Areas 7 & 9 (the Project). These longwalls are located at least 1.5 kilometres (km) northwest of the Nepean River near Appin. This Aquatic Flora and Fauna Assessment (AFFA) has been prepared to support the Extraction Plan (EP) for these longwalls, which outlines the monitoring and management activities required to assess and mitigate potential impacts due to mining. Previously, impacts to aquatic flora and fauna due to extraction of coal from Appin Area 7 and 9 were assessed as part of the wider Bulli Seam Operations (BSO) Environmental Assessment (EA). The proposed longwalls represent an update to the longwall layout considered in this assessment.

The AFFA focuses on the section of the Nepean River adjacent to these longwalls and sections of first, second and third order drainage lines located directly above and within 400 metres (m) of the longwalls. Potential impacts to associated aquatic flora and fauna may arise following subsidence and fracturing of bedrock resulting in water diversion, and consequent loss of aquatic habitat and biota in watercourses. The AFFA includes:

- A review and synthesis of existing information on the aquatic flora and fauna in the Nepean River and in drainage lines within the Study Area (area within 600 m of Longwalls 709, 710A, 710B, 711 and 905). The Nepean River is located outside the Study Area, but was included in the assessment because it supports significant aquatic habitat. The review included the findings of the most recent surveys at sites on the Nepean River in November 2019 as part of the ongoing aquatic ecology monitoring for Appin Areas 7 & 9;
- Assessment of the potential impacts on aquatic flora and fauna (including threatened species) arising directly and indirectly from the proposed mining. This included examination of whether the predicted impacts to aquatic habitats and biota differ from the Conditions of the BSO Project Approval; and
- Recommendations on impact mitigation measures and monitoring for inclusion within the EP.

Existing Environment

The Nepean River supports significant and permanent aquatic habitat including extensive beds of submerged macrophytes in the shallower river edges and large wood debris and boulders along the channel edge. Riparian vegetation is relatively undisturbed and provides a source of substantial in-stream woody debris, an important habitat for many species of aquatic fauna, including a number of species of native fish and aquatic macroinvertebrates. It is classified as Type 1 – Highly Sensitive Key Fish Habitat (KFH) (Type 1 - KFH). Aquatic habitat provided by first, second and third order drainage lines (including third order sections of Navigation Creek, Foot Onslow Creek and a small section of Harris Creek) within the Study Area generally consists of a series of disconnected ephemeral pools with connecting flow for short periods during and following rainfall. These watercourses have, and continue to, experience disturbance due to historic land clearance and current agricultural land use. This has resulted in fragmented riparian vegetation, elevated sediment input and at least on occasion impaired water quality. They provide aquatic habitat of relatively limited value, though do support native aquatic plants, macroinvertebrates and likely native species of fish. Third order sections of these drainage lines provide Type 1 to Type 2 – Moderately Sensitive KFH. First and second order sections are not KFH. The threatened Macquarie perch occurs in the Nepean River upstream of the Study Area, though the presence of Maldon Weir appears to prevent access to the section adjacent to the Study Area and it is considered unlikely to occur in this section. The only records of the threatened Sydney Hawk dragonfly are in the Nepean River approximately 5 km upstream of the Study Area.

Impact Assessment

The Nepean River would experience vertical subsidence, upsidence and closure of less than 20 mm and it is considered unlikely it would experience adverse physical impacts due to extraction of these longwalls. Thus, significant impacts to aquatic flora and fauna in the Nepean River, including any threatened species, are not expected. There would be no reduction in surface water availability or quality in the Nepean River due to mining. No impacts to aquatic ecology have been noted following previous gas releases in the Nepean River associated with mining in Appin Areas 7 & 9, and it is considered unlikely that significant impacts would occur due to any further gas releases.

Fracturing and flow diversions may occur in drainage lines directly above and up to 400 m away from the proposed longwalls. In total, approximately 5.1 km of third order drainage line habitat is located directly above and within 400 m of the proposed longwalls. A total of approximately 25 km of first and second order watercourses is located directly above and within 400 m of the proposed longwalls. Based on observations during extraction of previous Appin Area 7 and 9 longwalls, however, the likelihood of associated flow diversions or pool drainage is low. In the unlikely event flow diversions did occur, this may result in the

draining of pools in these watercourses, particularly during low flows, resulting in a reduction in the availability of aquatic habitat and the connectivity of remaining habitat. This would be expected to result in a reduction in population size of associated aquatic biota, including some aquatic plants, macroinvertebrates and some native fish. Such impacts would be significant at the scale of individual pools and drainage lines, though at the scale of the wider Nepean River catchment, would be relatively minor.

Recommendations and Management

Potential impacts on aquatic habitat and biota within the Study Area would be managed by:

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

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Figure 3-4 Mean (averaged across all surveys from September 2003 to November 2019 - **Appendix B**) OE50 Taxa Score at each site on the Nepean River arranged from X8 upstream to Site 8 downstream and on N1 on Navigation Creek (Nav. Ck.) and F1 and F2 on Foot Onslow Creek (F1 and F2). 17

Figure 3-5 Mean (averaged across all surveys from September 2003 to November 2019 - **Appendix B**) SIGNAL2 Score at each site on the Nepean River arranged from X8 upstream to Site 8 downstream and on N1 on Navigation Creek (Nav. Ck.) and F1 and F2 on Foot Onslow Creek (F1 and F2). 17

1 Introduction

1.1 Background

South32 – Illawarra Metallurgical Coal (South32), formerly BHP Billiton Illawarra Coal (BHPBIC), owns and operates the Appin Mine which extracts Bulli Seam coal of the Southern Coalfield of NSW. Extraction of coal from Appin Area 7 Longwalls 701 to 704 was completed in 2012. Extraction of Longwalls 705 to 708A was completed in October 2019 with extraction of Longwall 708B underway. Longwalls 901 and 902 in Appin Area 9 were completed April 2019 with extraction of Longwall 903 underway. The Subsidence Management Plan (SMP) for Longwalls 705 to 710 (Cardno Forbes Rigby 2008) was approved in February 2008 (Longwalls 705 and 706) and September 2012 (Longwalls 707 to 710). The Extraction Plan (EP) for Longwalls 901 to 904 (BHPBIC 2013), supported by the Aquatic Ecology Assessment (Cardno Ecology Lab 2011a) was approved in September 2014. The SMPs and EP satisfy legislative conditions and outline the monitoring and management activities required to assess and mitigate potential impacts due to mining. The overall objective of SMPs and EPs is to protect important watercourses, other natural features and built features from impacts associated with mine-induced subsidence. They contain environmental monitoring and management plans aimed at minimising any impacts to natural (e.g. groundwater quality, terrestrial ecology, aquatic ecology) and man-made (cultural heritage, infrastructure) features of the environment due to subsidence.

South32 are seeking secondary approval for extraction of Longwalls 709, 710A, 710B, 711 and 905 in Appin Areas 7 & 9. Cardno NSW/ACT Pty Ltd (Cardno) (formerly Cardno Ecology Lab and The Ecology Lab Pty Ltd) was commissioned by South32 to prepare the Aquatic Flora and Fauna Assessment (AFFA) to support the EP application required as part of the Bulli Seams Operation (BSO) Project Approval, granted by the Minister for Planning under the Environmental Planning and Assessment Act 1999 (EP&A Act). The BSO approval allows South32 to continue mining operations in the Appin Colliery for a further 30 years.

1.2 Scope of Works

The scope of works for the AFFA includes:

- Desktop review and compilation of information on existing aquatic habitat, vegetation and macroinvertebrates, fish, and any listed threatened species and populations, in the third or greater Strahler stream order (order) section of the Nepean River and its tributaries adjacent to the longwalls. This information was obtained primarily from previous investigations that have been underway for several years, as part of existing mining operations in Appin Areas 7 & 9.
- Assessment of the potential impacts of the Project on aquatic ecology, including threatened species, and any cumulative impacts, in the Nepean River and its tributaries that may experience impacts associated with potential mining subsidence. This included examination of whether the predicted impacts to aquatic habitats and biota differ from the conditions in the those presented within the Conditions of the BSO Project Approval (**Section 2.1**); and,
- Provide recommendations on measures to avoid and mitigate potential impacts on aquatic ecology and the form and content of the requisite aquatic ecology monitoring plan for these longwalls. This would be implemented to determine the nature and extent of any subsidence induced impacts on aquatic ecology and assess the response of aquatic ecology to any subsequent remediation and management works.

1.1 Summary of Previous Studies

Cardno has produced a number of reports on the aquatic habitat and biota associated with the Nepean River and nearby watercourses. These have incorporated reviews of existing literature, the results of baseline surveys, threatened species searches, predictions of mine-subsidence impacts on aquatic ecology, and results of during and post-mining monitoring. In this section, a brief timeline of these studies is presented.

The initial aquatic ecology investigation in Appin Area 7 in September 2003 included a review of existing literature on aquatic ecology relevant to Appin Area 7 Longwalls 701 to 704, a summary of field investigations describing the ecological conditions of the relevant watercourses, an assessment of the likely impacts on aquatic habitats and biota based on predictions of subsidence / upsidence and recommendations for additional work (The Ecology Lab 2004). Following a substantial change in the mine layout, South32 commissioned a further field study (September 2005) for inclusion in the SMP that addressed the effects of mine subsidence on aquatic ecology in the area that could potentially be affected by the mining of Longwalls

701 to 704 (The Ecology Lab 2006). The April 2008 field study provided further data to support the assessment of potential effects of mine subsidence on aquatic habitats and biota resulting from the proposed mining of Longwalls 705 to 710 (The Ecology Lab 2008a). This assessment was included in the SMP for Longwalls 705 to 710 submitted to the Department of Primary Industries Mineral Resources (Cardno Forbes Rigby 2008).

Additional monitoring in accordance with the recommendations made in the SMPs for Longwalls 701 to 704 and 705 to 710 was undertaken in November 2008 (The Ecology Lab 2008b), December 2010 (Cardno Ecology Lab 2011b), December 2011 (Cardno Ecology Lab 2012a), December 2012 (Cardno Ecology Lab 2013) December 2013 (Cardno Ecology Lab 2014), December 2014 and January 2015 (hereafter referred to as December 2014) (Cardno Ecology Lab 2015), November 2015 (Cardno 2016), November 2016 (Cardno 2017), November 2017 (Cardno 2018), November 2018 (Cardno 2019) and November 2019 (Cardno 2020). Aquatic ecology assessments were prepared by Cardno Ecology Lab following extraction of Longwalls 701-704 to support the End of Panel reports for these longwalls (The Ecology Lab 2008b and Cardno Ecology Lab 2009, 2011c and 2012b).

The AEA for Appin Longwalls 901 to 904 was undertaken in May 2012 (Cardno Ecology Lab 2012c). This assessment formed part of the Biodiversity Management Plan for the EP (BHPBIC 2014). It included a review and synthesis of existing information on the aquatic habitats and biota that may be affected by extraction of these longwalls and identified potential impacts to aquatic habitats and biota due to the predicted physical and water quality impacts. It also recommended actions to minimise such impacts, including the implementation of ongoing monitoring of aquatic habitats and biota. The first baseline survey for Appin Area 9 was undertaken in December 2014 and November 2015 (Cardno Ecology Lab 2015) with during-mining monitoring undertaken in November 2017 (Cardno 2018) and November 2019 (Cardno 2020)

The Environmental Assessment (EA) (BHPBIC 2009) for the BSO was supported by the Aquatic Ecology Assessment (AEA) (BioAnalysis 2009). Surveys undertaken to support the BSO AEA included surveys of aquatic habitat, plants, macroinvertebrates and fish in the Nepean River at NP1 approximately 400 m downstream of Maldon Weir, NP2 just upstream of the confluence with Allens Creek (located outside the Study Area) and NP3 at Menangle Weir.

Information on aquatic habitat, water quality, aquatic macroinvertebrates and fish in the Study Area available from these previous studies is reviewed in **Sections 3.2** to **3.7**. This review of existing information included the findings of surveys undertaken at Sites 1 to 8 and X1 to X8 on the Nepean River, sampled between 4 and 12 occasions since September 2003 and most recently in November 2019 (Cardno 2019). Details of the methods used in these studies and the GPS coordinates of monitoring sites are provided in **Appendix A**.

Information on aquatic habitat present in third order drainage lines that traverse the Study Area has been compiled based on the results of fields surveys undertaken in 2008 (The Ecology Lab 2008a), 2009 (Bioanalysis 2009) and from visits undertaken by the Illawarra Metallurgical Coal Field Investigation Team (IMCEFT) in 2020. Information in Bioanalysis (2009) relevant to the current assessment are descriptions of aquatic habitat of named third order drainage lines (Navigation Creek, Foot Onslow Creek and Harris Creek) and the results of autumn 2008 surveys of aquatic plants, macroinvertebrates and fish at Sites FC_1 and FC_2 on Foot Onslow Creek and Sites NP1_1, NP1_2, NP2_1, NP2_2, NP3_1 and NP3_2 in the Nepean River.

2 Relevant Legislation, Policies, Guidelines and Conditions

2.1 BSO Project Approval

The conditions specified in the BSO Project Approval (including Modifications 1 [April 2015] and 2 [October 2016]) (NSW DPIE 2016) that are relevant to aquatic ecology include:

- Subsidence Impact Performance Measures for Natural Features (**Table 2-1**);
- Preparation of an EP incorporating a Biodiversity Management Plan that provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on aquatic flora and fauna, particularly threatened species, populations and their habitats; endangered ecological communities; and water dependent ecosystems;
- Additional targeted surveys for threatened species, sufficient to identify any actions required to protect significant populations from potential impacts.

The term negligible, used in **Table 2-1**, is defined in the BSO Project Approval as small and unimportant, such as to be not worth considering.

Table 2-1 Subsidence Impact Performance Measures Pertinent to Aquatic Ecology in the current Study Area

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

2.2 Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) contains provisions for the conservation of fish stocks, Key Fish Habitat (KFH), biodiversity, threatened species, populations and ecological communities. The FM Act regulates the conservation of fish, marine vegetation and some aquatic macroinvertebrates and the development and sharing of the fishery resources of NSW for present and future generations. The FM Act lists threatened species, populations and ecological communities under Schedules 4, 4A and 5. Schedule 6 lists key threatening processes (KTPs) for species, populations and ecological communities in NSW waters and declared critical habitat are listed in a register kept by the Minister of Primary Industries. Impacts to these species, populations, communities, processes and habitats due to the Project need to be considered. Assessment guidelines to determine whether a significant impact is expected are detailed in Section 220ZZ and 220ZZA of the FM Act. The guidelines specify the important factors that must be taken into considered when assessing potential impacts on threatened species, populations, or ecological communities. The factors requiring consideration are:

- How is the Project likely to affect the lifecycle of a threatened species and/or population?
- How is the Project likely to affect the extent and composition of a threatened ecological community?
- How is the Project likely to affect the habitat of a threatened species, population or ecological community?
- Will the Project affect any critical habitat?
- Is the Project consistent with the objectives or actions of a recovery plan or threat abatement plan?
- Is the Project part of a KTP or is it likely to exacerbate a KTP?

The potential for adverse effects on the lifecycle of threatened fish species depends on whether the works are likely to cause loss or degradation of habitat, reduction in water quality, limit their foraging activities and disrupt their reproduction and recruitment.

Another objective of the FM Act is to conserve KFH. These are defined as aquatic habitats that are important to the sustainability of recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species. In freshwater systems, most permanent and semi-permanent rivers, creeks, lakes, lagoons, billabongs, weir impoundments and

impoundments up to the top of the bank are considered KFH. Small headwater creeks and gullies that flow for a short period after rain and farm dams on such systems are excluded, as are artificial water bodies except for those that support populations of threatened fish or invertebrates. At a broad scale, KFH relevant to the Project includes the following:

- Permanently flowing rivers and creeks including those where the flow is modified by upstream dam(s), up to the top of the natural bank regardless of whether the channel has been physically modified;
- Intermittently flowing rivers and creeks that retain water in a series of disconnected pools after flow ceases including those where the flow is modified by upstream dam(s), up to the top of the natural bank regardless of whether the channel has been physically modified; and
- Any waterbody if it is known to support or could be confidently expected (based on predictive modelling) to support threatened species, threatened populations or threatened communities listed under the provisions of FM Act.

2.3 NSW DPI (Fisheries) Policy and Guidelines for Fish Habitat Conservation and Management

The NSW Department of Primary Industries (DPI) Policy and Guidelines for Fish Habitat Conservation and Management (Update 2013) (NSW DPI 2013a) replaces the Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (NSW DPI 1999) and the former Fisheries NSW Policy and Guidelines for Fish Friendly Waterway Crossings (Fairfull and Witheridge 2003). These updated policies and guidelines are applicable to all planning and development proposals and various activities that affect freshwater, estuarine and marine ecosystems. The aims of the updated policies and guidelines are to maintain and enhance fish habitat for the benefit of native fish species, including threatened species, in marine, estuarine and freshwater environments. The updated document assists developers, their consultants and government and non-government organisations to ensure their actions comply with legislation, policies and guidelines that relate to fish habitat conservation and management. It is also intended to inform land use and natural resource management planning, development planning and assessment processes, and to improve awareness and understanding of the importance of fish habitats and how impacts can be mitigated, managed or offset. The policies and guidelines outlined in this document are considered when NSW DPI assesses proposals for developments and other activities that affect fish habitats. The document contains:

- Background information on aquatic habitats and fisheries resources of NSW;
- An outline of the legislative requirements relevant to planning and development which may affect fisheries or aquatic habitats in NSW;
- General policies and classification schemes for the protection and management of fish habitats and an outline of the information that NSW DPI requires to be included in development proposals that affect fish habitat;
- Specific policies and guidelines aimed at maintaining and enhancing the free passage of fish through instream structures and barriers;
- Specific policies and guidelines for foreshore works and waterfront developments; and
- Specific policies and guidelines for the management of other activities that affect waterways.

NSW DPI considers the ‘sensitivity’ of any KFH that would be affected by the Proposal (NSW DPI 2013a). The term ‘sensitivity’ refers to the importance of the habitat to the survival of fish and its ability to withstand disturbance. In freshwater ecosystems, instream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 m in length, native aquatic plants, and areas known or expected to contain threatened and protected species are considered highly sensitive KFH. Other freshwater habitats plus weir pools and dams across natural waterways are considered to be moderately sensitive KFH. Ephemeral aquatic habitat that does not support native aquatic or wetland vegetation is considered to be of minimal sensitivity. It is important to note that aquatic habitats within first and second order gaining streams, sections of stream that have been concrete-lined or piped (excluding waterway crossings) and artificial ponds are not regarded as KFH unless they support a listed threatened species, population or ecological community or ‘critical habitat’. NSW DPI may in addition assess development proposals in relation to waterway class (i.e. their ability to provide habitat that is suitable for fish), which in turn determines the appropriate type of any waterway crossings.

2.4 Key Threatening Processes

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. KTPs are listed under the FM Act, *Biodiversity Conservation Act 2016* (BC Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). There are eight listed KTPs under the FM Act, 38 listed under the BC Act and 21 listed under the EPBC Act. Broadly, the KTPs include threats to threatened species, population and ecological communities as well as cause species, population or ecological communities to become threatened.

One KTP listed under the BC Act is directly applicable to the Project: *Alteration of habitat following subsidence due to longwall mining.*

In the final determination for this KTP, the NSW Scientific Committee found that:

- Mining subsidence following longwall mining is frequently associated with cracking of valley floors and creek lines and with subsequent effects on surface and groundwater hydrology.
- Subsidence-induced cracks occurring beneath a stream or other surface water body may result in the loss of water to near-surface groundwater flows. If the water body is located in an area where the coal seam is less than approximately 100 to 120 m below the surface, longwall mining can cause the water body to lose flow permanently. If the coal seam is deeper than approximately 150 m, the water loss may be temporary unless the area is affected by severe geological disturbances such as strong faulting.
- In the majority of cases, surface waters lost to the sub-surface re-emerge downstream. The ability of the water body to recover is dependent on the width of the crack, the surface gradient, the substrate composition and the presence of organic matter. An already-reduced flow rate due to drought conditions or an upstream dam or weir will increase the impact of water loss through cracking.
- Subsidence can cause decreased stability of slopes and escarpments, contamination of groundwater by acid drainage, increased sedimentation, bank instability and loss, creation or alteration of riffle and pool sequences, changes to flood behaviour, increased rates of erosion with associated turbidity impacts, and deterioration of water quality due to a reduction in dissolved oxygen (DO) and to increased salinity, iron oxides, manganese, and electrical conductivity (EC).
- Loss of native plants and animals may occur directly via iron toxicity, or indirectly via smothering. Long-term studies in the United States indicate that reductions in diversity and abundance of aquatic invertebrates occur in streams in the vicinity of longwall mining and these effects may still be evident 12 years after mining.
- In the Southern Coalfield, substantial surface cracking has occurred in watercourses within the Upper Nepean, Avon, Cordeaux, Cataract, Bargo, Georges and Woronora catchments, including Flying Fox Creek, Wongawilli Creek, Native Dog Creek and Waratah Rivulet. The usual sequence of events has been subsidence-induced cracking within the streambed, followed by significant dewatering of permanent pools and in some cases complete absence of surface flow.
- Subsidence associated with longwall mining has contributed to adverse effects on upland swamps. The conversion of perched water table flows into subsurface flows through voids, as a result of mining-induced subsidence may significantly affect the water balance of upland swamps. The timeframe of these changes is likely to be long-term. While subsidence may be detected and monitored within months of a mining operation, displacement of susceptible species by those suited to altered conditions is likely to extend over years to decades as the vegetation equilibrates to the new hydrological regime.

The Department of Environment and Conservation (now the DPIE) has identified several priority actions to promote the abatement of this KTP, including:

- Examine the effects of subsidence from longwall mining on priority ecosystems including streams, wetlands and threatened species, populations and ecological communities.
- Prepare guidelines outlining key factors that should be considered when assessing impacts of new longwall mines on biodiversity.
- Develop recommendations for monitoring impacts of new longwall mines on biodiversity and mitigation methods.

> Ensure rigorous assessment of new mines continues through existing approval processes including the preparation of SMPs.

Consideration of the effect of exacerbation of any KTP on a listed threatened species, population or ecological community must be taken into consideration during any assessment.

2.5 Biodiversity Conservation Act (2016)

The *Biodiversity Conservation Act 2016* (BC Act) contains provisions for the conservation of some aquatic species and communities except for those listed under the FM Act (i.e. fish, crayfish and all other aquatic animals, but not freshwater vegetation). Listings under the BC Act are considered in detail by in the terrestrial ecology specialist study. Regardless, listings and records of aquatic plants were reviewed in this assessment.

3 Existing Environment

3.1 Study Area

The Study Area for the AEA is the surface environment directly above and within 600 m of the footprint of Longwalls 709, 710A, 710B, 711 and 905 (**Figure 3-1**). The Nepean River is located outside this area and is not expected to experience impacts related to subsidence. However, as a precautionary measure, the adjacent section from existing Site 8 upstream to Site X8 has been included in this assessment. The water in the section of the Nepean River is derived from the licensed discharges of the Cataract, Cordeaux, Avon and Nepean Dams and flow is controlled by Maldon Weir, which is situated approximately 5 km south-west of the proposed longwalls. The Study Area is also traversed by several ephemeral drainage lines which flow into the Nepean River after rainfall events. The third order and greater drainage lines considered individually within the Study Area are Navigation Creek, a tributary of Navigation Creek (Tributary 1), Foot Onslow Creek and the far upstream section of Harris Creek. A number of first and second order drainage lines also flow through the Study Area.

Figure 3-1 also includes the 400 m boundary and the area within the 35° angle of draw. The 35° angle of draw indicates where conventional longwall mine subsidence impacts would be expected to occur. In the Southern Coalfield, subsidence induced fracturing has been observed up to 400 m from the longwall goaf. Therefore the 400 m boundary has been used as a reference to make predictions about the extent of impacts to watercourses in MSEC (2021) and in this AFFA.

3.2 Aquatic Habitat and Riparian Vegetation

3.2.1 Nepean River

The Nepean River between Site 8 and Site X8 can be divided into two relatively distinct sections. A flooded lower section (**Plate 1a** and **b**) from around 1 km upstream of Site 1 to Site 8 where surface water level is controlled by Douglas Park Weir and an upper section (**Plate 1c** and **d**) upstream of here to Site X8 where surface flow is controlled by boulder fields and small riffle sections.

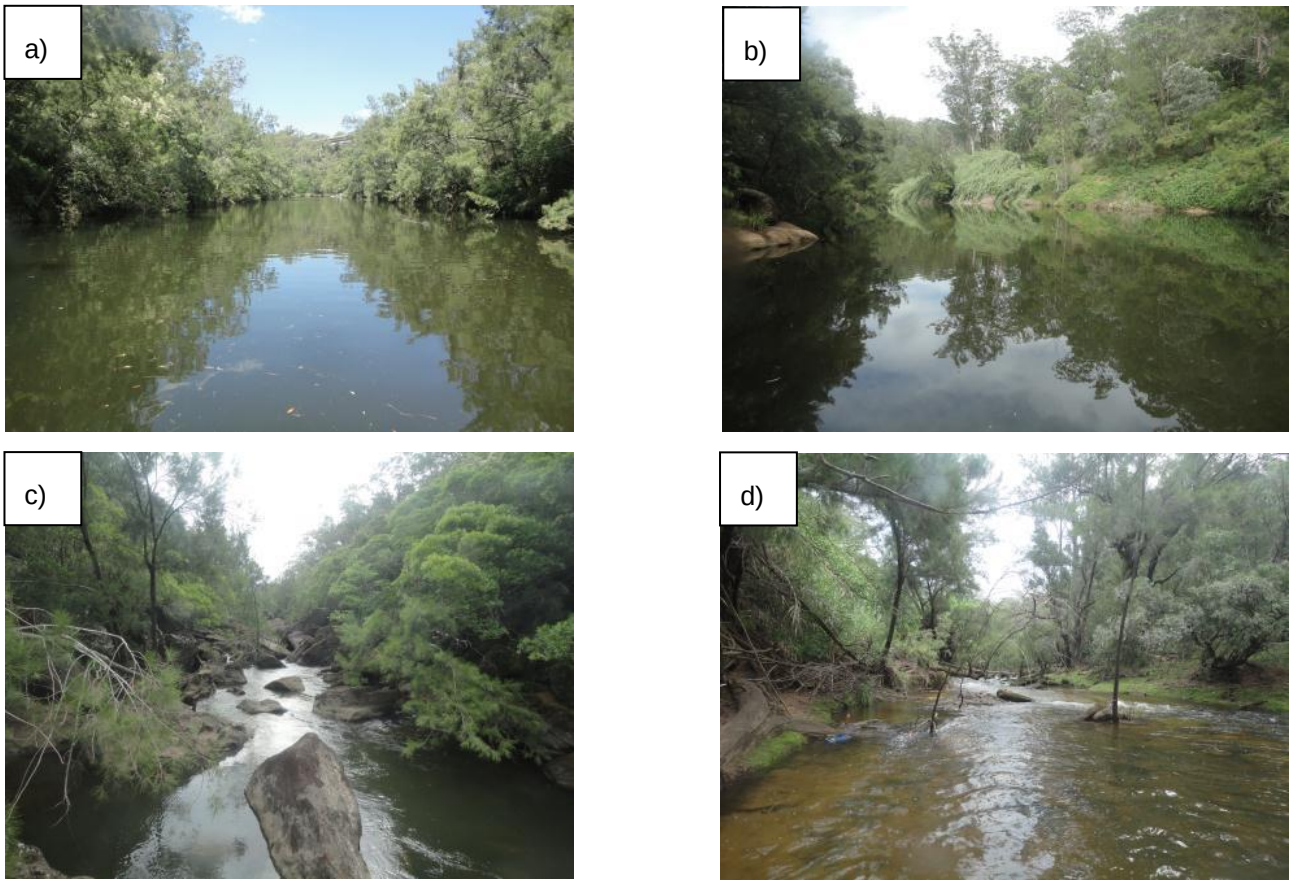

Plate 1 a) and b) wide channel and relatively deep and slow flowing water typical of Sites 1 to 8, X1 and X2, and c) and d) narrower and shallower channel typical of Sites X3 to X8 on the Nepean River.

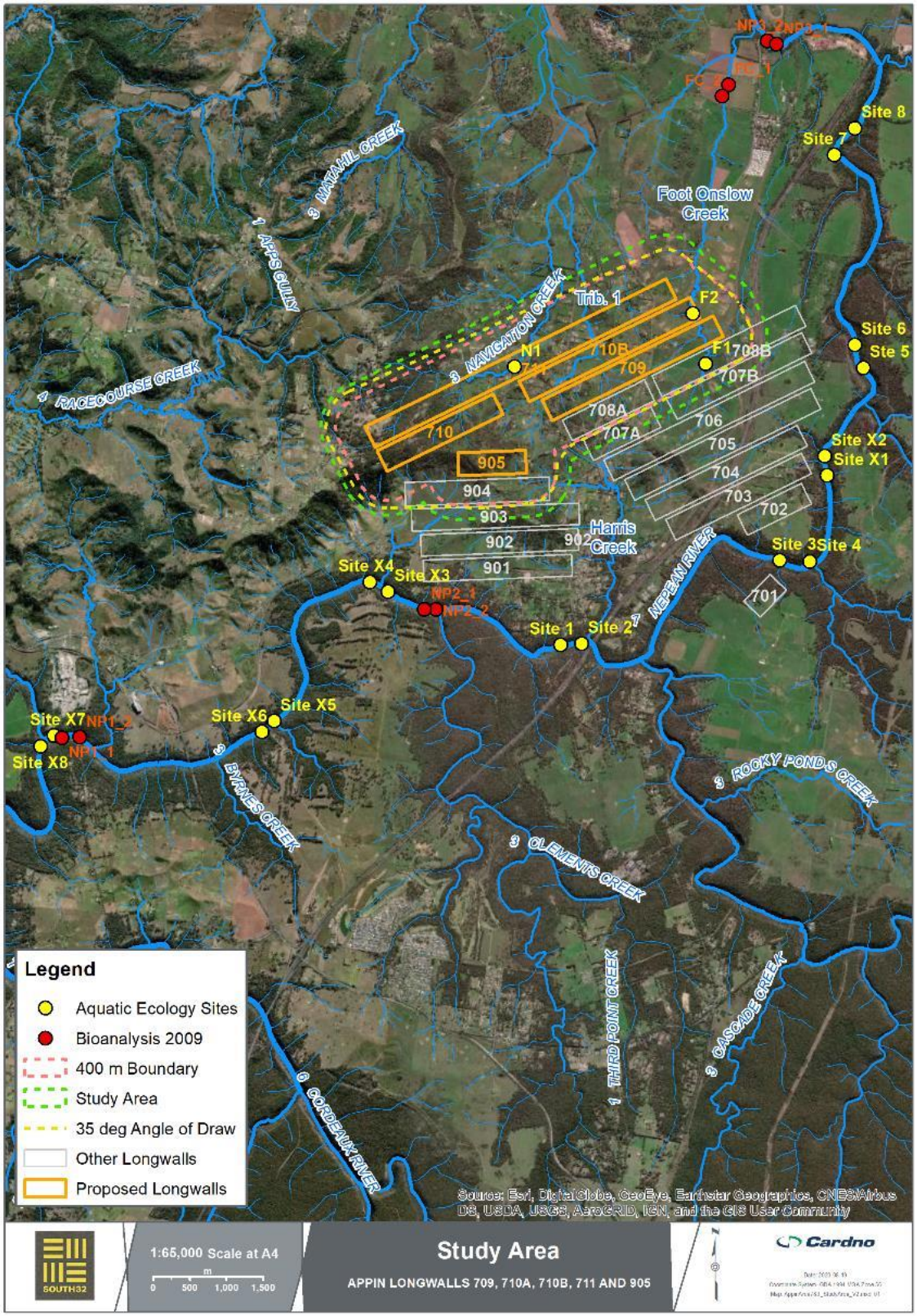

Figure 3-1 Aerial image overlaid with longwall layouts, watercourses and aquatic ecology sites within and adjacent to the Longwall 709, 710A, 710B, 711 and 905 Study Area (600 m boundary). The 400 m boundary is presented to provide context for the subsidence predictions (Fracturing has been observed up to approximately 400 m outside of previously extracted longwalls in the Southern Coalfield (MSEC 2020)).

The lower section includes the 1 m high causeway at Douglas Park. The channel above and below this causeway consists of a continuous pool, approximately 50 m wide and 3.5 m deep, with no observable flow except during flood events. The riverbanks support a mixture of native and exotic trees and shrubs, including Casuarina, Eucalyptus and Lantana. There are extensive beds of submerged macrophytes in the shallower river edges and large wood debris and boulders along the channel edge. The riverbanks generally support a combination of native and exotic trees, shrubs and grasses. Aquatic habitats include sand bars, overhanging banks, snags and some boulders. In the upper section, aquatic habitat comprises shallow pools interspersed by riffles over gravel and boulders. The riparian zone in the section upstream of the boulder field is continuous and dominated by native species. The substratum includes bedrock, boulders, gravel and sand.

Overall, aquatic habitat at these sites on the Nepean River are generally in good condition, although the AUSRIVAS modelling does not fully reflect this observation, indicating impaired habitat and / or water quality (**Section 0**). The relatively undisturbed riparian strip present would not be expected to result in any impaired aquatic habitat in this section of river and would help stabilise river banks and prevent erosion and sediment mobilisation. Furthermore, riparian vegetation is a source of in-stream woody debris, which provides important habitat for many species of aquatic fauna, including fish. It is also an important source of allochthonous material such as insects and leaves etc. The relatively dense patches of macrophytes observed at most sites would also fulfil many important ecological roles, including the provision of refuge and nursery habitat for aquatic fauna, serve as a source of food for macroinvertebrates and fish and assist in nutrient cycling.

There are no barriers to fish passage within the Nepean River adjacent to the Study Area (a fishway is present at the Douglas Park Causeway), however both Menangle Weirs would create significant barriers to upstream fish movement. There does not appear to be any livestock access to these sections of the Nepean River. There is no public access via the adjacent land, however recreational fishers, canoeists and other members of the public do access this area by boat from either Douglas Park Weir or Menangle Weir.

3.2.2 Drainage Lines

3.2.2.1 Navigation Creek

A 2.2 km third order section of Navigation Creek flows through cattle pasture within the Study Area, with 1.1 km of this located directly above Longwall 711 and 1.9 km within 400 m. This reach was classified as Class 2 (moderate - i.e. containing some small semi-permanent refuge pools which are unlikely to persist through prolonged drought **Appendix A**) aquatic habitat (The Ecology Lab 2008a) (**Plate 2a** to **c**). At the time of inspection (which followed recent rainfall) the pools at Site N1 (**Plate 2c**) were connective by shallow flow, though pool connectivity would not be expected to persist during dry periods.

Riparian vegetation was generally sparse with some patches of mature eucalypt and melaleuca trees. Exotic shrubs and grasses were common along the banks. Vegetation noted within the channel and associated the farm dams and included *Typha sp*., *Ludwigia sp*., *Ottelia sp*., *Cyperus sp*. and *Juncus sp*. Only *Ottelia sp.* would be considered an in-stream aquatic macrophyte. The substratum of the watercourse was dominated by soft silt and clay sediments, with some sections of shale bedrock, gravel and sand bars. Sections of the channel banks were eroded from cattle access (The Ecology Lab 2008a, Bioanalysis 2009).

One unnamed third-order tributary of Navigation Creek (Tributary 1) (**Plate 2d**) is located within the Study Area east of the main channel of Navigation Creek and west of Foot Onslow Creek. A 2.3 km section is located in the Study Area, with 1.6 km located directly above Longwalls 710B and 711 and 2.0 km within 400 m. This watercourse provided very little aquatic habitat, apart from several farm dams along or adjacent to the channel, and pools formed where road culverts have had a dam effect (The Ecology Lab 2008a). The watercourse provided minimal aquatic habitat (containing some small semi-permanent refuge pools which are unlikely to persist through prolonged drought). During visits by IMCEFT in August 2020, no flow and in-stream wood debris or large rocks were observed (**Plate 2e** and **f**).

The numerous first and second order drainage lines that flow to these watercourses were considered as Class 4 (unlikely) aquatic habitat (The Ecology Lab 2008a). It was noted that the introduced fish species, eastern gambusia (*Gambusia holbrooki*), was present in both of these watercourses at the Carrols Road and Finns Road Culverts, and is likely to be present the Navigation Creek catchment.

Plate 2 a) and b) Navigation Creek at road crossings and at c) Site N1 and d-f) Tributary 1 of Navigation Creek.

3.2.2.2 Foot Onlsow Creek

A 2.3 km section of Foot Onslow Creek is located in the Study Area, with 0.8 km of this located directly above Longwalls 709 and 710B and 1.2 km within 400 m. This section of the creek provides moderate aquatic habitat and contains a number of relatively large, deep pools that would be expected to persist through prolonged dry periods (The Ecology Lab 2008a) (**Plate 3a** to **d**). At the time of inspection, there was no flow connectivity and standing pools were separated by sections of dry creek bed. Riparian vegetation was sparse and consisted of some native eucalypt, tea tree and melaleuca trees. There were also numerous exotic tree, shrub and grass species amongst the riparian vegetation. No instream aquatic macrophytes

were present in the reach of the watercourse inspected. The substratum of the watercourse was primarily soft silt and clay, with some sand and gravel bars. The banks of the watercourse were heavily eroded likely due to removal of riparian vegetation and extensive stock access. The water was generally very turbid, with some surface scum present.

There are a number of first and second order drainage lines of Foot Onslow Creek within the SMP Area. These were all classed as minimal or unlikely aquatic habitat, contain no natural pools and are generally within cleared pasture. There is some highly modified, albeit artificial, aquatic habitat within the numerous farm dams along these watercourses.

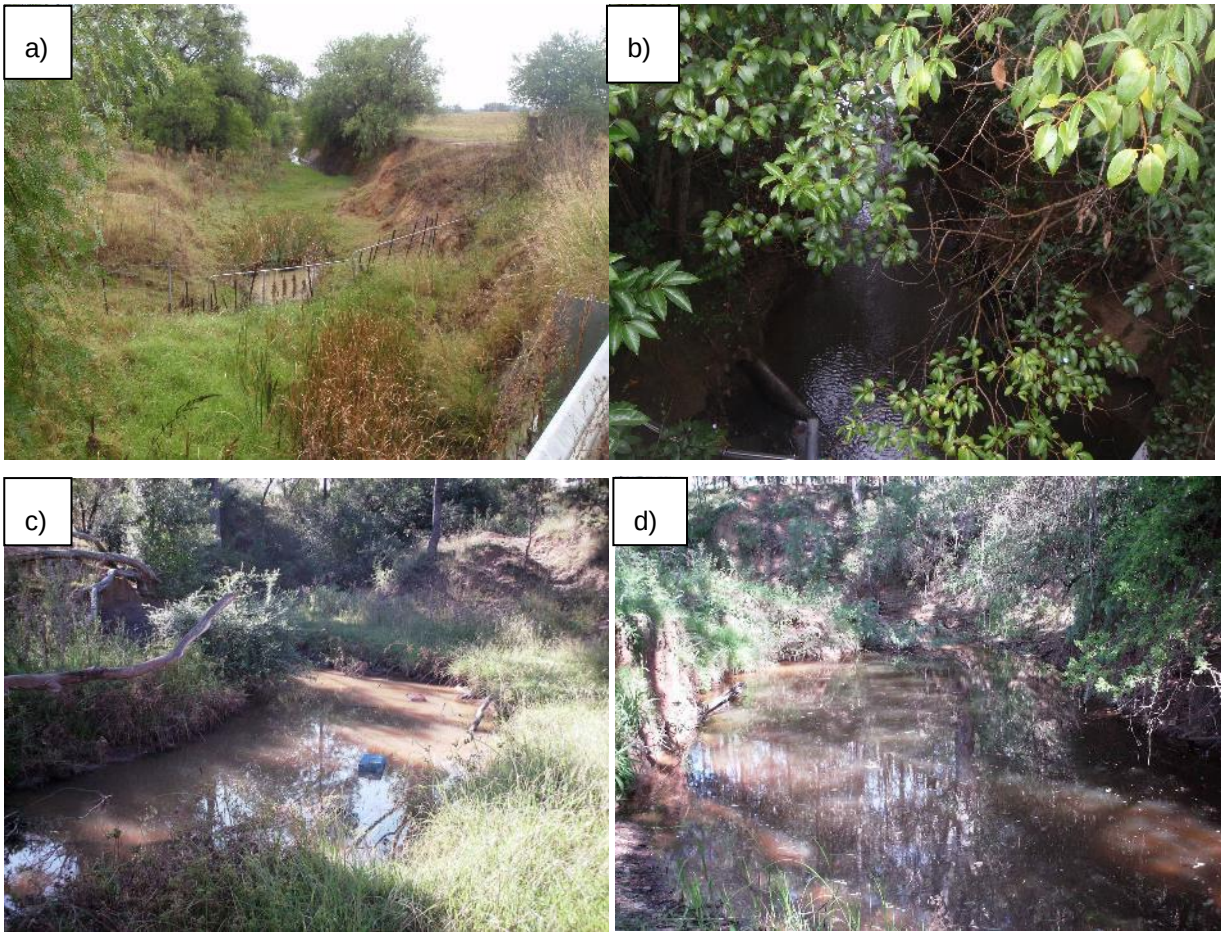

Plate 3 a) to d) Foot Onslow Creek.

3.2.2.3 Harris Creek

A 150 m section of Harris Creek is located in the Study Area, though none is located directly above the longwalls or within 400 m. The downstream section of this creek was visited at the Mountbatten Road crossing by The Ecology Lab (2008a). There were a few scattered permanent pools providing habitat in these lower sections, and there was some flow connectivity at the time of inspection, however it is expected that connectivity would not be maintained during extended dry periods. The upper section flows through pasture, forming a gully with limited aquatic habitat. Stock had access to these upper reaches and there was extensive stock induced erosion of the banks and channel. Several farm dams are scattered along the channel interrupting downstream flow. The section of Harris Creek within the Study Area provided unlikely (i.e. Ephemeral drainage lines that only contain flow during and immediately after significant rainfall – **Appendix A**).

3.3 Key Fish Habitat

The broad scale KFH map for Wollondilly available on the NSW DPI website indicates that the Nepean River is KFH (NSW DPI 2020). The first, second and third order drainage lines that traverse the Study Area are not identified as KFH by this map. The third order sections of Foot Onslow Creek, Tributary 1 and Harris Creek within the Study Area have been identified as Type 2 – Moderately Sensitive KFH (**Figure 3-2**), as large rocks, wood debris and aquatic plants have not been identified within the channel. As a conservative

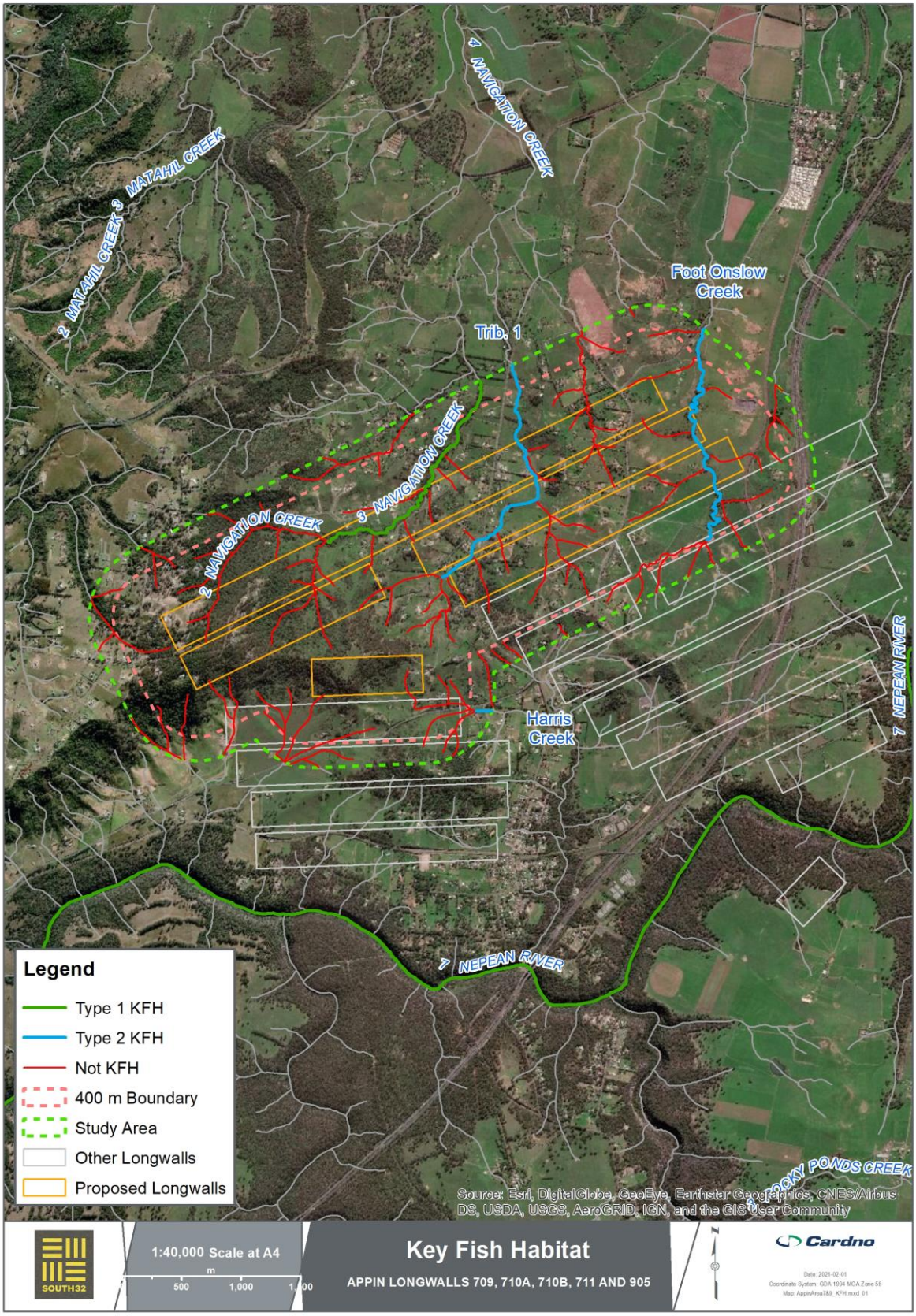

Figure 3-2 Key fish habitat in watercourses within the Study Area an in the Nepean River adjacent to the Study Area

measure, Navigation Creek within the Study Area has been identified as Type 1 – Highly Sensitive KFH. This is due to the previous identification of an instream aquatic plant in the section within the Study Area (**Section 3.2.2**). However, it is noted that this watercourse provides relatively limited aquatic habitat for native fish due to its degraded condition from land clearance and cattle access. The aquatic habitat that is present consists primarily of a series of disconnected pools, except during and following rainfall. The Nepean River provides Type 1 – Highly sensitive KFH, and contains substantial areas of aquatic plants, large rocks and large wood debris. First and second order streams, including the first and second order drainage lines within the Study Area are not KFH (NSW DPI 2013a) (**Figure 3-2**).

3.4 Water Quality

Water input to Nepean River is contributed from a number of environmental and industrial sources: including rainfall within catchment areas, licensed discharges from collieries, sewage treatment plants, agricultural and industrial sites and stormwater runoff from urban areas. Consequently, its chemistry is highly variable (Geoterra 2005). The surface water quality indicators measured by Cardno have been largely within, or very slightly outside, guidelines for the protection of aquatic ecosystems (Cardno 2019). Deeper samples taken near the river bed have shown that DO at the river bed to be, on occasions, below the lower DTV. Turbidity was also often below the lower DTV, but values marginally outside of DTVs are unlikely to be cause for concern for aquatic ecology. The low levels of DO measured in the current study (and previously) are indicative of stratification of the water column with hypoxic water at the bottom and oxygenated water at the surface. Stratification can occur naturally in summer due to limited vertical mixing between the warm upper water layer and colder, denser layer(s) below. It can also occur due to inflow of saline water. Stratification could lead to impacts on aquatic systems, particularly if the water column mixes dramatically, possibly in a flood event. It can be deleterious to biota due to anoxia, or toxicity from contaminants liberated from bottom sediments during periods of reduced pH. Gas releases could also result in reductions in DO due to microbial consumption of dissolved methane (Ecoengineers 2009).

There is some evidence of variable water quality in drainage lines. EC on Foot Onslow Creek range from between 1,781 µS/cm to 2,446 µS/cm in April 2008 (The Ecology Lab 2008a) to between 188 µS/cm and 192 in March 2008 (Bioanalysis 2009), with measures in April 2008 above the upper ANZECC (2000) Default Trigger Value (DTV). During April 2008, turbidity ranged from 7.8 to 60.2 ntu and from 8.0 to 25.9 in March 2008. DO ranged between 74.3 % and 84.7 % in April 2008 and between 71 % and 100 % in March 2008. pH has ranged between 8.3 in April 2008 and 5.5 in March 2008. EC (1,946 µS/cm) and turbidity (21 ntu) were also elevated in Navigation Creek in April 2008 and DO (58 % saturation) was below the lower DTV (The Ecology Lab 2008a).

Ferruginous springs have been observed in watercourses when mining areas of the Bulli Seam (SLR 2021a). These occur occasionally following subsidence induced fracturing and increased permeability between Hawkesbury Sandstone and the Wianamatta Shale. Winamatta Shale, being marine sediment, contains traces of connate water with an elevated salt and cation load. Weakly acidic infiltrating water liberates cations resulting in increased EC. The shale also contains a high concentration of iron (Fe) and manganese (Mn) oxides which can undergo microbiologically-mediated reductive dissolution resulting in an orange precipitate in the water. Streams that are acidic and have low alkalinity are more likely to be impacted as they have less buffering capacity against changes to pH.

3.5 Macrophytes

A number of aquatic macrophytes are present within the Nepean River. These were surveyed most recently in November 2019 as part of the ongoing monitoring in Appin Areas 7 & 9 (Cardno 2019). They generally grow on the shallower riverbed reaches (confined to a maximum river depth of about 3.5 m) where soft sediment is present. In 2019, tenspecies of aquatic macrophytes were recorded across the six sites sampled for Area 7 (Sites 1, 2 and 5 to 8) and Area 9 (Sites X3 to X8) (**Table 3-1**).

Floating pondweed (*Potamogeton tricarinatus*), ribbonweed (*Vallisneria* sp.) (**Plate 4a** and **b**), hydrilla (*Hydrilla verticillata*) and elodea (*Elodea canadensisi*) (**Plate 4c** and **d**) were the most common species occurring at most (at least 4 of 6) sites visited. The species composition at each Appin Area 7 monitoring site was identical to that observed in the most recent previous survey in 2018. The exception was the presence of tall spikerush (*Eleocharis sphacelata*) (**Plate 4c** and **d**)) at Site 8 where it was not observed previously and clasped pondweed (*Potamogeton perfoliatus*), which was observed in 2016 (Cardno 2017).

Five species were identified at Appin Area 9 sites in 2019. These were hydrilla, curly pondweed, floating pondweed, alligator weed, and watercress (*Rorippa nasturtium-aquaticum*). All have been identified previously at these sites and all except watercress have been identified at Appin Area 7 sites. The species composition at Appin Area 9 sites in 2019 was very similar to that in the most recent previous survey in

Appin Area 9 in 2017 (Cardno 2018). The only difference was the absence of watercress from Site X8 where it was present in 2017.

It appears that the extent and species composition of aquatic macrophytes at these sites is highly dependent on flow variability, with high flows scouring away river sediments, and thus associated plants, and providing new areas for colonisation following high flows (Cardno 2019). This appears to be the explanation for the apparent reduction in the extent of ribbonweed observed at Sites 7 and 8 in November 2016 compared with previous surveys. Since this time, including in November 2019, the extent of ribbonweed and tall spikerush has increased as these plants have colonised nearby areas of unvegetated sediment exposed following high flows.

Surveys of aquatic macrophytes by Bioanalysis (2009) did not identify any native in-stream aquatic plants on Foot Onslow Creek. Five species (*Elodea canadensis*, *Hydrilla verticillate*, *Vallisneria Americana, Potamogeton sulcatus* and *Triglochin procerum*) of in-stream aquatic plants were identified across the six sites sampled by Bioanalysis (2009) on the Nepean River. The first four have been identified at one or more sites on the Nepean River by Cardno (it is possible that *Valisneria* sp. was *V. Americana*). The latter two species identified by Bioanalysis (2009) are additional species. *T. procerum* was identified downstream of Site 8 at NP1_1 and NP1_2 and *P. sulcatus* between X3 and Site 1.

Table 3-1 Species of aquatic macropytes observed in the Nepean River in November 2019

Common Name	Scientific Name	1	2	5	6	7	8	X3	X4	X5	X6	X7	X8
Hydrilla	*Hydrilla verticulata*	x	x	x	x	x	x	x	x				
Curly pondweed	*Potamogeton crispus*	x	x										x
Floating pondweed	*Potamogeton tricarinatus*	x	x	x		x	x	x	x	x			
Blunt pondweed	*Potamogeton ochreatus*	x	x		x								
Elodea	*Elodea canadensis*	x	x	x	x	x	x						
Ribbonweed	*Vallisneria* sp.			x	x	x	x						
Alligator weed	*Alternanthera philoxeroides*									x	x		
Cumbungi	*Typha* sp.					x	x						
Tall spikerush	*Eleocharis sphacelata*					x	x						
Watercress	*Rorippa nasturtium-aquaticum*									x	x		

Plate 4. Beds of ribbonweed (*Vallisneria* sp.) at a) Site 8 and b) Site 7, c) and d) hydrilla / elodea at Sites 7 and 8 and e) and f) ribbonweed and tall spikerush (*Eleocharis sphacelata*) at Sites 1 and 2.

3.6 Macroinvertebrates

Between September 2003 and November 2019, Cardno has undertaken 14 surveys of macroinvertebrates in the Nepean River in relation to Appin Areas 7 & 9, with a total of 112 AUSRIVAS edge samples collected across Sites 1 to 8 and X1 to X8 (though the individual sites sampled on each occasion varied with the staging of longwall extraction) (**Appendix B**).

In total, 97 taxa were identified from the 112 samples collected. The most common taxa (occurring in ≥ 90 % samples) were Hydracarina (water mites), Corixidae (water boatmen), Chironominae (non-biting midge) and Leptoceridae (caddisfly). Leptoceridae and Hydracarina are somewhat pollution sensitive (SIGNAL2 grade 6) and Corixidae and Chironominae are pollution tolerant (SIGNAL2 grade 2 or 3). Of the 87 taxa assigned a SIGNAL2 grade, 68 were very to moderately pollution tolerant (SIGNAL2 grade 1 to 5). Fifteen pollution sensitive taxa (SIGNAL2 grade 7 and above) were also sampled. These included Telephlebiidae and Corduliidae (families of dragonfly), Leptophlebiidae (a family of mayfly), Galamoceratidae (a family of caddisfly), Gripopterygiidae (a family of stonefly) and Elmidae (riffle beetles). Telephlebiidae, Leptophlebiidae, Galamoceratidae and Elmidae occurred in over a third of all samples collected, whilst Corduliidae, Synlestiddae and Gripopterygiidae occurred once only.

During September 2003 to 2019 on the Nepean River, the number of taxa per sample has ranged from 13 to 34 (**Appendix B**), the OE50 Taxa Score has ranged from 0.47 (Band C - severely impaired relative to reference condition) to 1.20 (Band A - equivalent to reference condition) (**Appendix B**) and the SIGNAL2 Score ranged from 3.0 (indicative of severe water pollution) to 4.7 (indicative of moderate water pollution) (**Appendix B**). The mean number of taxa per site was relatively comparable among sites, though there was a slight trend for fewer taxa at upstream sites X3 to X8 compared with most sites farther downstream (**Figure 3-3**). This likely reflects the variable habitat conditions between these sections of the Nepean River. There was also relatively little difference in mean OE50 Taxa Scores (**Figure 3-4**) and SIGNAL2 Scores (**Figure 3-5**) among sites on the Nepean River.

The aquatic macroinvertebrate fauna in this section of the Nepean River appears to have experienced some degree of environmental stress prior to, and hence independent of, mining, and continues to do so. This is evident throughout the 2003 to 2019 monitoring period, with AUSRIVAS Band Scores generally being indicative of impaired macroinvertebrate assemblages (i.e. AUSRIVAS Band B) and SIGNAL2 Indices, indicative of moderate to severe water pollution. There is no evidence that any impaired aquatic habitat or water quality is due to any previous mining related disturbance in the Nepean River. Despite this, several pollution sensitive taxa have been identified, and, on occasion, AUSRIVAS Bands were equivalent to the AUSRIVAS reference condition (i.e. B and A) and hence have been, at times, indicative of undisturbed macroinvertebrate assemblages. Due to the relatively undisturbed condition of the riparian vegetation, it is probable that poor water quality, such as low DO, and alteration to the natural flow regime of the river, may explain the somewhat depauperate condition of the macroinvertebrate fauna in this section of the river. It is possible, if not likely, that the macroinvertebrate assemblage in the deeper hypoxic sections of the river is depauperate also. Site N1 on Navigation Creek was surveyed using AUSRIVAS in April 2008 (The Ecology Lab 2008a) and Sites F1 and F2 on Foot Onlsow Creek were surveyed using AUSRIVAS in April 2008 (The Ecology Lab 008a) and November 2008 (The Ecology Lab 2008b). The number of taxa (26 at Navigation Creek and 15 to 23 on Foot Onslow Creek) and SIGNAL2 Score (3.4 to 4.1 on Foot Onslow Creek, this index was not calculated for N1) were largely comparable to those on the Nepean River, with SIGNAL2 Scores indicating severe to moderate water pollution. The OE50 Taxa Score at N1 on April 2008 was 0.65, indicating significant impairment of the macroinvertebrate assemblage. The OE50 taxa score on Foot Onslow Creek ranged from 0.66 (significantly impaired) to 1.20 (more diverse than reference condition), with the latter score greater than any from the Nepean River.

AUSRIVAs surveys undertaken by Bioanalysis (2009) at the six sites on the Nepean River indicated an OE50 Taxa Score of 0.22 (Band C) to 0.76 (Band B). The OE50 Taxa Score at the two sites on Foot Onslow Creek were 0.20 (Band C) and 0.51 (Band C). These are largely comparable to those measured by Cardno.

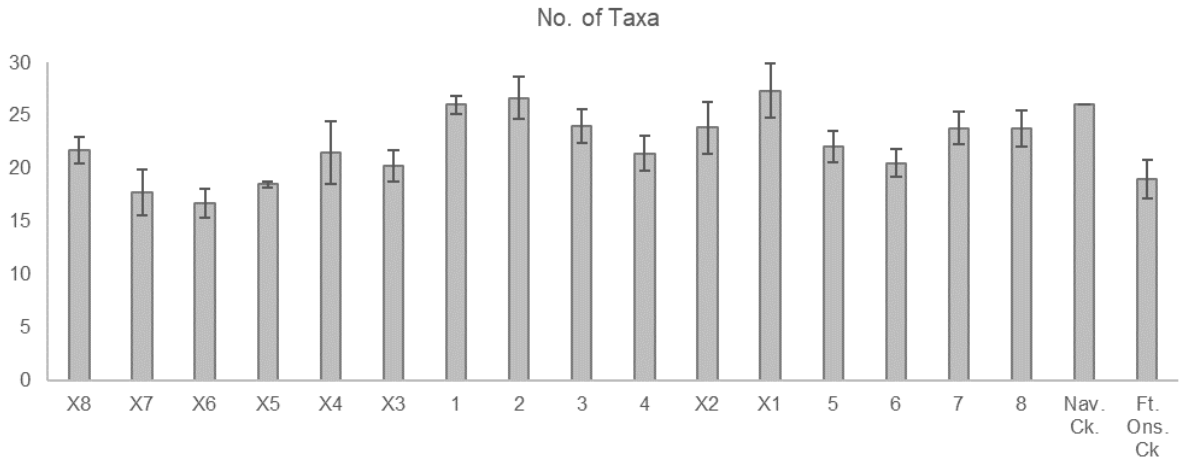

Figure 3-3 Mean (averaged across all surveys from September 2003 to November 2019 - **Appendix B**) number of taxa at each site on the Nepean River arranged from X8 upstream to Site 8 downstream and on N1 on Navigation Creek (Nav. Ck.) and F1 and F2 on Foot Onslow Creek (F1 and F2).

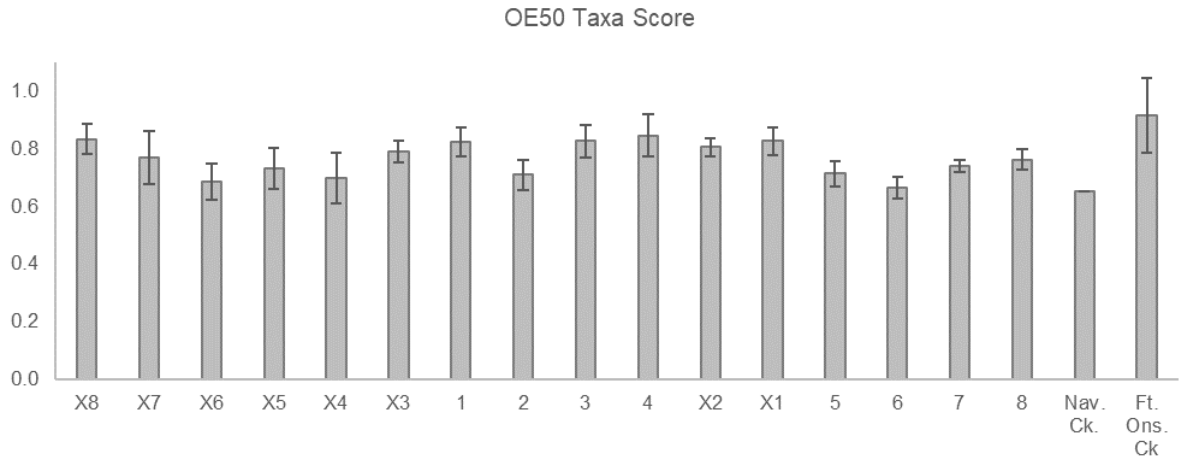

Figure 3-4 Mean (averaged across all surveys from September 2003 to November 2019 - **Appendix B**) OE50 Taxa Score at each site on the Nepean River arranged from X8 upstream to Site 8 downstream and on N1 on Navigation Creek (Nav. Ck.) and F1 and F2 on Foot Onslow Creek (F1 and F2).

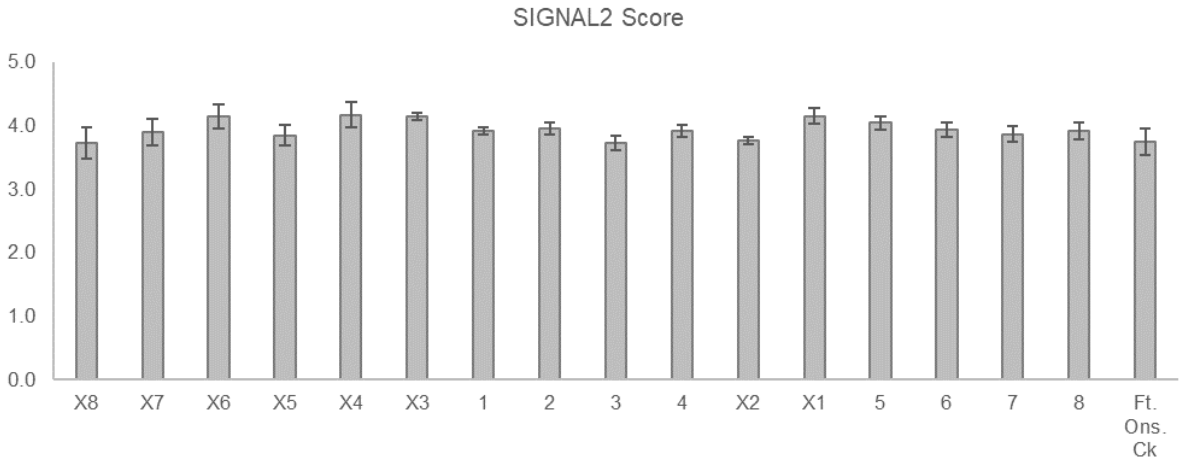

Figure 3-5 Mean (averaged across all surveys from September 2003 to November 2019 - **Appendix B**) SIGNAL2 Score at each site on the Nepean River arranged from X8 upstream to Site 8 downstream and on N1 on Navigation Creek (Nav. Ck.) and F1 and F2 on Foot Onslow Creek (F1 and F2).

3.7 Fish

The regulated flows from the three dams in the upper reaches of the Nepean River system and the 13 weirs that have been constructed along the main channel of the river are likely to have had a major impact on the fish fauna (Baumgartner and Reynoldson 2007). These weirs are substantial barriers to the passage of fish and have probably resulted in fragmentation of populations, reduced opportunities for genetic exchange and prevented the larvae of species that migrate to the estuary/sea to spawn from making recolonising migrations (Gehrke *et al*. 2000). The recent installation of vertical slot fishways at the barriers along the river from Penrith Weir up to Douglas Park weir will enable some species to increase their upstream distribution (Rourke and Baumgartner 2011).

The current Study Area is situated adjacent to the 12 km section of the Nepean River between Douglas Park Weir and Maldon Weir and is therefore likely to show an increase in fish diversity now that species in a large section of the downstream reach of the river are now able to move upstream via the fishways. The movement of fish into the Study Area from the upper reaches of the Nepean River is restricted by the 15 m high x 40 m wide fixed crest weir at Maldon, which restricts fish passage during all flow conditions due to excessive head loss and by Pheasants Nest Weir (Mallen-Cooper and Smit 2005; NSW DPI 2006a). Maldon Weir is the upstream limit of migration for Australian bass and other species that require estuarine areas to spawn (Sammut and Erskine 1995).

Seven species of fish have been caught using bait traps at Sites 1 to 8, X1 and X2 (those relevant to Appin Area 7 longwalls surveyed from 2003 to 2019) (**Table 3-2**) and eight species using backpack electrofishing at Sites 1, 2 and X3 to X8 (those relevant to Appin Area 9 surveyed from 2014 to 2019) (**Table 3-3**) on the Nepean River by Cardno (Cardno 2019) (10 species total overall). Ornamental carp (*Cyprinus carpio*) have also been observed in the Nepean River by Cardno, but not caught.

Most recently in 2019, five species were caught, including native juvenile and adult Coxs gudgeon (*Gobiomorphus coxii*), flathead gudgeon (*Philypnodon grandiceps*), dwarf flathead gudgeon and carp gudgeon *(Hypseleotris* sp.). The non-native eastern gambusia (*Gambusia holbrooki*) was caught also. The species composition of fish sampled in 2019 was comparable to that sampled previously. Australian bass (*Macquaria novemaculeata*), which was sampled at Site X8 in 2014 (Cardno Ecology Lab 2015), has not been caught since. Though it is noted that accumulations of debris following the high flows that occurred prior to the 2017 survey have limited access to where Australian bass were caught previously, just downstream of Maldon Weir. Fewer Coxs gudgeon were sampled in 2017 than in 2014, but this was apparent across all sites. Australian smelt (*Retropinna semoni*) and longfinned eel (*Anguilla reinhardtii*) were caught in previous surveys in 2014, 2015 and 2017. They tended to be caught in relatively low abundance and at a few sites, and there is no suggestion their occurrence or abundance has been affected by mining. No fish have been caught in any of the bait traps deployed at Appin Area 9 Sites X3 to X8 during any survey. Glass shrimp and freshwater prawns also occur in this section of the Nepean River (Cardno Ecology Lab 2011).

Table 3-2 Fish species caught by bait trapping in the Nepean River during the aquatic ecology monitoring undertaken for the Appin Area 7 Longwalls from September 2003 to November 2019. Note the number of sites sampled per survey varied, for more detail see Cardno (2019).

Scientific Name	Common Name	Sep 03	Apr 08	Nov 08	Dec 10	Dec 11	Dec 12	Dec 13	Dec 14	Nov 15	Nov 16	Nov 17	Nov 18	Nov 19
Philypnodon grandiceps	Flathead gudgeon	x	x	x	x	x	x	x	x	x	x	x	x	x
Hypseleotris sp.	Carp gudgeon	x	x	x	x	x	x	x	x	x	x	x	x	x
Philypnodon macrostomus	Dwarf flathead gudgeon	x		x	x	x	x	x				x		x
Gambusia holbrooki	Eastern gambusia		x		x			x	x			x	x	x
Retropinna semoni	Australian smelt		x		x	x	x	x				x		
Tandanus	Freshwater catfish					x	x							
Hypseleotris compressa	Empire gudgeon			x										

Table 3-3 Fish species caught by backpack electrofishing in the Nepean River during the aquatic ecology monitoring undertaken for the Appin Area 9 Longwalls in December 2014 and November of 2015, 2017 and 2019.

Scientific Name	Common Name	Dec 14	Nov 15	Nov 17	Nov 19
Philypnodon grandiceps	Flathead gudgeon	x	x	x	x
Macquaria novemaculeata	Australian bass	x			
Anguilla reinhardtii	Longfinned eel	x	x	x	
Retropinna semoni	Australian smelt	x	x	x	
Gobiomorphus coxii	Coxs gudgeon	x	x	x	x
Gambusia holbrooki	Eastern gambusia	x		x	x
Philypnodon macrostomus	Dwarf flathead gudgeon			x	x
Hypseleotris sp.	Carp gudgeon	x		x	x

Fish surveys were also undertaken in April 2008 at N1 on Navigation Creek and two its tributaries (including Tributary 1) and in Foot Onslow Creek by The Ecology Lab (2008a). No fish were caught using backpack electrofishing in Navigation Creek or its tributaries, though several hundred eastern gambusia were caught in AUSRIVAS dip nets. Yabby (*Cherax destructor*) were caught using backpack electrofishing and bait traps at sites.

Bioanalysis (2009) sampled eight species of fish (Longfinned eel, striped gudgeon (*Gobiomorphus australis*), eastern gambusia, Australian smelt, flathead gudgeon, Australian bass, dwarf flathead gudgeon and freshwater catfish), across the 6 sites on the Nepean River using backpack electrofishing and two species (Australian smelt, flathead gudgeon using bait traps. All of these, except striped gudgeon, one individual which was caught at NP1_1, has been caught on the Nepean River by Cardno previously.

It should be noted that the surveys undertaken adjacent to Appin Areas 7 & 9 were based on a combination of back-pack electrofishing, baited traps and dip netting and were consequently limited to relatively shallow (< 1m) areas. Goldfish (*Carrasius auratus*) and carp (*Cyprinus carpio*), as well as Cox's gudgeon, longfinned eel, freshwater eel, flathead gudgeon, and firetail gudgeon and Australian bass, were recorded during a boat-based electrofishing survey of the sections of the river upstream of the Douglas Park and Menangle weirs (Baumgartner and Reynoldson 2007). Several species of fish, including striped gudgeon, bully mullet, freshwater mullet, bullrout and freshwater herring that have been recorded further downstream in the section of the Nepean River upstream of Penrith Weir (Baumgartner and Reynoldson (2007) could potentially colonise the Study Area now that fishways have been installed on the intervening weirs. There is evidence that some species have already increased their distribution in the Nepean River (Rourke and Baumgartner 2011).

3.8 Listed Threatened Species, Populations and Ecological Communities

3.8.1 Information Sources

A search for information on records and distributions of threatened species, populations and ecological communities listed under the FM Act, EPBC Act and BC Act in the Nepean River catchment within the Study Area was undertaken to update searches completed for previous assessments for Appin Areas 7 & 9 (The Ecology Lab 2008a; Cardno Ecology Lab 2011). The search used the following resources:

- The Department of the Environment and Energy (DEE) Protected Matters Search Tool (DEE 2020) was used to determine whether any Matters of National Environmental Significance (MNES) listed under schedules of the EPBC Act occurred in a 10 km radius from the centre of the Study Area;
- The DPIE managed BioNet searched for records of BC Act listed flora and fauna within the Hawkesbury-Nepean Catchment held in the Atlas of NSW Wildlife. The Atlas of Living Australia (ALA 2020) was also searched for records of species of fish (including invertebrates and vertebrates) listed under the FM Ac; and
- Species distribution maps contained in the NSW DPI Fish Communities and Threatened Species Distributions of NSW (NSW DPI 2016a) were examined for the occurrence of threatened species listed under the FM Act in the Study Area and surrounding catchments.

The desktop search indicated several species that occur, or have potential to occur, in the Study Area. Amphibians, aquatic mammals and reptiles are being considered by other specialists and were excluded

from the search. None of the aquatic plants listed under the BC Act were identified in the Nepean Catchment. Species of threatened fish and invertebrates listed under the FM Act and / or EPBC Act with records in the Study Area or surrounding catchments are identified in **Sections 3.8.2** to **3.8.5**.

3.8.2 Macquarie Perch

Macquarie perch is listed as endangered under the EPBC Act and the FM Act. The records from the Australian Museum indicate that Macquarie perch were present in the upper Nepean River between 1894 and 1905. Recent records indicate that Macquarie perch occurs in the Nepean River upstream and downstream of Pheasant's Nest Weir (Baumgartner and Reynoldson 2007), including a 2005 record from the Cordeaux River at the confluence with the Nepean River. This structure is believed to block the downstream passage of this species (Gehrke *et al*. 1996). The presence of this weir and another significant barrier to fish passage further downstream at Maldon Weir, and absence of any recent records from the downstream reaches of the Nepean River and its tributaries as far as Glenbrook Creek near Glenbrook (in 2012) (ALA 2020) suggests that it is highly unlikely that the Nepean River adjacent to the Study Area supports a population of Macquarie perch. This section of the Nepean River from around Site 5 upstream to Buxton (upstream of X8) is mapped as providing suitable habitat for Macquarie perch (NSW DPI 2016a).

Macquarie perch prefer clear water and deep, rocky holes with extensive cover in the form of aquatic vegetation, large boulders, debris and overhanging banks (NSW DPI 2016b). They spawn in spring or summer and lay their eggs over stones and gravel in shallow, fast-flowing upland streams or flowing parts of rivers. Macquarie perch is an active predator of macroinvertebrates. While other large-bodied percichthyids are generally higher-order ambush predators that may have limited range, the Macquarie perch tends to have a relatively larger linear (along shore) diel range (Ebner *et al*. 2010). A study in a Canberra reservoir found that Macquarie perch have a mean linear diel range of 516 m (± 89 S.E.) which suggests that discontinuous and small pools would not provide suitable habitat for this species (Ebner *et al*. 2010).

The National Recovery Plan for Macquarie perch has recently been released (DEE 2018). This contains background information on the biology, ecology, distribution and populations, decline and threats and recovery objectives and strategies and associated actions for this species. Identified threats include:

- Habitat degradation;
- Alien (non-native) fish;
- Barriers to fish movement;
- Altered flow and thermal regimes;
- Disease;
- Illegal / incidental capture;
- Chemical water pollution; and
- Climate change.

Recovery Strategies are:

- Conserve existing Macquarie perch populations;
- Protect and restore Macquarie perch habitat;
- Investigate threats to Macquarie perch populations and habitats;
- Establish additional Macquarie perch populations;
- Improve understanding of the biology and ecology of the Macquarie perch and its distribution and abundance; and
- Increase participation by community groups in Macquarie perch conservation.

Actions directly applicable to the Project include the provision of advice on the distribution of Macquarie perch to determining authorities to ensure appropriate consideration during development assessment processes, and the undertaking of targeted surveys to determine the current distribution and abundance of Macquarie perch.

3.8.3 Australian Grayling

Australian grayling is listed as a vulnerable species under the EPBC Act and is a protected species under the FM Act. It occurs in coastal streams and rivers on the eastern and southern flanks of the Great Dividing Range from Sydney southwards to the Otway Ranges in Victoria, and Tasmania (NSW DPI 2006). Australian grayling has been recorded in the Grose River, but there are no records of this species from the upper Nepean Catchment. They have also been recorded in estuarine areas. The life cycle of

Australian grayling is dependent upon migration to and from the sea (McDowall 1996). Spawning occurs in late summer or autumn and larvae are swept downstream to the sea (NSW DPI 2006b). Juvenile fish return to freshwater when they are about six months old and remain in rivers and streams for the rest of their life. Australian Grayling has undergone a considerable decline in its distribution and abundance and, although it was historically present in the Hawkesbury-Nepean, it is now restricted to the coastal rivers of southern New South Wales (Morris *et al*. 2001; NSW DPI 2016a). The decline of this species has been attributed to dams, weirs and culverts preventing it from migrating to and from the sea and completing its life cycle. As Australian grayling is highly unlikely to occur within the Study Area, further consideration of this species is not considered necessary.

3.8.4 Sydney Hawk Dragonfly

The Sydney hawk dragonfly (*Austrocordulia leonardi*) is listed as endangered under the FM Act. It is extremely rare, having been collected in small numbers at only a few locations in a small area to the south of Sydney, between Audley and Picton (NSW FSC 2004). The species is also known from the Hawkesbury-Nepean, Georges River and Port Hacking drainages. It was discovered in 1968 from Woronora River and Kangaroo Creek, south of Sydney, and has subsequently been found in the Nepean River at Maldon Bridge (seven records from 1979 to 1980 in the vicinity of Sites X7 and X8) near Picton and further upstream at Nepean Dam (one record from 1979) (ALA 2020). Extensive sampling has failed to discover further specimens in other areas suggesting that it has a highly restricted distribution within the catchment of the Nepean River (NSW DPI 2007). This species has not been found in the AUSRIVAs samples collected by Cardno from any sites on the Nepean River nor was it caught by Bioanalysis (2009).

Most of the lifecycle of this species is spent as an aquatic larva, with adults living for only a few weeks. The larvae appear to have specific habitat requirements, being found under rocks in deep, cool, shady pools (NSW DPI 2007). Relative environmental stability appears to be an important habitat feature, with rapid variation in water level and flow rate likely to have a negative effect on the suitability of habitat for larvae.

No Recovery and Threat Abatement Plans exist for this species. Several conservation and recovery actions for Sydney hawk dragonfly are included in NSW DPI (2007):

- Allocate and manage environmental water through water sharing planning processes, to lessen the impacts of altered flows;
- Prevent sedimentation and poor water quality by using conservation farming and grazing practices, conserve and restore riparian (river bank) vegetation and use effective erosion and sediment control measures;
- Rehabilitate degraded habitats. Protect riparian vegetation and encourage the use of effective sediment control measures in catchments where the dragonfly may occur;
- Protect the few remaining sites with the potential to support the species, and address key threats such as habitat degradation and water quality decline;
- Conduct further research into the species' biology, ecology and distribution; and
- Implement the Protected, Threatened and Pest Species Sighting Program and report any sightings to NSW DPI.

3.8.5 Adams Emerald Dragonfly

Adams emerald dragonfly (*Archaeophya adamsi*) is listed as endangered under the FM Act. It is extremely rare, having been collected only in small numbers at a few locations in the greater Sydney region (NSW DPI 2013b). Specimens have been collected at five localities: Somersby Falls and Floods Creek in Brisbane Waters National Park near Gosford; Berowra Creek near Berowra and Hornsby; Bedford Creek in the Lower

Blue Mountains; and Hungry Way Creek in Wollemi National Park. There are no records for this species within the Study Area or the Cordeaux and Lake Avon catchments (ALA 2020). There are no records of Adam's emerald dragonfly occurring south of Sydney, despite active collecting in the Hawkesbury-Nepean River catchment (NSW FSC 2008). This species was not collected by Cardno nor was it caught by Bioanalysis (2009), but aquatic habitat that appears suitable for this species does occur in the upper section of the Nepean River from around X8 to X3. The larvae of Adam's emerald dragonfly have been found in narrow, shaded riffle zones with moss and abundant riparian vegetation (often closed canopy) in small to moderate sized creeks with gravel or sandy bottoms (NSW DPI 2013b). The larvae live for approximately seven years before metamorphosing into adults that probably live for only a few months. They are thought to have a low natural rate of recruitment and limited dispersal abilities.

No Recovery and Threat Abatement Plans exist for this species. Conservation and recovery actions (NSW DPI 2007) for Adams emerald dragonfly are:

- Rehabilitate degraded habitats. Protect riparian vegetation and encourage the use of effective erosion and sediment control measures in catchments where the dragonfly may occur;
- Protect the few remaining sites that still support the species, and address key threats such as habitat degradation and water quality decline from expanding development;
- Conduct further research into the biology and distribution of the species; and
- Report any sightings to NSW DPI.

3.8.6 Likelihood of Occurrence

Table 3-4 assesses the likelihood of occurrence of Listed Threatened Species in the Study Area. Although there are records of Macquarie perch and Sydney hawk dragonfly in the Nepean River adjacent to the Study Area, there are none from drainage lines within the Study Area. This is not unexpected given the unsuitable habitat provided by these drainage lines. There are no records of Adams emerald dragonfly within or adjacent to the Study Area and Australian grayling occurs only in coastal rivers of southern NSW outside of the Study Area. As such, and given no significant mining impacts are expected in the Nepean River, formal Assessments of Significance were not considered necessary.

Table 3-4 Likelihood of Occurrence of FM Act and / or EPBC Act Listed Threatened Aquatic Species in the Study Area

Species and Listing	Likelihood of Occurrence
Macquarie perch (endangered under FM Act and EPBC Act)	Not expected to occur in the Study Area due to the limited aquatic habitat provided by ephemeral first, second and third order drainage lines present here. Occurs in the Nepean River upstream of Maldon Weir with recent records upstream and downstream of Pheasants Nest Weir (approximately 10 km upstream). Considered unlikely to occur in the Nepean River downstream of Maldon Weir and adjacent to the Study Area, though suitable habitat is mapped as occurring downstream of Maldon Weir to Site 5 (NSW DPI 2016a). However, as a precautionary measure, assessment of significance was undertaken for this species in accordance with the Threatened Species Assessment Guidelines (DECC 2007) and the Significant Impact Criteria for Endangered Species (EPBC Act) (**Appendix C**).
Adams emerald dragonfly (endangered under FM Act)	Not expected to occur in drainage lines within the Study Area. No records within, or adjacent to the Study Area despite extensive sampling, though suitable microhabitat appears to exist adjacent to the Study Area in the Nepean River.
Sydney hawk dragonfly (endangered under FM Act)	Not expected to occur in drainage lines in the Study The only records of this species are from 1979 and 1980 in the Nepean River upstream of the Study Area near Sites X7 and X8 and further upstream near Nepean Dam. Not caught in the AUSRIVAs samples collected from X7 and X8 (or from any other site on the Nepean River) by Cardno or from nearby by Bioanalysis (2009). However, as a precautionary measure, assessment of significance was undertaken for this species in accordance with the Threatened Species Assessment Guidelines (DECC 2007) (**Appendix C**).

Species and Listing	Likelihood of Occurrence
Australian grayling (endangered under FM Act and vulnerable under EPBC Act)	Does not occur in the Study Area. Present in coastal rivers of southern NSW outside of the Study Area.

3.9 Critical Habitat

The Study Area does not contain any critical habitats listed under the FM Act, BC Act or EPBC Act.

3.10 Observed Mining Impacts

There has been relatively limited evidence of subsidence related physical and water quality impacts in the Nepean River due to extraction of Appin Area 7 Longwalls 701 to 704 and 705 to 708 and of Appin Area 9 Longwalls 901 to 903. Surface monitoring undertaken during and following the extraction of Longwalls 701 to 704 identified several gas releases in the Nepean River adjacent to Sites 3 and 4 (impact sites for Longwalls 701 to 704) and X1 and X2 (impact sites for Longwalls 702 to 704). In total, approximately 50 gas release zones have been observed by IMCEFT during extraction in Appin Areas 7 & 9. No fracturing, changes in water levels and flow or changes in water quality were observed following extraction of these longwalls. Some minor iron staining following gas releases associated with Longwall 701 was observed (BHPBIC 2008a and b). There was no evidence that gas releases and iron staining, or any other potential mining impact, has had any adverse effects on aquatic habitat and biota. The changes in a biotic index of aquatic habitat and / or quality (OE50 Taxa Score) at one of the monitoring sites in 2011 more likely represented natural variation, rather than any potential impact due to mining (Cardno Ecology Lab 2012a). While marked changes in the distribution, extent and composition of macrophyte beds have been observed after the commencement of extraction, similar changes were apparent before extraction (Cardno Ecology Lab 2011a). Changes in macrophytes were attributed to localised differences in the depth of the water column, aspect of the site relative to the sun, suitability of the substratum for attachment, shading effects from vegetation on the banks, water flow, water transparency and availability of nutrients rather than any effect due to mining.

Similarly, several gas releases were identified in the Nepean River during extraction of Longwalls 705 to 708A, though no fracturing, changes in water levels and flow or changes in water quality were observed during or following extraction (Cardno 2020 and references therein). No fracturing, ponding, flooding or desiccation was observed in the monitored tributaries of the Nepean River. No loss or diversions of flow or impacts to water quality were observed in the Nepean River during extraction of these longwalls. No changes to aquatic ecology indicators that could be associated with extraction of Longwalls 705, 706, 707A, 707B, 708A were identified (Cardno 2020). In November 2016, high flows that occurred in the river since the previous survey in 2015 appeared to have a substantial effect on the extent of aquatic macrophytes (Cardno 2017). Despite this, the species composition of macrophytes has been relatively consistent and the number and type of species identified in November 2016 were very similar to those identified previously. There were also no observed impacts to indicators of aquatic ecology (number of taxa and biotic indices derived from macroinvertebrate sampling, fish and macrophytes) monitored in November 2017, November 2018 that could be attributed to extraction of these longwalls (Cardno 2018a, 2019 and 2020).

In Appin Area 9, approximately 30 gas release zones were identified in an approximate 2 km section of the Nepean River located just downstream of Impact Sites X3 and X4. No fracturing was observed in the Nepean River during extraction of Longwall 901, though the flooded valley and sediment profile limits observations of some sections of the river bed. There was also no observed ponding, flooding, changes in stream alignment or any surface water flow diversions. Monthly monitoring by South32 indicated a decline in pool water levels at site NR0 (on the Nepean River just west of Longwall 901 and adjacent to aquatic ecology monitoring sites X3 and X4) relative to baseline levels, however, due to the limited water level data the cause for these changes was uncertain (HGeo 2018). Changes in EC at some monitoring sites were identified, however, these were upstream of Longwall 901 and therefore not attributed to mining (HGeo 2018). Assessment of changes in water levels and water quality undertaken by HGeo (2019) for Longwall 902 indicted a 0.43 m reduction water level at Site NR0 (adjacent to aquatic ecology monitoring Site X3) below the baseline level that occurred throughout the reporting period of Longwalls 901 and 902. An increase in EC (greater than two standard deviations for two consecutive months) was observed at Sites NR0 and SW3 (also known as NR1) (adjacent to Site X3), and NR2 (adjacent to Sites 1 and 2). A decrease in pH (between one and two standard deviations for two consecutive months) occurred at Sites NR0 and NR1 during the reporting period. Water quality triggers associated with these changes occurred during May 2018 to March 2019. However, these changes appeared to be short-term and surface water quality in the Nepean River has since returned to baseline levels. Similar changes were also observed at upstream reference sites during this period. Changes in DO and the concentration of iron were not observed. A change

in concentration of magnesium was identified, however, it was not attributed to mining (HGeo 2019). There was a single water quality TARP level one trigger at site NR1 during extraction of Longwall 903. Similar changes were observed at the control site upstream on the Nepean River. There was no indication of any associated impacts to aquatic ecology during the November 2017 and November 2019 surveys undertaken as part of the monitoring for Appin Area 9 Longwalls (Cardno 2018 and 2020).

4 Impact Assessment

4.1 Subsidence Predictions

The extraction of coal from the proposed longwalls may result in vertical and horizontal movements of the rock and soil mass above the extracted coal seam. These ground movements, referred to as subsidence, may affect natural features on and below the land surface. Subsidence that occurs under watercourses may cause fracturing of the streambed and banks, movements of joint and bedding plates in the streambed, uplift and buckling of strata in the streambed. These physical impacts can cause diversions of surface and sub-surface flows, drainage of pools and increases in groundwater inflows. These changes, in turn, may have adverse effects on aquatic flora and fauna by resulting in loss of aquatic habitat, desiccation of fringing vegetation, reductions in longitudinal connectivity and deterioration of water quality. Ground movements can also lead to tilting of streambeds that can, in turn, lead to erosion of the streambed and banks and increased instream sediment load, changes in flow rates and migration of stream channels. Subsidence may also allow the release of gas from sub-surface strata that could reduce water quality and, in some cases, lead to dieback of riparian vegetation. Mining does not occur beneath the Nepean River, thus, fracturing and flow diversions are not expected.

The subsidence related physical impacts predicted to occur in watercourses in the Study Area and in the Nepean River by MSEC (2021) are summarised as follows:

- The Nepean River is located a minimum distance of 1.5 km from the longwalls. The Nepean River would experience vertical subsidence, upsidence and closure of less than 20 mm. It is considered unlikely, therefore, that the Nepean River would experience adverse physical impacts due to the mining-induced movements from Longwalls 709, 710A, 710B, 711 and 905. Further gas release zones could develop due to the mining of the proposed longwalls.
- There would be no reversals of stream grade in third order watercourses (Foot Onslow Creek, Harris Creek, Navigation Creek and Navigation Creek Tributary 1) or in first and second order watercourses due to the proposed mining. Large-scale adverse changes in the levels of ponding or scouring of the banks along the creeks and tributaries within the Study Area due to the mining induced tilt are, thus, unlikely. It is possible that localised increased ponding could develop in some locations, where the natural grades are small, and upstream of the chain pillars and the edges of the mining area. The potential impacts of increased ponding and scouring of the drainage lines are, therefore, expected to be minor and localised. Impacts resulting from changes in surface water flows due to mining-induced tilt are expected to be small in comparison with those which occur during natural flooding conditions.
- Fracturing of the uppermost bedrock could occur along watercourses that are located directly above or adjacent to the proposed longwalls (including Navigation Creek, Foot Onslow Creek and a small section of Harris Creek). Surface water flow diversions could occur in these watercourses. Fracturing can also occur outside the mining area, with minor and isolated fracturing occurring at distances up to approximately 400 m outside the 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. It is unlikely, however, that there would be a net loss of water from the catchment.

4.2 Impacts on Aquatic Habitat and Biota

4.2.1 Nepean River

No fracturing is predicted to occur in the Nepean River, thus there would be no reductions in the availability and connectivity of aquatic habitat. Longwall extraction is not anticipated to have any significant impacts on surface water quality as a result of mining the proposed longwalls (SLR 2021a). Mining of previous longwalls within Appin Area 7 and 9 has not led to induction of any detectable ferruginous springs in the walls of the Nepean River. It is therefore considered that there is a low likelihood of ferruginous springs induced by the mining of the proposed Longwalls 709 to 711 and 905 (SLR 2021a). It is possible that gas releases may result in localised changes in water quality, such as reductions in DO, though localised changes are not expected to result in significant impacts to aquatic biota. No impacts to aquatic biota have been observed in the Nepean River associated with gas releases observed during extraction of previous Appin Area 7 and 9 longwalls (Cardno 2020 and references therein). Similarly, no impacts to aquatic habitat and biota have been observed associated with the relatively minor changes in water levels and water quality that occurred during extraction of Appin Area 9 Longwalls 901 and 902 (**Section 3.10**).

Longwall extraction is not predicted to reduce baseflow contributions in surface water as there is no predicted drawdown within the surface strata (SLR 2021b).

Overall, based on predictions of subsidence, changes to water quality and observations from previous aquatic ecology monitoring in the Nepean River, impacts to aquatic habitat and biota are not expected to occur in the Nepean River due to extraction of Longwalls 709 709, 710A, 710B, 711 and 905.

4.2.2 Drainage Lines

Localised and minor changes in habitat availability and connectivity may occur along the first, second and third order drainage lines due to tilt but these effects will be difficult to detect due the high variability in natural flows within these ephemeral watercourses. The impacts resulting from the changes in surface water flows are expected to be small in comparison with those which occur during natural flooding conditions. Consequently, impacts to aquatic habitat and biota due to tilt, if any, are expected to be minor and localised in drainage lines located directly above and within 400 m of the proposed longwalls.

Fracturing and flow diversions may occur in drainage lines directly above and up to 400 m away from the proposed longwalls. In total, approximately 5.1 km of third order drainage line habitat is located directly above and within 400 m of the proposed longwalls (**Section 3.2.2**). A total of approximately 25 km of first and second order watercourses is located directly above and within 400 m of the proposed longwalls. This may result in the draining of pools in these watercourses, particularly during low flows, resulting in a reduction in the availability of aquatic habitat and the connectivity of remaining habitat. This would be expected to result in associated reductions in the population sizes of aquatic biota. The aquatic biota within these watercourses consists of a mixture of native (e.g. *Ottelia sp.,* a floating aquatic macrophyte, and a number of aquatic macroinvertebrates) and non-native (e.g. eastern gambusia) species, and, thus, have limited conservation value. It is noted, however, that these watercourses could provide habitat for some native albeit relatively widespread and common species of fish such as longfinned eels and species of gudgeons such as flathead gudgeon and carp gudgeons. An impact on the local population size of these and other native aquatic species could be expected. This could be significant at the scale of individual pools and possibly individual watercourses. However, given the natural ephemeral nature of these watercourses and pools (albeit water would provide some refuge for several weeks and potential months depending on weather conditions), the predicted localised reductions in habitat availability and connectivity and the abundance of such habitat in the Nepean River Catchment, impacts on population size are expected to be negligible at wider scales. Further, there have been no fracturing, flow diversions or pool drainage in drainage lines overlying Longwalls extracted from Appin Areas 7 and 9 have been observed during monitoring undertaken by South32. It is possible that the relatively deep soil profile that overlies the sandstone rock (compared with the often exposed sandstone outcrops in the Dendrobium Mine Area) obscures any fractures and limits any associated flow diversions. Given these observations, it is probable that flow diversions resulting in reductions in the availability of aquatic habitat would also not occur during extraction of Longwalls 709, 710A, 710B, 711 and 905.

Longwall extraction is not anticipated to have any significant impacts on surface water quality as a result of mining the proposed longwalls (SLR 2021a). Longwall extraction is not predicted to result in groundwater drawdown in surface strata (SLR 2021b). Although the lower seams will be depressurised this will not extend upwards and therefore not affect groundwater levels in the upper layers (SLR, 2021b); SLR (2021b) note that changes in shallow groundwater as a result of fracturing, dilatation and shear of shallow strata can result in changes to surface water bodies and shallow groundwater, where they are connected. However, as described above, while associated changes to water availability and thus aquatic habitat and biota in drainage lines may be significant at the scale of individual pools and possibly individual watercourses, impacts are expected to be negligible at wider scales.

Given the current ephemeral nature of these watercourses, and the current disturbed nature of riparian vegetation along drainage lines, it is unlikely that any reduction in flow and water availability here would have any significant impact on this vegetation.

Although impacts at the scale of individual pools and watercourses could be significant, at the scale of the Nepean River catchment, and considering the abundance of comparable first, second and third order watercourse habitat in the local area, such impacts represent a minor impact to aquatic habitat and biota at these scales. The aquatic habitat provided by these watercourses is also relatively degraded and associated with historic land clearing and current pasture land-use. It is also largely ephemeral aquatic habitat, which would naturally consist of disconnected pools during the majority of the time during natural conditions. Thus, there would be no substantial change to the nature of these watercourses (i.e. they are largely ephemeral prior to any potential mining related impacts).

4.2.3 Key Fish Habitat

Impacts to KFH would also be relatively minor. Although Navigation Creek was identified as providing Type 1 – Highly Sensitive KFH, this was based on the identification of one instream native aquatic plant *Ottelia sp*. This plant would provide microhabitat, including cover from prey/predators and potentially a substratum for laying eggs. Other aspects of the creek, such as the general pool quality of riparian habitat (though some is present in places), generally disconnected and ephemeral pool habitat, silty substratum and likely generally pool water quality, would limit the value of this habitat for native fish. Thus, the potential reduction in availability and further reduction in connectivity of this habitat due to fracturing and flow diversions is not expected to result in significant impacts to any native fish here and the wider catchment. Some Type 2 – Moderately Sensitive KFH in other third order drainage lines (Tributary 1, Foot Onslow Creek and the far upstream extent of Harris Creek) may be lost, though again this habitat is likely to be of limited value to native fish. No impacts to Type 1 - Highly Sensitive KFH provided by the Nepean River is expected.

4.2.4 Threatened Species

The potential for adverse effects on the lifecycle of threatened species depends on whether the works are likely to cause loss or degradation of habitat, reduction in water quality, limit their foraging activities and disrupt their reproduction and recruitment. The assessments for Macquarie perch and Sydney hawk dragonfly presented in **Appendix C** indicated the risk of these species being impacted by extraction of Longwalls 709, 710A, 710B, 711 and 905 as unlikely.

4.3 Comparison with BSO Assessment

Table 4-1 compares the impacts on aquatic habitat and biota predicted using the original Part 3A Application layout (Bioanalysis 2009) and predicted based on the current layout of Longwalls 709, 710A, 710B, 711 and 905. Overall, the current predictions indicate impacts to aquatic habitat and biota would be comparable to or of lesser magnitude and / or extent than those predicted by Bioanalysis (2009). Impacts to aquatic habitat, riparian vegetation, macrophytes, macroinvertebrates and fish in the Nepean River are generally less likely to occur and are less severe than predicted previously. This is due to the absence of adverse physical impacts predicted to occur here due to extraction of Longwalls 709, 710A, 710B, 711 and 905. Impacts to threatened species (i.e. unlikely to occur) are comparable, primarily because Macquarie perch and Sydney hawk dragonfly do not appear to be located within the Study Area. Predictions for drainage lines are comparable, with the potential for fracturing, flow diversions and localised impacts to aquatic biota expected to occur in the BSO AEA and the current assessment.

Table 4-1 Potential impacts on aquatic habitat and biota described in the BSO AEA (Bioanalysis 2009) and predicted as a result of the current Extraction Plan layout for Longwalls 709, 710A, 710B, 711 and 905.

Component of Aquatic Ecology	Impacts Predicted in the AEA prepared for the BSO EA	Potential Impacts Predicted on for Longwalls 709, 710A, 710B, 711 and 905
Nepean River		
Aquatic habitat	Nepean River - Impacts on flow and pool depth are not expected in the Douglas Park Weir pool.	Same as for BSO EA. It is considered unlikely, that the Nepean River would experience adverse physical impacts due to the mining-induced movements from Longwall 709, 710A, 710B, 711 and 905.
	Some fracturing of bed rock is expected, as well as mobilisation of iron and other minerals and transient gas emissions in the weir pool.	Fracturing not expected to occur in the Nepean River. Further gas release zones could develop due to the mining of the proposed longwalls. Any short term and localised impact on water quality is not expected to significantly affect aquatic biota. Minor localised iron staining may occur, but is unlikely to lead to changes in water quality and should not therefore affect the quality of aquatic habitat.
Riparian vegetation	Changes in the level of water in streams and gas emissions are unlikely to disturb riparian vegetation to the extent that its ecological role would be significantly adversely impacted.	Substantial localised gas emissions could result in localised die-back of riparian vegetation. Such impacts are considered unlikely and would be transient. No fracturing is predicted to occur in the Nepean River and no associated impacts to riparian vegetation is expected.

Component of Aquatic Ecology	Impacts Predicted in the AEA prepared for the BSO EA	Potential Impacts Predicted on for Longwalls 709, 710A, 710B, 711 and 905
Aquatic macrophytes	Nepean River – limited to no detectable changes in composition or distribution.	Increase in the level of the bank or bed of the Nepean River that could reduce the wetted perimeter and lead to stranding and desiccation of aquatic vegetation along the edge of the river is not expected. Localised gas releases may lead to minor changes in the composition and extent of macrophyte beds, but these are unlikely to be detected, because of the natural variability of these beds. Impacts to water quality and surface water availability, and thus associated impacts to aquatic habitat and biota, are not expected.
Aquatic macroinvertebrates	Potential impacts would be similar in scale to those observed during mining of Appin Area 7 (i.e. none detected).	Minor changes in riparian and aquatic vegetation potentially associated with localised gas releases could lead to the loss of edge habitat and reduction in the abundance of aquatic macroinvertebrates living therein. Losses would be negligible relative to the amount of habitat available within the downstream reach of the river. Impacts to water quality and surface water availability, and thus associated impacts to aquatic habitat and biota, are not expected.
Fish	Potential impacts would be similar in scale to those observed during mining of Appin Area 7 (i.e. none detected). Reductions in dissolved oxygen associated with gas emissions are likely to be short-lived and localised and unlikely to have a significant effect, because fish populations are highly mobile.	Same as for BSO EA.
Threatened Species	It is unlikely that a viable population of Macquarie perch is present in the section of the Nepean River adjacent to the Study Area. This is because of a lack of suitable habitat (including natural riffle habitat required for spawning and numerous barriers to fish passage from downstream. Mine subsidence induced impacts resulting from the proposal are not predicted to lead to loss of riffle habitat or large permanent pools within watercourses that provide suitable habitat for Macquarie perch. Changes in water quality are predicted to be localised, transient. It was therefore considered unlikely that the Project would have a significant adverse effect on Macquarie perch. Likewise, impacts to Sydney hawk dragonfly (which was not located in the BSO Part 3A Application layout), were also unlikely.	Same as for BSO EA.
Drainage Lines		
Aquatic habitat	Potential impacts in Foot Onslow and Navigation Creeks creek are expected to be limited to localised areas of iron staining; possibly fracturing and enhanced leakage from farm dams and pools (where present) and possible low flow diversion in areas of rock outcrop or where bedrock is covered by a thin mantle of alluvium. Potential impacts in Harris Creek include isolated incidents of iron staining, short-term spikes in water quality parameters such as iron, gas emissions, reduced pool levels in dry weather and localised underflow and a reduction in the frequency and persistence of inter-pool flow. If diversion of surface water occurs, drainage of pools may result in a temporary loss of small areas of aquatic habitat.	Fracturing could occur and could result in flow diversions and localised reductions in the availability and connectivity of ephemeral pool habitat. This is unlikely to have a detectable effect on the availability of aquatic habitats beyond the scale of individual pools and watercourses. Impacts to water quality are not expected.
Riparian vegetation	It is considered unlikely that changes in the level of water in streams or the emission of strata gas caused by mine subsidence within this domain would disturb riparian vegetation to the extent	Given the current ephemeral nature of these watercourses, and the current disturbed nature of riparian vegetation along drainage lines, it is unlikely that any reduction in flow and water availability here would have any significant impact on this vegetation.

Component of Aquatic Ecology	Impacts Predicted in the AEA prepared for the BSO EA	Potential Impacts Predicted on for Longwalls 709, 710A, 710B, 711 and 905
	that its ecological role would be significantly adversely impacted.	
Aquatic macrophytes	In Harris Creek, Reduced water levels in the downstream reach could lead to exposure and desiccation of macrophytes. These impacts would be short-term and localised and would not persist once water levels are restored.	Impacts on the aquatic flora that may inhabit these ephemeral watercourses are unlikely to be detectable, because of the large variability in natural flows. In any case, the extent of native aquatic plants in these ephemeral drainage lines appears limited.
Aquatic macroinvertebrates	Significant adverse impacts are unlikely given that changes in water quality are expected to be short-lived and localised and macroinvertebrates should recover quickly once water levels return. Given that changes in water quality were predicted to be localised and transient macroinvertebrates should recover quickly once water levels return following rain events. it is considered unlikely that populations in drainage lines would be significantly affected. Moreover, any potential impacts affecting these areas would be hard to discern, should they occur, because of the degraded nature of the existing aquatic habitat in this area.	Fracturing and flow diversions could occur and could be associated with reductions in the availability and connectivity of aquatic habitat. An impact on the local population size of these and other native aquatic species could be expected. This could be significant at the scale of individual pools and possibly individual watercourses. However, given the natural ephemeral nature of these watercourses, the predicted localised reductions in habitat availability and connectivity and the abundance of such habitat in the Nepean River Catchment, impacts on population size are expected to be negligible at wider scales.
Fish	If fracturing of bedrock leads to loss of habitat, a few species (e.g. eels) may be able to relocate to nearby pools, but others would perish due to desiccation and/or predation. As losses would be restricted to small, localised areas of habitat, this is unlikely to have a significant effect on fish assemblages within the Study Area.	Same as for BSO EA.
Threatened Species	No threatened species identified in drainage lines.	Same as for BSO EA.

5 Recommendations

Four approaches would be used to manage potential impacts on aquatic ecology within the Study Area from Longwalls 709, 710A, 710B, 711 and 905:

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

5.1 Impact Minimisation

The potential impacts from the extraction of Longwalls 709, 710A, 710B, 711 and 905 on aquatic habitats and biota in the Nepean River will be minimised as the mining is 1.5 km from the river. Temporary erosion and sediment control measures such as sediment fences, sandbag weirs, temporary drains, and temporary silt traps should be installed prior to any minor surface works (e.g. associated with subsidence monitoring, mitigation and rehabilitation) in the vicinity of watercourses and swamps to prevent the input of sediment into watercourses and perched aquifer systems during rainfall events.

5.2 Monitoring

5.2.1 Background

An aquatic ecology monitoring program would be implemented to:

- Determine the nature and extent of any subsidence-induced impacts on aquatic ecology due to extraction of Longwalls 709, 710A, 710B, 711 and 905; and
- Assess the response of aquatic ecosystems to any stream remediation and management works implemented.

Monitoring plans designed to assess the potential impacts of mine subsidence on aquatic habitat and biota within watercourses of Appin Area 7 and 9 was outlined in The Ecology Lab (2008a) and Cardno Ecology Lab (2011a). The objective of the monitoring is to measure changes in the aquatic habitats and biota that may arise during or following the extraction of Appin Area 7 and 9 longwalls or as a result of any remediation works undertaken. In order to better understand and adequately assess the potential effects of subsidence on aquatic substrata and water quality and consequent changes in the ecology of the Nepean River, a baseline condition is established two years prior to mining, in accordance with the recommendations in the “Southern Coalfields Strategic Review” (NSW DoP 2008). Aquatic biota would be monitored and relevant water quality variables measured at appropriate spatial and temporal scales, so that changes in aquatic habitats and biota resulting from extraction of longwalls and any remediation works can be distinguished from natural variability.

The Independent Expert Panel for Mining in the Catchment was established in late February 2018 to provide informed expert advice to the (then) Department of Planning and Environment, now the DPIE) on the impact of mining activities in the Greater Sydney Water Catchment Special Areas, with a focus on risks to the quantity of water and swamps. Part 1 (IEPMC 2019a) reviewed specific mining activities at the Metropolitan and Dendrobium coal mines and Part 2 (IEMPC 2019b) focused on the impacts of mining on water quantity and swamps, including cumulative impacts, and includes review and update of relevant findings of the strategic review (NSW DoP 2008). Recommendations specific to monitoring of aquatic ecology were not included, though several recommendations relevant to monitoring of groundwater and surface water and the development of associated TARPs will assist in the future assessment and identification of causes of any impacts to aquatic ecology.

5.2.2 Sites and Timing

Two types of monitoring sites have been incorporated into the plan: ‘Impact’ sites that may be subject to mine subsidence impacts during and after longwall extraction and ‘Control’ sites that will provide a measure of the background environmental variability within the catchments as distinct from any mine subsidence impacts. Monitoring sites have been established previously for Appin Areas 7 & 9 on the Nepean River. Existing impact sites applicable to monitoring potential impacts associated with Longwalls 709, 710A, 710,

711 and 905 on the Nepean River (albeit it is unlikely impacts would occur here due to extraction of these longwalls) are Sites 5, 6, X3 and X4 (i.e. those closest to the proposed longwalls). Sites 1, 2, 7, 8, X5, X6, X7 and X8 would provide Control data.

It is recommended that baseline surveys at Impact and Control sites are undertaken over a 24-month period prior to the commencement of longwall mining and during and post-extraction monitoring to determine the extent and nature of any impacts and recovery. This would provide a measure of background temporal variability and provide confidence regarding potential changes occurring several years into the future. Monitoring of these sites has been underway as part of the ongoing Appin Area 7 and 9 investigations. It is recommended that monitoring specific to Longwalls 709, 710A, 710, 711 and 905 be undertaken annually in spring to align with the timing of previous surveys undertaken from 2008 to 2019. Although, monitoring of Appin Area 9 Longwalls 901 to 904 is currently undertaken biennially, monitoring of all longwalls in Appin Areas 7 & 9 could be readily incorporated into the annual monitoring of Appin Area 7 longwalls.

5.2.3 Indicators and Methods

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

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

5.2.3.1 Aquatic Habitat

Ongoing monitoring of physical attributes (such as flow and depth of water in pools) of the Nepean River and larger drainage lines would be undertaken by IMCEFT. These data would be examined alongside aquatic ecology data during the aquatic ecology reporting. These observations may also trigger additional surveys of aquatic ecology (**Section 5.3**).

5.2.3.2 Water Quality

At each site, two replicate measurements of DO, EC, ORP, pH, temperature and turbidity of the water would be taken from just below the surface of the water. The measurements taken would be used to help interpret differences in biotic assemblages. The EC, DO, pH and turbidity measures would also be compared with the ANZECC (2000) DVTs for slightly disturbed upland rivers in south-east Australia. Specific guidelines are not available for temperature and ORP measures.

A more comprehensive assessment of changes in surface water quality at selected sites would be undertaken by IMCEFT and other specialist consultants.

5.2.3.3 Aquatic Macrophytes

A species inventory of macrophytes would be compiled and observations of any signs of desiccation, die back or other features of the macrophytes that could be indicative of potential mining-related impacts would be recorded at each site.

Prior to December 2012, the extent of each aquatic macrophyte species and group of species was mapped in detail at each site using a Differential GPS. The results of these studies indicated that the distribution, extent and composition of aquatic macrophytes was naturally highly variable, and that it would be very difficult to detect any changes due to mining above background variation. Following a review of this monitoring component, the focus was shifted to detection of broader scale changes to species composition at each site, rather than the fine-scale changes in the extent of beds documented previously. The recommended method is more appropriate to the magnitude of change that would be required to confidently link changes in aquatic macrophytes with potential mining impacts. This methodology is currently undertaken in surveys for the Appin Area 7 and 9 monitoring programs.

5.2.3.4 Aquatic Macroinvertebrates

The AUSRIVAS protocol for NSW streams (Turak *et al.* 2004) would be used to monitor aquatic macroinvertebrates. At each site, samples of aquatic macroinvertebrates associated with the pool edge habitat would be collected by using dip nets (250 µm mesh) to agitate and scoop up material from vegetated areas of the river bank. Samples would be collected over a period of 3 to 5 minutes from a 10 m length of

habitat along the river, in accordance with the AUSRIVAS Rapid Assessment Method (RAM) (Turak *et al.* 2004). If the required habitat was discontinuous, patches of habitats with a total length of 10 m would be sampled. Each RAM sample would be rinsed from the net onto a white sorting tray from which animals are picked using forceps and pipettes. Each tray would be picked for a minimum period of forty minutes, after which they would be picked at 10-minute intervals for either a total of one hour or until no new specimens are found. These samples would be preserved in alcohol and transported to the laboratory for identification.

In accordance with the AUSRIVAS protocol, RAM samples would be sorted under a binocular microscope (at 40 X magnification), macroinvertebrates identified to family level and up to ten animals of any one taxon counted (Turak *et al.* 2004). A randomly chosen 10% of the RAM sample identifications would be checked by a second experienced scientist to validate macroinvertebrate identifications.

Data would be analysed using the spring AUSRIVAS predictive models for the edge habitat (Coysh *et al.* 2000). The AUSRIVAS methodology and predictive model requires that sampling be done in autumn (15 March to 15 June) and/or spring (15 September to 15 December).

AUSRIVAS models generate the following indices:

- OE50Taxa Score - This is the ratio of the number of macroinvertebrate families with a greater than 50% predicted probability of occurrence that were actually observed (i.e. collected) at a site to the number of macroinvertebrate families expected with a greater than 50% probability of occurrence. OE50 taxa values range from 0 to 1 and provide a measure of the impairment of macroinvertebrate assemblages at each site, with values close to 0 indicating an impoverished assemblage and values close to 1 indicating that the condition of the assemblage is similar to that of the reference streams.
- Overall Bands - These indicate the level of impairment of the assemblage and are derived from OE50Taxa scores. These bands are graded as follows:
    - Band X = Richer invertebrate assemblage than reference condition.
    - Band A = Equivalent to reference condition.
    - Band B = Sites below reference condition (i.e. significantly impaired).
    - Band C = Sites well below reference condition (i.e. severely impaired).
    - Band D = Impoverished.

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

5.2.3.5 Fish

Fish would be sampled using and baited traps at each site. Five bait traps (350 mm long, 200 mm wide with an entrance that tapered to a 45 mm aperture, with 3 mm mesh size) would be deployed at each site and baited with 70 ml of a mixture of chicken pellets and sardines and deployed amongst macrophytes and snags (submerged woody debris). Caught fish would identified and released. Fish collected incidentally in the AUSRIVAs macroinvertebrate dip net samples were also recorded. Backpack electrofishing would also be undertaken at sites with suitable water depth (Sites 1, 2 and X3 to X8). Backpack electrofishing, a non-destructive technique that is restricted to depths of approximately 1 m (hip height) and water bodies with low to moderate salinity, would be used to sample fish occurring in shallow sections of the river. The operator of the electrofisher would stun fish by discharging electric pulses into the water enabling them to be captured by an assistant equipped with a dip net. Electrofishing would be conducted in riffles, shallow pools and beneath overhanging banks and vegetation along standardised 50 m lengths of river bank or for a set time interval (8 replicates of 150 minutes).

5.2.3.6 Threatened Species

Searches would be undertaken in AUSRIVAS samples for the two threatened aquatic macroinvertebrate species (Adams emerald dragonfly and Sydney hawk dragonfly) identified in this assessment. There are records of Sydney hawk dragonfly near Sites X7 and X8, and, although Adam's emerald dragonfly does not

appear to occur in the local area, suitable habitat may exist in the Nepean River. All the dragonfly larvae collected would be identified to family level. Any individuals of the genera Austrocorduliidae and Gomphomacromiidae found would be identified to species level, if possible. If there is any uncertainty as to their identification, specimens will be referred to a specialist taxonomist. The presence of either one or both of these threatened species would trigger further investigations into the species and its habitats in relation to potential subsidence impacts. Any Macquarie perch caught during surveys of fish in the Nepean River would also be identified and reported.

5.2.3.7 Statistical Analysis

The aim of the statistical analyses would be to identify differences in the selected indicators of aquatic ecology at the Impact sites that are in a different direction, or of a different magnitude, to those at the Controls. Statistically significant differences provide evidence that an impact may have occurred. Evidence would be assessed by examining data from before with those collected after commencement of longwall extraction. Spatial and temporal changes in macroinvertebrate abundance data from artificial collectors would be examined using permutational analysis of variance - PERMANOVA) for analysis of univariate data. Spatial differences and temporal changes, and their interaction, in macroinvertebrate assemblages sampled using artificial collectors would be examined (PERMANOVA+). Multivariate patterns in the data would also be examined using the unconstrained ordination technique Principal Coordinates Analysis (PCO). This will provide a graphical representation of assemblages based on their similarity within and among places or times sampled. In these plots, samples which have similar sets of organisms are grouped closer together than ones containing different sets of organisms.

5.3 Additional Aquatic Ecology Studies

The aquatic ecology monitoring program outlined in **Section 5.2** has been designed to detect and determine the extent and nature of impacts on aquatic habitat and biota resulting from mining induced subsidence impacts in the Nepean River. It incorporates monitoring events throughout the duration of mining regardless of observed physical and chemical impacts within watercourses. Physical-chemical impacts detected within watercourses by routine surface monitoring by IMCEFT that may require further investigation into potential impacts on the aquatic ecology include:

- Reductions in flow in the Nepean River that exceed predictions; and
- Greater than minor change in water chemistry (particularly pH, dissolved oxygen, turbidity, or metal concentration) in the Nepean River.

Other observations made during routine surface monitoring that may require further investigation of the aquatic ecology would include:

- Fish/crayfish kills; and
- Die-off of macrophyte beds (if present).

Trigger values for aquatic ecology monitoring parameters are contained in the Appin Area 7 Longwalls 707 to 710 Environmental Management Plan (South32 2015) and the Biodiversity Management Plan for Appin Area 9 Longwalls 901 to 904 (BHPBIC 2014). These are based on the duration of reductions in aquatic habitat that may occur in watercourses due to mining impacts.

5.4 Contingent Measures

In the event that the impacts due to the extraction of Longwalls 709, 710A, 710B, 711 and 905 on aquatic habitats and biota in the Nepean River are greater than predicted, the following contingent measures are recommended:

- Implementing watercourse remediation measures, such as backfilling or grouting, in areas where fracturing of controlling rock bars and/or the creek bed leads to diversion of creek flow and drainage of pools; and
- Implementing appropriate control measures, such as installation of sediment fences down slope of areas where subsidence has led to erosion and stabilisation of areas prone to erosion and soil slumping using rock, brush matting or vegetation, to limit the potential for deposition of eroded sediment into the watercourses.

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

6 Conclusion

The layout design for Longwalls 709, 710A, 710B, 711 and 905 includes a setback of at least 1.5 km from the Nepean River. As a result, it is unlikely the Nepean River would experience adverse physical impacts due to the mining-induced movements. Significant impact to aquatic habitat and biota including threatened aquatic species, are, thus, not expected.

Although fracturing could occur in ephemeral drainage lines directly above and within 400 m of the proposed longwalls, no flow diversions or pool drainage has been observed during extraction of previous Appin Area 7 and 9 longwalls. The aquatic habitat provided by these ephemeral drainage lines is also relatively limited. In the unlikely event flow diversion or pool drainage did occur, impacts to aquatic biota at the local scale (e.g. individual pools and drainage lines) would be significant. However, due to the abundance of this habitat in the Nepean River catchment, impacts to aquatic biota at this wider scale would be minor. No significant impacts to the threatened Macquarie perch, Sydney hawk dragonfly or Adams emerald dragonfly are expected as these species are unlikely to occur in drainage lines that traverse the Study Area that would be most susceptible to mining related subsidence impacts.

Ongoing monitoring associated with Appin Area 7 and 9 longwalls will incorporate monitoring of impacts to aquatic ecology that may occur due to extraction of Longwalls 709, 710A, 710B, 711 and 905. This will also consider the results of monitoring of physical and water quality impacts undertaken by IMCEFT. The detection of physical impacts, such as rockbar fractures resulting in water loss in a pool within the Nepean River or more than minor changes in water chemistry, would trigger investigations into potential impacts on aquatic ecology. Observations of fish/crayfish kills or die-off of any macrophyte beds would also trigger further monitoring to determine the nature and extent of secondary impacts on aquatic ecology. The level of impact would determine the type of response. The implementation of such management measures would reduce impacts on aquatic ecology.

Overall, potential impacts to aquatic habitat and biota associated with extraction of Longwalls 709, 710A, 710B, 711 and 905 are comparable to or less severe than those predicted to occur in the BSO EA. Potential impacts are expected to result in negligible consequences to aquatic habitat and biota at the scale of the Nepean River catchment and negligible consequences to threatened aquatic species.

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APPENDIX

A

SURVEY METHODS

Site Coordinates

Table A-i. Cardno Monitoring Site Coordinates

Site	Easting	Northing
Site 1 upstream extent	288463	6214100
Site 1 downstream extent	288780	6214152
Site 2 downstream extent	289008	6214219
Site 2 upstream extent	288851	6214182
Site 3 downstream extent (sampling ceased)	291889	6215263
Site 3 upstream extent (sampling ceased)	291644	6215370
Site 4 upstream extent (sampling ceased)	292071	6215217
Site 4 downstream extent (sampling ceased)	292281	6215350
Site 5 downstream extent	292791	6218045
Site 5 upstream extent	293002	6217805
Site 6 downstream extent	292647	6218567
Site 6 upstream extent	292785	6218240
Site 7 upstream extent	292582	6220829
Site 7 downstream extent	292581	6221116
Site 8 upstream extent	292815	6221295
Site 8 downstream extent	292963	6221582
Site X1 upstream extent (sampling ceased)	292378	6216501
Site X1 downstream extent (sampling ceased)	292348	6216638
Site X2 upstream extent (sampling ceased)	292356	6216590
Site X2 downstream extent (sampling ceased)	292379	6216875
Site X3 centre	286453	6214934
Site X4 centre	286194	6215120
Site X5 centre	284800	6213117
Site X6 centre	284680	6213032
Site X7 centre	281754	6212912
Site X8 centre	281655	6212798

Datum: GDA 94 Zone 56H

Aquatic Habitat and Vegetation

Habitat Types

The Ecology Lab (2008a) mapped four habitat types (adapted from Fairfull and Witheridge 2003) within The Nepean River and its drainage lines:

- Unlikely habitat: Ephemeral drainage lines that only contain flow during and immediately after significant rainfall. Permanent or semi-permanent pools that could provide refuge for aquatic biota during prolonged dry weather are absent.
- Minimal habitat: Watercourses that contain some small semi-permanent refuge pools which are unlikely to persist through prolonged drought. Flow connectivity would only occur during and following significant rainfall. These pools may provide habitat for some aquatic species including aquatic macroinvertebrates and freshwater crayfish.
- Moderate habitat: Watercourses that contain some larger permanent and semi-permanent refuge pools, which would persist through prolonged drought, although become greatly reduced in extent. These watercourses should support a relatively diverse array of aquatic biota including some fish, freshwater crayfish and aquatic macroinvertebrates. There may also be some aquatic plant species present.
- Significant habitat: Watercourses that contain numerous large, permanent pools and generally have flow connectivity except during prolonged drought. They provide extensive and diverse aquatic habitat for aquatic flora and fauna.

Key Fish Habitat

The occurrence of sensitive fish habitat in the Study Area was assessed using the criteria in NSW DPI (2013a) relevant to freshwater habitat (**Table A-ii**).

Mapping was done initially as a desktop exercise with the aid of existing information from previous surveys including information on habitat types (Fairfull and Witheridge 2003). Findings were used to inform the detailed KFH mapping using the updated classifications in NSW DPI (2013a). Where sections of drainage lines could not be accessed, KFH type was inferred based on the findings from other drainage lines in the Study Area.

Table A-ii. Classification of KFH according to sensitivity (NSW DPI 2013a)

Classification	Habitat Type
Type 1 – highly sensitive KFH	Instream gravel beds, rocks greater than five hundred millimeters in two dimensions, snags (wood debris) greater than three hundred millimeters in diameter or three meters in length, native aquatic plants, and areas known or expected to contain threatened and protected species
Type 2 – Moderately sensitive KFH:	Freshwater habitats other than those defined in Type 1
Type 3 – Minimally sensitive KFH	Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation
Not considered KFH	First and second order streams on gaining (those where streams are coming together and becoming progressively larger) streams (based on the Strahler method of stream ordering)

In-situ Water Quality

At each site, two replicate measurements of DO, EC, oxidation-reduction potential (ORP), pH, temperature and turbidity of the water were taken from just below the surface of the water using a YSI multiprobe. The measurements taken would be used to assist in interpretation of the results of biotic sampling. The EC, DO, pH and turbidity measures were also compared with the ANZECC (2000) DTVs for slightly disturbed upland rivers in south-east Australia. Specific guidelines are not available for temperature and ORP measures.

AUSRIVAS Macroinvertebrates

Field and Laboratory Methods

At each site, samples of aquatic macroinvertebrates associated with the pool edge habitat were collected by using dip nets (250 µm mesh) to agitate and scoop up material from vegetated areas of the river bank. Samples were collected over a period of 3 to 5 minutes from a 10 m length of habitat along the river, in accordance with the AUSRIVAS Rapid Assessment Method (RAM) (Turak *et al*. 2004). If the required habitat was discontinuous, patches of habitats with a total length of 10 m were sampled. Each RAM sample was rinsed from the net onto a white sorting tray from which animals were picked using forceps and pipettes. Each tray was picked for a minimum period of forty minutes, after which they were picked at ten-minute intervals for either a total of one hour or until no new specimens were found. Samples were preserved in alcohol and transported to the laboratory for identification and subsequent derivation of biotic indices and assessment of habitat and water quality using the AUSRIVAS modelling software.

AUSRIVAS samples were sorted under a binocular microscope (at 40 X magnification) and identified to family level with the exception of Oligochaeta and Polychaeta (to class), Ostracoda (to subclass), Nematoda and Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily). Up to ten animals of each family were counted, in accordance with the latest AUSRIVAS protocol (Turak *et al*. 2004). There is a possibility, albeit unlikely, that two threatened aquatic macroinvertebrate species (Adams emerald dragonfly and Sydney hawk dragonfly) occur in the Study Area. Therefore, if any individuals of the family Austrocorduliidae and Gomphomacromiidae were found these would have been identified to species level.

AUSRIVAS Model

The AUSRIVAS protocol uses an internet-based software package to determine the environmental condition of a waterway based on predictive models of the distribution of aquatic macroinvertebrates at reference sites (Coysh *et al.* 2000). The ecological health of the creek is assessed by comparing the macroinvertebrate assemblages collected in the field (i.e. 'observed') with macroinvertebrate assemblages expected to occur in reference waterways with similar environmental characteristics. The data from this study were analysed

using the NSW models for pool edge habitat sampled in spring. The AUSRIVAS predictive model generates the following indices:

- OE50Taxa Score – The ratio of the number of macroinvertebrate families with a greater than 50% predicted probability of occurrence that were actually observed (i.e. collected) at a site to the number of macroinvertebrate families expected with a greater than 50% probability of occurrence. OE50 taxa scores provide a measure of the impairment of macroinvertebrate assemblages at each site, with values close to 0 indicating an impoverished assemblage and values close to 1 indicating that the condition of the assemblage is similar to that of the reference streams.
- Overall Bands derived from OE50Taxa scores that indicate the level of impairment of the assemblage. These bands are graded as described in **Table A-iii**.

Table A-iii. AUSRIVAS Bands and corresponding OE50 Taxa Scores for AUSRIVAS edge habitat sampled in spring

Band	Description	Spring OE50 Score
X	Richer invertebrate assemblage than reference condition	>1.16
A	Equivalent to reference condition	0.84 to 1.16
B	Sites below reference condition (i.e. significantly impaired)	0.52 to 0.83
C	Sites well below reference condition (i.e. severely impaired)	0.20 to 0.51
D	Impoverished (i.e. extremely impaired)	≤0.19

The SIGNAL2 biotic index (Stream Invertebrate Grade Number Average Level) developed by Chessman (2003) was also used to determine the environmental quality of sites on the basis of the presence or absence of families of macroinvertebrates. This method assigns grade numbers between 1 and 10 to each macroinvertebrate family, based largely on their responses to chemical pollutants. The sum of all grade numbers for that site was then divided by the total number of families recorded in each site to obtain an average SIGNAL2 index. The SIGNAL2 index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site. SIGNAL2 values are as follows:

- SIGNAL > 6 = Healthy habitat;
- SIGNAL 5 – 6 = Mild pollution;
- SIGNAL 4 – 5 = Moderate pollution; and
- SIGNAL < 4 = Severe pollution.

Fish

Fish were sampled using a backpack electrofisher (model LR-24 Smith-Root) and baited traps. At each site, five baited traps were set for approximately one hour in a variety of habitats, such as amongst aquatic plants and snags, in deep holes and over bare substratum. Bait traps were approximately 30 cm x 30 cm x 40 cm with 0.3 cm aperture mesh and a 3 cm opening and were unbaited. The backpack electrofisher was operated around the edge of pools and in riffles (if present) at Sites 1, 2 and X3 to X8 (i.e. where water depth was suitable for sampling), with four two minute shots being performed at each site. Fish stunned by the current were collected in a scoop net, identified and measured. All captured fish were be handled with care to minimise stress and be released as soon as possible.

APPENDIX

B

COMPILED ASRIVAS DATA

Site:	1	2	3	4	5	6	7	8	X1	X2	X3	X4	X5	X6	X7	X8
Number of Taxa																
Sep 03	13	14	15	16	13	14										
Nov 08	32	30	32	32	25	27	33	30	31	27						
Dec 10	30	27	25	31	25	15	27	30	23	27						
Dec 11	28	24	19	30	28	21			24	27						
Dec 12	28	24	28	31	20	21	25	26	26	26						
Dec 13	19	22			25	22	22	20	22	27						
Dec 14	22	20	24	24	27	26	23	21	34	22	17	25	19	15	23	23
Nov 15	20	29			27	23	28	29			19	22	19	18	16	18
Nov 16	22	22			25	23	17	24								
Nov 17	27	16			19	15	25	15			21	13	18	14	19	23
Nov 18	25	14			16	23	19	26								
Nov 19	22	15			15	16	19	17			24	26	18	20	13	23
OE50 Taxa Score																
Sep 03	0.52	0.58	0.64	0.58	0.52	0.58										
Nov 08	1.05	0.87	0.99	0.93	0.64	0.76	0.81	0.99	0.81	0.81						
Dec 10	0.93	0.99	0.82	0.76	0.81	0.47	0.81	0.76	0.76	0.81						
Dec 11	0.99	0.76	0.70	0.99	0.82	0.52			0.64	0.76						
Dec 12	1.11	0.70	0.93	1.05	0.64	0.58	0.76	0.70	0.87	0.70						
Dec 13	0.76	0.82			0.87	0.70	0.82	0.76	0.88	0.93						
Dec 14	0.81	0.58	0.87	0.76	0.87	0.87	0.70	0.64	0.99	0.82	0.83	0.87	0.87	0.82	0.98	0.94
Nov 15	0.70	0.99			0.82	0.81	0.76	0.81			0.87	0.57	0.83	0.70	0.86	0.69
Nov 16	0.70	0.70			0.87	0.70	0.70	0.81								
Nov 17	0.64	0.58			0.70	0.52	0.76	0.58			0.76	0.53	0.58	0.52	0.64	0.82
Nov 18	0.87	0.47			0.52	0.81	0.64	0.76								
Nov 19	0.81	0.47			0.47	0.64	0.64	0.81			0.70	0.82	0.64	0.7	0.59	0.88
SIGNAL2 Score																
Sep 03	3.7	3.9	3.6	4.0	3.8	3.5										
Nov 08	3.9	3.7	3.3	4.0	3.7	3.4	3.8	3.6	4.2	3.7						
Dec 10	3.8	3.8	3.8	3.5	3.9	3.2	3.2	3.3	4.1	3.8						
Dec 11	3.8	3.8	3.7	3.9	3.6	4.1			3.7	4.0						
Dec 12	4.1	4.1	4.0	3.9	4.3	4.5	3.3	3.7	4.0	3.6						
Dec 13	3.6	4.6			4.3	3.9	4.2	3.8	4.6	3.8						
Dec 14	3.9	3.9	4.0	4.2	4.3	3.7	3.7	4.1	4.3	3.7	4.1	4.5	4.1	4.1	3.6	4.1
Nov 15	4.3	4.1			4.0	4.2	4.2	4.0			4.1	4.5	3.4	3.8	3.6	3.0
Nov 16	4.1	4.6			4.5	4.1	4.0	4.2								
Nov 17	4.2	3.8			4.5	4.3	3.9	4.6			4.1	3.7	3.8	4.7	3.9	3.8
Nov 18	4.0	3.6			4.2	4.4	4.5	3.5								
Nov 19	3.7	3.7			3.5	4.0	3.9	4.4			4.3	4.0	4.1	4.0	4.5	4.0

APPENDIX

C

ASSESSMENTS OF SIGNIFICANCE

A-i) Assessment of Significance (FM Act) – Macquarie perch

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The records from the Australian Museum indicate that Macquarie perch were present in the upper Nepean River between 1894 and 1905. Recent records indicate that Macquarie perch occurs in the Nepean River upstream and downstream of Pheasant's Nest Weir (Baumgartner and Reynoldson 2007), including a 2005 record from the Cordeaux River at the confluence with the Nepean River. This structure is believed to block the downstream passage of this species (Gehrke and Harris 1996). The presence of this weir and another significant barrier to fish passage further downstream at Maldon Weir, and absence of any recent records from the downstream reaches of the Nepean River and its tributaries as far as Glenbrook Creek near Glenbrook (in 2012) (ALA 2020) suggests that it is highly unlikely that the Nepean River adjacent to the Study Area supports a population of Macquarie perch. This section of the Nepean River from around Site 5 upstream to Buxton (upstream of X8) is mapped as providing suitable habitat for Macquarie perch (NSW DPI 2016a).

Life history studies of Macquarie perch have been largely carried out on western drainage populations. These populations are known to spawn just above riffles in shallow upland streams in October to January when water temperatures rise to around 16 C. Eastern populations, however, inhabit rivers with very different hydrological conditions to the inland populations and very little is known of their life cycle. The eggs are adhesive and stick to gravel. Hatching commences 13 days after fertilisation and is completed by 18 days after fertilisation at water temperatures of 11 to 18°C Newly-hatched larvae shelter amongst pebbles. In impounded waters, hatched fish move back downstream to the lake habitat from their upstream spawning sites.

The lifecycle of Macquarie perch could be adversely affected if mining results in changes in levels of ponding, flooding or scouring of river banks, fracturing of rock bars and diversion of surface flows and these, in turn, lead to drainage of pools, loss of habitat, and reductions in habitat connectivity and/or water quality. The subsidence predictions indicate that extraction of the proposed longwall is not expected to result in major fracturing in the Nepean River that could otherwise result in adverse impacts. Likewise, impacts to water quality in the Nepean River are not expected. In any case, there are no recent records of Macquarie perch in the Nepean River adjacent to the Study Area. Macquarie perch also do not occur in the drainage lines in the Study Area. Thus, it is highly unlikely that mining would have any adverse effects on the life cycle of Macquarie perch in the Nepean River or place a viable local population at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

No endangered populations of Macquarie perch have been listed on the Schedules of the FM Act.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the proposed action is likely to:

i) Have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

ii) Substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to placed at risk of extinction.

Macquarie perch is not part of a listed endangered ecological community.

d) In relation to the habitat of a threatened species, population or ecological community:

i) The extent to which habitat is likely to be removed or modified as a result of the action proposed;

ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action;

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Subsidence predictions indicate fracturing and flow diversions would not occur in the Nepean River. Thus, there are unlikely to be any reduction in Macquarie perch habitat availability, quality or connectivity here due to fracturing. Although fracturing and flow diversions are likely to result in more severe impacts to habitat in drainage lines, these are very unlikely to provide habitat for Macquarie perch. Thus, it is highly unlikely that mining would lead to removal, fragmentation or isolation of a Macquarie perch population.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

There is no listed critical habitat for Macquarie perch listed on the NSW Register of Critical Habitat.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

The National Recovery Plan for Macquarie perch (DEE 218) contains background information on the biology, ecology, distribution and populations, decline and threats and recovery objectives and strategies and associated actions for this species. The objectives are:

- Conserve existing Macquarie perch populations;
- Protect and restore Macquarie perch habitat;
- Investigate threats to Macquarie perch populations and habitats;
- Establish additional Macquarie perch populations;
- Improve understanding of the biology and ecology of the Macquarie perch and its distribution and abundance; and
- Increase participation by community groups in Macquarie perch conservation.

Identified threats include:

- Habitat degradation;
- Invasive fish;
- Barriers to fish movement;
- Altered flow and thermal regimes;
- Disease;
- Illegal and incidental capture;
- Chemical water pollution;
- Climate change.

Potential impacts to Macquarie perch associated with the Project (primarily loss of habitat following significant fracturing leading to flow diversions and reductions in pool water levels) are not expected. The Project would not interfere with these objectives and the recovery of the species.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

One KTP listed under the BC Act is directly applicable to the Project: *Alteration of habitat following subsidence due to longwall mining.*

While the Project is expected to exacerbate this KTP, associated impacts to Macquarie perch due to subsidence are unlikely. Macquarie perch is very unlikely to be found in the Study Area where fracturing and flow diversions could occur.

A-ii) Assessment of Significance Based on Significant Impact Criteria for Endangered Species (EPBC Act) – Macquarie perch

An action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it will:

a) Lead to a long-term decrease in the size of a population

The records from the Australian Museum indicate that Macquarie perch were present in the upper Nepean River between 1894 and 1905. Recent records indicate that Macquarie perch occurs in the Nepean River upstream and downstream of Pheasant's Nest Weir (Baumgartner and Reynoldson 2007), including a 2005 record from the Cordeaux River at the confluence with the Nepean River. This structure is believed to block the downstream passage of this species (Gehrke and Harris 1996). The presence of this weir and another significant barrier to fish passage further downstream at Maldon Weir, and absence of any recent records from the downstream reaches of the Nepean River and its tributaries as far as Glenbrook Creek near Glenbrook (in 2012) (ALA 2020) suggests that it is highly unlikely that the Nepean River adjacent to the Study Area supports a population of Macquarie perch. This section of the Nepean River from around Site 5 upstream to Buxton (upstream of X8) is mapped as providing suitable habitat for Macquarie perch (NSW DPI 2016a).

Life history studies of Macquarie perch have been largely carried out on western drainage populations. These populations are known to spawn just above riffles in shallow upland streams in October to January when water temperatures rise to around 16 C. Eastern populations, however, inhabit rivers with very different hydrological conditions to the inland populations and very little is known of their life cycle. The eggs are adhesive and stick to gravel. Hatching commences 13 days after fertilisation and is completed by 18 days after fertilisation at water temperatures of 11 to 18°C Newly-hatched larvae shelter amongst pebbles. In impounded waters, hatched fish move back downstream to the lake habitat from their upstream spawning sites.

The subsidence predictions indicate that extraction of the proposed longwall is not expected to result in major fracturing in the Nepean River that could otherwise result in adverse impacts. Likewise, impacts to water quality in the Nepean River are not expected. In any case, there are no recent records of Macquarie perch in the Nepean River adjacent to the Study Area. Macquarie perch also do not occur in the drainage lines in the Study Area. Thus, it is highly unlikely that mining would have any adverse effects on the habitat of Macquarie perch further upstream in the Nepean River and result in any impact on population size.

b) Reduce the area of occupancy of the species

As described above, reductions in availability of aquatic habitat due to fracturing is not expected in the Nepean River, nor would Macquarie perch be expected to occur in sections of these watercourses within the Study Area. The Project would also not require any crossings over the Nepean River that could hinder fish passage and impacts to water quality in the river are not expected. Thus, reductions in the occupancy of this species die to the Project are not expected.

c) Fragment an existing population into two or more populations

As described in a) and b), potential impacts to Macquarie perch due to the Project are not expected. No structures that may hinder fish passage would be installed. Macquarie perch is not expected to occur within drainage lines in the Study Area where fracturing and flow diversions could occur.

d) Adversely affect habitat critical to the survival of a species

As described in a), potential impacts to Macquarie perch habitat are not expected. Critical breeding habitat (shallow flowing sections of rivers) is likely present in the upper section of the Nepean River adjacent to the Study Area. However, the Project would not result in any significant impacts here, and, in any case, the presence of Maldon Weir appears to prevent access to this section of river from further upstream

e) Disrupt the breeding cycle of a population

It is highly unlikely that mining would have any adverse effects on the life cycle of any Macquarie perch in the Nepean River or place a viable local population at risk of extinction. Macquarie perch are considered very unlikely to occur in drainage lines in the Study Area, and, thus, would not be affected by any mining induced impacts here. The population in the Nepean Ricer is located upstream of the proposed mining and would not be affected by the project.

f) Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

As described in (a) – (d) potential impacts to Macquarie perch and their habitat due to the Project are not expected and not expect to affect its forage, resting or spawning habitat to the extent that the species is likely to decline.

g) Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat

Invasive species that may predate on Macquarie perch eggs or young fish and/or potentially compete with Macquarie perch for food and habitat include redfin perch (*Perca fluviatilis*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), wild goldfish (*Carassius auratus*), eastern gambusia (*Gambusia holbrooki*) and carp (*Cyprinus carpio*). The Project does not include any vectors that may introduce or result in the proliferation of these species within the Study Area.

h) Introduce disease that may cause the species to decline

The invasive species listed in g) may carry disease or parasites that could infect Macquarie perch. However, the Project would not result in the introduction or further introduction of disease or parasites to the Study Area.

i) Interfere substantially with the recovery of the species

The National Recovery Plan for Macquarie perch (DEE 218) contains background information on the biology, ecology, distribution and populations, decline and threats and recovery objectives and strategies and associated actions for this species. The objectives are:

- Conserve existing Macquarie perch populations;
- Protect and restore Macquarie perch habitat;
- Investigate threats to Macquarie perch populations and habitats;
- Establish additional Macquarie perch populations;
- Improve understanding of the biology and ecology of the Macquarie perch and its distribution and abundance; and
- Increase participation by community groups in Macquarie perch conservation.

Identified threats include:

- Habitat degradation;
- Invasive fish;
- Barriers to fish movement;
- Altered flow and thermal regimes;
- Disease;
- Illegal and incidental capture;
- Chemical water pollution;
- Climate change.

Potential impacts to Macquarie perch associated with the Project (primarily loss of habitat following significant fracturing leading to flow diversions and reductions in pool water levels) are not expected. The Project would not interfere with these objectives and the recovery of the species.

B-i) Assessment of Significance (FM Act) – Sydney hawk dragonfly

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The larvae of Sydney hawk dragonfly have specific habitat requirements, including deep, cool, shady pools (NSW DPI 2007). It has been recorded in the Nepean River at Maldon Bridge (seven records from 1979 to 1980 in the vicinity of Sites X7 and X8) near Picton and further upstream at Nepean Dam (one record from 1979) (ALA 2020). Extensive sampling has failed to discover further specimens in other areas suggesting that it has a highly restricted distribution within the catchment of the Nepean River (NSW DPI 2007). This species has not been found in the AUSRIVAs samples collected by Cardno from any sites on the Nepean River nor was it caught by Bioanalysis (2009). The drainage lines within the Study Area do not provide suitable habitat for this species.

Extraction of the longwalls could have an adverse effect on the life cycle of this dragonfly if subsidence results in significant changes in levels of ponding, flooding or scouring of banks, fracturing of bedrock and diversion of surface flows, which, in turn, result in significant loss of aquatic habitat and reductions in habitat connectivity or water quality. The mine subsidence predictions for the Nepean River indicate that such impacts would not occur here. Likewise, impacts to water quality in the Nepean River are not expected. It does not occur in the drainage lines in the Study Area where fracturing and flow diversions could occur. It is therefore highly unlikely that mining would have any adverse effects on the life cycle of Sydney hawk dragonfly in the Nepean River.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

No endangered populations of Sydney hawk dragonfly have been listed on the Schedules of the FM Act.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the proposed action is likely to:

i) Have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

ii) Substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to placed at risk of extinction.

Sydney hawk dragonfly is not part of a listed endangered ecological community.

d) In relation to the habitat of a threatened species, population or ecological community:

i) The extent to which habitat is likely to be removed or modified as a result of the action proposed;

ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action;

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Subsidence predictions indicate fracturing and flow diversions would not occur in the Nepean River. Thus, there are unlikely to be any reduction in Sydney hawk dragonfly habitat availability, quality or connectivity here due to fracturing. Although fracturing and flow diversions are likely to result in more severe impacts to habitat in drainage lines, these are very unlikely to provide habitat for Sydney hawk dragonfly. Thus, it is highly unlikely that mining would lead to removal, fragmentation or isolation of a Sydney hawk dragonfly population.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

There is no listed critical habitat for Sydney hawk dragonfly listed on the NSW Register of Critical Habitat.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No Recovery and Threat Abatement Plans exist for this species. Several conservation and recovery actions for Sydney hawk dragonfly are included in NSW DPI (2007):

- Allocate and manage environmental water through water sharing planning processes, to lessen the impacts of altered flows;
- Prevent sedimentation and poor water quality by using conservation farming and grazing practices, conserve and restore riparian (river bank) vegetation and use effective erosion and sediment control measures;
- Rehabilitate degraded habitats. Protect riparian vegetation and encourage the use of effective sediment control measures in catchments where the dragonfly may occur;
- Protect the few remaining sites with the potential to support the species, and address key threats such as habitat degradation and water quality decline;
- Conduct further research into the species' biology, ecology and distribution; and

> Implement the Protected, Threatened and Pest Species Sighting Program and report any sightings to NSW DPI.

Potential impacts to Sydney hawk dragonfly associated with the Project (primarily loss of habitat following significant fracturing leading to flow diversions and reductions in pool water levels) are not expected. The Project would not interfere with these objectives and the recovery of the species.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

One KTP listed under the BC Act is directly applicable to the Project: *Alteration of habitat following subsidence due to longwall mining.*

While the Project is expected to exacerbate this KTP, associated impacts to Sydney hawk dragonfly due to subsidence are unlikely. Sydney hawk dragonfly is very unlikely to be found in the Study Area where fracturing and flow diversions could occur.

Appendix B - Niche Environment and Heritage, 2021. *Appin – Longwalls 709 to 711 and 905 Biodiversity Impact Assessment*

Excellence in your environment

niche Environment and Heritage

Appin – Longwalls 709 to 711 and 905 Biodiversity Impact Assessment

Prepared for South32 Illawarra Metallurgical Coal | 12 May 2021

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Excellence in your environment

Document control

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Executive Summary

Project outline

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by South32 Illawarra Metallurgical Coal (IMC) to prepare a Biodiversity Impact Assessment (BIA) to inform the Biodiversity Management Plan (BMP) component of the Appin Area 9 and Appin Area 7, Longwalls 905, 709, 710A, 710B and 711 Extraction Plan (the Study Area), as required by the Conditions of Project Approval.

The BIA involved flora and fauna surveys within the Study Area and focused on landscape features and associated biodiversity which may be sensitive to the impacts of subsidence from longwall extraction. The Study Area was defined by the limit of subsidence associated with proposed Longwalls 905, 709, 710A, 710B and 711.

Literature review

The findings from the MSEC (2021) report form the basis to which the impact assessments for threatened flora, fauna and ecological communities have been assessed in this report.

A significant body of work relating to previous approvals and monitoring for underground mining within the Study Area and surrounds was reviewed as part of this report:

- Illawarra Coal Bulli Seam Operations Project Terrestrial Flora Assessment (FloraSearch 2009).
- Illawarra Coal Bulli Seam Operations Project – Appendix F – Terrestrial Fauna Assessment (Biosphere Environmental Consultants 2009).
- Appin Area 9 Longwalls 901 to 904 Biodiversity Impact Assessment (Biosis 2012).
- Appin Colliery Area 7 Longwalls 705-710 Impacts of Subsidence on Terrestrial Flora and Fauna (Biosis Research 2008).

Summary of methods

The literature review was supplemented with field survey concentrating on landscape features and associated biodiversity which may be sensitive to impacts of subsidence from longwall extraction, such as watercourses and rocky areas. Survey was conducted in August 2020.

Survey activities involved validation of vegetation mapping and habitat assessment. A likelihood of occurrence and impact analysis was conducted for threatened species after considering the literature review and survey results.

Summary of MSEC (2021) conclusions

Natural areas and features sensitive to subsidence within the Study Area include watercourses, cliffs, rock outcrops and steep slopes. Significant conclusions from the MSEC (2021) report, relevant to this BIA include the following:

- It is unlikely that the Nepean River would experience adverse physical impacts due to the mining-induced movements from Longwall 709 to Longwall 711 and Longwall 905.
- It is unlikely that there would be large-scale adverse changes in the levels of ponding or scouring of the banks along the creeks and tributaries within the Study Area due to the mining-induced tilt. The potential impacts of increased ponding and scouring of the drainage lines are expected to be minor and localised. Impacts resulting from changes in surface water flows due to mining-induced tilt are expected to be small in comparison with those which occur during natural flooding conditions.

- Fracturing could develop along the creeks and tributaries due to the mining of the proposed Longwall 709 to Longwall 711 and Longwall 905. Fracturing will predominately occur where the creeks and tributaries are located directly above the mining area. Impacts can also occur outside the mining area, with minor and isolated fracturing occurring at distances up to approximately 400 m outside the longwalls.
- The mining-induced compression due to valley closure effects can also result in dilation and the development of bed separation in the topmost bedrock, as it is less confined. Compression can also result in buckling of the topmost bedrock resulting in heaving in the overlying surface soils.
- Surface water flow diversions could occur along the creeks and tributaries that are located directly above the mining area. 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 creeks and tributaries are ephemeral and, therefore, surface water flows only occur during and for short periods after rain events.
- Previously mined beneath creeks in Appin Areas 7 and 9 have not reported fracturing which resulted in surface water flow diversions, except West Cliff Area 5 (Longwall 29 to Longwall 37), which observed fracturing in the bed of Mallaty Creek and loss of water holding capacity in one pool.
- It is estimated that between 3 % and 5 % of the total length, or between 1 % and 3 % of the total face area of the cliffs that are located directly above the proposed longwalls would experience adverse impacts. Cliffs that are not above the proposed longwalls are not predicted to experience adverse impacts. However, it is possible that isolated rock falls could occur at these cliffs, representing less than 1 % of the total length or total face area.
- Rock outcrops are expected to experience the full range of predicted subsidence movements. It is likely that fracturing would occur where rock outcrops are located directly above the proposed longwalls, and where the rock is marginally stable, this could then result in instabilities.
- As the slopes along the Razorback range are steep, exhibit natural soil erosion and are predicted to experience the full range of predicted subsidence movements, it is likely that the extraction of the proposed longwalls would result in large surface cracks near the tops and along the sides of these slopes. If tension cracks were to develop, as the result of the extraction of the proposed longwalls, it is possible that soil erosion could occur if these cracks were left untreated.
- While in most cases, impacts on steep slopes are likely to consist of surface cracks, there remains a low probability of large-scale downslope movements. Experience indicates that the probability of mining induced large-scale slippages is extremely low due to the significant depth of cover within the Study Area.
- Water quality influences due to mining is expected to be minor in stream reaches within subsidence affected areas. Effects are likely to include temporary changes in water salinity, pH and iron content with local impacts to streambeds and rock faces by iron hydroxide.

Summary of results and impact assessment

Groundwater dependant and riparian vegetation may experience some floristic changes in response to changed groundwater conditions, as a result of subsidence. Two plant community types (PCT) (Table 1) that meet the definition of the Threatened Ecological Community (TEC) under the NSW *Biodiversity Conservation Act 2016* (BC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), display structural and floristic variation within their composite community in response to more frequent contact with shallow groundwater.

Table 1: Threatened ecological communities subject to water fluctuations in the Study Area

Threatened ecological communities	BC Act	EPBC Act
Moist Shale Woodland in the Sydney Basin Bioregion		
PCT830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	E	CE
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions		
PCT835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	E	CE

Habitats such as pools are likely to experience some level of subsidence impacts (comprising both direct and indirect impacts). Subsidence impacts to features such as cliffs, overhangs and rocky outcrops have the potential to occur but are likely to have limited impacts on threatened biodiversity within the Study Area due to the small area of predicted impacts.

One threatened flora species was known to occur in the Study Area, *Pimelea spicata*. Impacts for this species are likely to be minimal, given its occurrence within drier PCTs that are less reliant on groundwater and surface water flows and hence less likely to be impacted by subsidence.

One threatened fauna species, *Myotis macropus* (Southern Myotis) was considered potentially impacted by the proposal. Although due to the minor subsidence predictions in cliffs, impacts are unlikely to be significant to the habitat for the population or individuals within the Study Area.

Impacts of the proposed mine expansion on threatened biodiversity were previously assessed within the BSO Project EIA (BHPBIC 2009). Predicted impacts as a result of the current proposal are likely to be minimal. Therefore, the predicted impacts for the current proposal are consistent with the impact predictions of the BSO EA.

Ongoing monitoring requirements for biodiversity are provided within the recommendations section of the report. Recommendations are focussed around frog and habitat monitoring along watercourses in conjunction with end of panel reports or established aquatic monitoring programs for measuring physical impacts of subsidence.

Glossary and list of abbreviations

Term or abbreviation	Definition
BC Act	NSW *Biodiversity Conservation Act 2016*
BCS	Biodiversity Conservation Science Directorate of DPIE
BHPBIC	BHP Billiton Illawarra Coal, now IMC
BIA	Biodiversity Impact Assessment
BMP	Biodiversity Management Plan
BSO EA	Bulli Seam Operations Environmental Assessment
CEEC	Critically Endangered Ecological Community
DAWE	Commonwealth Department of Agriculture, Water and the Environment
DEE	Commonwealth Department of Environment and Energy, now DAWE
DPE	NSW Department of Planning and Environment, now DPIE
DPIE	Department of Planning, Industry and Environment (formerly OEH)
EEC	Endangered Ecological Community
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ha	Hectares
KTP	Key Threatening Process
IMC	South32 Illawarra Metallurgical Coal
Locality	The area within a 10 kilometre radius of the Study Area
MNES	Matters of National Environmental Significance listed on the EPBC Act
NPWS	National Parks and Wildlife Service
OEH	NSW Office of Environment and Heritage (now DPIE)
Proposal	The development, activity or proposed action
SIS	Species Impact Statement
SMP	Subsidence Management Plan
Study Area	Area potentially directly or indirectly impacted by the proposal
TARP	Trigger Action Response Plan
TEC	Threatened Ecological Community

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1 Introduction

1.1 Background

South32 Illawarra Metallurgical Coal (IMC) owns and operates the Appin Colliery. The Appin Colliery is located in the Southern Coalfield of New South Wales (NSW), approximately 25km west of Wollongong, in the Wollondilly Local Government Area (LGA) (Figure 1). The Appin Colliery uses longwall mining techniques to extract premium quality, hard coking coal (used for steel production) and some energy coal from the Bulli Seam.

In 2009 BHP Billiton Illawarra Coal (BHPBIC, now IMC) sought approval under *Part 3A of the Environmental Planning and Assessment Act 1979* (EP&A Act) to expand its underground coal mining operations at Appin Colliery to extract coal in Areas 5, 7, 8, and 9. Collectively this area is known as the Bulli Seam Operations (BSO Project). On 22nd December 2011 the Planning Assessment Commission (under delegation of the Minister for Planning) approved the BSO Project. This approval allowed IMC to continue mining operations for a further 30 years. In September 2014 IMC sought and gained approval for the Longwalls 901-904 Extraction Plan in Appin Area 9 (IMC 2014) and in April 2020 an extension for the Longwalls 707 to 710 Subsidence Management Plan was approved by DPIE.

An assessment of the impacts of subsidence on terrestrial ecological values in accordance with the EP&A Act and *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) was completed for the BSO Project Part 3A Environmental Assessment (EA) (BHPBIC 2009) and subsequent longwall layouts (IMC 2014 and IMC 2015). The Part 3A EA and subsequent assessments were conducted on a different longwall layout to that referred to in this report.

IMC are now seeking an Extraction Plan approval for a modified layout of Longwall 709 to Longwall 711 and Longwall 905 in Appin Area 9 and Appin Area 7.

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by IMC to prepare a Biodiversity Impact Assessment (BIA) to inform the Biodiversity Management Plan (BMP) component of the Appin Area 9 and Appin Area 7, Longwalls 905, 709, 710A, 710B and 711 Extraction Plan (Figure 1, Figure 2).

1.2 Statutory and other approvals

The statutory obligations with regard to Appin Areas 7 and 9 are contained in:

- The Conditions of Project Approval for the BSO Project
- Relevant biodiversity legislation, including:
    - NSW *Biodiversity Conservation Act 2016* (BC Act)
    - Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

This BIA satisfies Condition 5(i), Schedule 3 of the BSO Approval (08_0150) which states:

Each extraction plan must:

(i) *include a Biodiversity Management Plan, which has been prepared in consultation with OEH and DPI (Fisheries), which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on aquatic and terrestrial flora and fauna, with a specific focus on threatened species, populations and their habitats; endangered ecological communities; and water dependent ecosystems, including (for Appin Areas 7, 8 and 9):*

- *additional targeted surveys for threatened species, sufficient to identify any actions required to protect significant populations from potential impacts.*

This BIA will be used to assist IMC with the development of a BMP for the proposed Longwalls.

1.3 Timeline and project justification

Mine layouts for Appin Area 9 and Appin Area 7 have been developed using IMC's Integrated Mine Planning Process (IMPP). This process considers mining and surface impacts when designing mine layouts. IMC has assessed mining layout options for the Appin Mining lease against the following criteria:

- Extent, duration and nature of any community, social and environmental impacts;
- Coal customer requirements;
- Roadway development and longwall continuity;
- Mine services such as ventilation;
- Recovery of the resource for the business and the State; and
- Gas drainage, geological and geotechnical issues.

Several layout alternatives were assessed by IMC using a multi-disciplinary team including environment, community, mining and exploration expertise. These included variations in the number of longwalls and orientations, lengths, and setbacks of the longwalls from key surface features (Figure 2). These options were reviewed, analysed and modified until an optimised longwall layout in Appin Areas 7 and 9 was achieved (Figure 2).

There are a number of surface and subsurface constraints within the vicinity of the Study Area including major surface water features such as the Nepean River; and a number of geological constraints such as dykes and faults. The process of developing the layout for Longwall 709 to Longwall 711 and Longwall 905 has considered predicted impacts on major natural features and aimed to minimise these impacts within geological and other mining constraints. The layouts in Appin Area 7 and 9 have been modified to reduce the potential for impacts to surface features. The process adopted in designing the mine layout incorporated the hierarchy of avoid/minimise/mitigate as requested by the DPIE and its incorporated Biodiversity Conservation Division (BCD).

1.4 Objectives

The objectives of this BIA include:

- Outline the biodiversity values present within the Study Area using data collected during the BSO Project Part 3A EA, as well as supplementary data collected by Niche.
- Consideration of the existing consent for BSO (Appin and West Cliff Collieries) and BMPs of previously approved adjacent longwalls near the Study Area.
- Identify potential impacts to these biodiversity values resulting from subsidence predictions contained in MSEC (2021).
- Determine if the predicted impacts to biodiversity values differ from those contained within the BSO EIS (BHPBIC 2009).
- Provide recommendations to avoid, minimise and mitigate impacts to identified biodiversity values.
- Report on residual impacts to biodiversity values and ensure they are consistent with the Conditions of the BSO Approval.

1.5 Approach

The approach to this assessment has been informed by previous ecological survey work and impact assessment for the Study Area and surrounds, field survey of the Study Area, current knowledge of subsidence impacts on the landscape, legislative guidelines and consultation.

While biodiversity impact assessments for the Appin Area 9 and Appin Area 7 Study Area has already been completed in the form of previous impact assessments (refer to Section 2) the current assessment is required to ensure that the findings of the previous reports remain relevant to the modified layout of the proposal, given the following:

- Updates to schedules of relevant legislation concerning threatened species (which may confer a different conservation status for certain species or community).
- New information regarding predicted subsidence impacts, the accuracy of previous subsidence predictions and results from monitoring of impacts to ecological features and threatened species.

The impact assessments for the Bulli Seam Operations Plan (BSOP) and other previous longwalls in the Appin Area 9 and 7, which incorporated the majority of the current Study Area, were completed in 2008 and 2012 (Ecology Lab 2008, Biosis Research 2008, Cardno Ecology Lab, 2012, Biosis 2012). Some data gaps within these assessments have been identified in this report, and appropriate surveys completed to address these gaps. The target of the current survey and assessment has been to focus on the ecological values sensitive to the effects of subsidence, as identified in MSEC (2021) and Section 2.2.

1.6 Study Area

Five longwalls (Longwall 905, Longwall 709, Longwall 710A, Longwall 710B and Longwall 711) (hereafter referred to as 'the proposal') have been proposed in the Study Area. The Study Area for the BIA is defined as the surface area that could potentially be affected by vertical subsidence movements as well as any sensitive features where additional subsidence effects may occur as a result of the extraction of coal from longwalls (Figure 2). Additional features that are located outside the 600 m boundary that could experience either far-field horizontal or valley-related effects including: the road bridges and survey control marks.

The Study Area considered within this report (Figure 2) is consistent with the area described in MSEC 2021 as the surface area that could be affected by the mining of the proposal consisting of:

- The 35° angle of draw line from the extent of the proposed Longwall 709 to Longwall 711 and Longwall 905.
- The predicted limit of vertical subsidence, taken as the additional 20 mm subsidence contour, due to the mining of Longwall 709 to Longwall 711 and Longwall 905 only.
- The natural features located within 600 metres (m) of the extent of the longwall mining area, in accordance with Condition 5(i), Schedule 3 of the BSO Approval (08_0150).
    - Primarily watercourses and water related ecosystems, cliffs, rock outcrops and steep slopes.

The Study Area at its largest (Figure 2) constitutes approximately 1,340 ha with a mix of undisturbed bushland, pastureland paddocks and urban development. There are also two main ephemeral creeks (Navigation Creek and Foot Onslow Creek) with their associated streams and watercourses inside the Douglas Park suburbs. These creeks form part of the Hawkesbury-Nepean Catchment. Housing development and agricultural lands occur within the Study Area and are the primary sources of disturbance. There are no drinking water catchment areas or declared special areas within the Study Area (Figure 3).

2 Subsidence predictions for natural features

2.1 Natural features of the Study Area

2.1.1 Rivers, creeks and drainage lines

There are no rivers within the Study Area. The closest river is the Nepean River to the east and south of the Study Area. The Nepean River is located 1.5 km south of the commencing (i.e. western) end of Longwall 710A and 1.6 km east of the finishing (i.e. eastern) end of Longwall 709, at its closest points to the proposed longwalls (MSEC 2021). There are no stream reaches greater than third order located within the Study Area (Table 2). The upper reaches of the third order creeks have shallow incisions into the surface soils, with some sandstone outcropping. Additionally, the first and second order creeks and tributaries have shallow incisions into the natural surface soils (Figure 3), which have been derived from the Wianamatta Group. The lower reaches of the third order creeks have substantial incisions into the surface soils, with exposed sandstone platforms in the bases and rock outcropping in the valley sides. Pools have developed along the lengths of these creeks within the surface soils and rock platforms. In some locations farm dams have also been established (MSEC 2021).

Table 2: Third order creeks located within Study Area (MSEC 2021)

Name	Location	Total length above mining area (km)	Total length within the Study Area (km)
Foot Onslow Creek	Directly above Longwall 708B, Longwall 709 and Longwall 710B	1.5	2.2
Harris Creek	Outside mining area, adjacent to Longwall 706	0	0.4
Navigation Creek	Directly above Longwall 711	1.2	2.1
Navigation Creek Tributary 1	Directly above Longwall 709, Longwall 710B and Longwall 711	1.7	2.2
Total		**4.4**	**6.9**

2.1.2 Swamps, wetlands or water related ecosystems

No swamps or wetlands have been identified within the Study Area. There are water related ecosystems within the Study Area associated with the major streams (MSEC 2021).

2.1.3 Cliffs

Cliffs are defined as '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)' (MSEC 2021).

Seven cliffs have been identified in the western part of the Study Area along Razorback Range, four of which occur directly above proposed longwalls (Longwalls 710A and 905) and the other three occurring between 150 m and 470 m from the longwalls (MSEC 2021). The total length of cliffs that are located within the Study Area is 290 m (MSEC 2021).

Cliffs have also been identified along the Nepean River and Harris Creek; however, these features are located outside the Study Area and are at distances of more than 1 km from the proposed longwalls (MSEC 2021).

Minor cliffs and rock outcrops have also been identified within the Study Area. These rock features are generally located along the steeper sections of the streams (MSEC 2021).

2.1.4 Rock outcrops

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 along the Razorback Range and the incised creeks and tributaries (MSEC 2021).

2.1.5 Steep slopes

A steep slope is defined as "*An area of land having a gradient between 1 in 3 (33% or 18.3º) and 2 in 1 (200% or 63.4º)"* (MSEC 2021).

The steep slopes within the Study Area have been identified along Razorback Range above Longwall 710A, the western end of Longwall 711 and above Longwall 905 (MSEC 2021). Steep slopes are also located above the proposed Longwall 709, Longwall 710B and the eastern end of Longwall 711, and along the ridgeline above the approved Longwall 902 to Longwall 904 (MSEC 2021).

2.2 Subsidence predictions for natural features

Subsidence predictions for the proposal within Appin Area 7 and 9 were investigated and reported by MSEC (2021). Subsidence impacts for natural features prone to subsidence impacts were examined including:

- Major creeks and associated drainage features.
- Cliffs, rock outcrops and steep slopes.

These natural features may provide important habitat for threatened species or constitute TECs and are the focus of this assessment. A summary of the predicted impacts that the proposal will have on these features is described below (Table 3), as documented in MSEC (2021).

Table 3: Predicted subsidence impacts to natural features and potential biodiversity impacts for Longwall 905, 709, 710A,710B and 711 (MSEC 2021; SLR 2021)

Feature	Description of natural feature	Predicted subsidence or surface water impact (MSEC 2021; SLR 2021)	Previously observed impacts in other areas (MSEC 2021)
Nepean River	There are no rivers within the Study Area. The closest river is the Nepean River to the east and south of the Study Area and to the east of the proposed longwalls. The thalweg (i.e. centreline) of the Nepean River is located 1.5 km south of the commencing (i.e. western) end of Longwall 710A and 1.6 km east of the finishing (i.e. eastern) end of Longwall 709, at its closest points to the proposed longwalls (MSEC 2021).	The predicted subsidence effects for the Nepean River, due to the mining of Longwall 709 to Longwall 711 and Longwall 905, are less than 20 mm vertical subsidence, less than 20 mm upsidence and less than 20 mm closure. While the river could experience very low levels of vertical subsidence or valley-related effects, it is not predicted to experience measurable tilts, curvatures or strains. It is unlikely that the Nepean River would experience adverse physical impacts due to the mining-induced movements from Longwall 709 to Longwall 711 and Longwall 905.	Gas release zones have been observed along the river during the mining of longwalls in Areas 7 and 9. Further gas release zones could develop due to the mining of the proposed longwalls.
Creeks and tributaries	The creeks that have third order reaches located within the Study Area are: Foot Onslow Creek, Harris Creek, Navigation Creek and Navigation Creek Tributary 1.	It is unlikely that there would be large-scale adverse changes in the levels of ponding or scouring of the banks along the creeks and tributaries within the Study Area due to the mining-induced tilt. It is possible that localised increased ponding could develop in some isolated locations, where the natural grades are small, and upstream of the chain pillars and the edges of the mining area. The potential impacts of increased ponding and scouring of the drainage lines are expected to be minor and localised. Impacts resulting from changes in surface water flows due to mining-induced tilt are expected to be small in comparison with those which occur during natural flooding conditions (MSEC 2021). Fracturing could develop along the creeks and tributaries due to the mining of the proposed Longwall 709 to Longwall 711 and Longwall 905. Fracturing will predominately occur where the creeks and tributaries are located directly above the mining area. Impacts can also occur outside the mining area, with minor and	Creeks and tributaries have been directly mined beneath by the completed longwalls in Appin Areas 7 and 9. Mining within Appin Areas 7 and 9 has not resulted in observed fracturing resulting in surface water flow diversions (MSEC 2021). Based on the experience of mining beneath ephemeral creeks and tributaries in the Southern Coalfield, it is likely that some fracturing will occur along the streams within the Study Area, particularly those located directly above or adjacent to the mining area. Some standing pools could experience a reduction or loss of water holding capacity (MSEC 2021).

Feature	Description of natural feature	Predicted subsidence or surface water impact (MSEC 2021; SLR 2021)	Previously observed impacts in other areas (MSEC 2021)
		isolated fracturing occurring at distances up to approximately 400 m outside the longwalls (MSEC 2021). The mining-induced compression due to valley closure effects can also result in dilation and the development of bed separation in the topmost bedrock, as it is less confined. This additional dilation due to valley closure is expected to develop predominately within the top 10 m to 20 m of the bedrock (MSEC 2021). Compression can also result in buckling of the topmost bedrock resulting in heaving in the overlying surface soils (MSEC 2021). Surface water flow diversions could occur along the creeks and tributaries that are located directly above the mining area. 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 creeks and tributaries are ephemeral and, therefore, surface water flows only occur during and for short periods after rain events (MSEC 2021; SLR 2021).	
Cliffs	Seven cliffs have been identified in the western part of the Study Area along Razorback Range, four of which occur directly above proposed longwalls and the other three occurring between 150 m and 470 m from the longwalls (MSEC 2021).	Based on the experience of mining beneath cliffs it is estimated that between 3 % and 5 % of the total length, or between 1 % and 3 % of the total face area of the cliffs that are located directly above the proposed longwalls would experience adverse impacts (MSEC 2021). Cliffs RR-CL3, RR-CL5, RR-CL6 and RR-CL7 are located directly above the proposed Longwall 710A and Longwall 905 (Section 5.5 in MSEC 2021). The total length of these cliffs is	There were a total of ten cliff instabilities recorded along the Cataract and Nepean Rivers, due to the mining of Tower Longwalls 1 to 17, all of which occurred where the longwalls mined directly beneath the cliffs. The total length of cliff instabilities due to the mining of Tower Longwalls 1 to 17 was approximately 4 %

Feature	Description of natural feature	Predicted subsidence or surface water impact (MSEC 2021; SLR 2021)	Previously observed impacts in other areas (MSEC 2021)
		approximately 185 m and the total face area is approximately 3,180 m^2. Cliffs RR-CL1, RR-CL2 and RR-CL4 are located outside the mining area at distance varying between 150 m and 470 m (Section 5.5 in MSEC 2021). At these distances, the cliffs are not predicted to experience measurable conventional tilts, curvatures or strains. It is not anticipated, therefore, that adverse impacts would occur to Cliffs RR-CL1, RR-CL2 and RR-CL4. However, it is possible that isolated rock falls could occur at these cliffs, but it is expected that this would represent less than 1 % of the total length or total face area of cliffs (MSEC 2021).	of the total length of the cliffs (MSEC 2021). Tahmoor Longwalls 14 to 19 mined directly beneath the Bargo River. No cliff instabilities were observed during the mining period (MSEC 2021).
Rock outcrops	There are rock outcrops located across the Study Area, primarily along the Razorback Range and the incised creeks and tributaries (MSEC 2021).	These features are expected to experience the full range of predicted subsidence movements. It is likely that fracturing would occur where these features are located directly above the proposed longwalls, and where the rock is marginally stable, this could then result in instabilities.	Previous experience of mining beneath rock outcrops at the Mine indicates that the percentage of rock outcrops that experience adverse impacts is small, representing less than 3 % of the total surface area (MSEC 2021).
Steep slopes	The steep slopes within the Study Area have been identified along Razorback Range above Longwall 710A, the western end of Longwall 711 and above Longwall 905 (MSEC 2021). Steep slopes are also located above the proposed Longwall 709, Longwall 710B and the eastern end of Longwall 711, and along the ridgeline above the approved Longwall 902 to Longwall 904 (MSEC 2021).	Mining-induced tilts are unlikely to result in adverse impacts on the stability of the steep slopes (MSEC 2021). The steep slopes are more likely to be impacted by the mining-induced curvatures and strains. The potential impacts would generally result from the increased horizontal movements in the downslope direction, causing tension cracks to appear at the tops and along the sides of the slopes and compression ridges to form at the bottoms of the slopes (MSEC 2021). As the slopes along the Razorback range are steep, exhibit natural soil erosion and are predicted to experience the full	There is extensive experience of mining beneath steep slopes in the Southern Coalfield. These include steep slopes along the Cataract, Nepean, Bargo and Georges Rivers. No large-scale slope failures have been observed along these slopes, even where longwalls have been mined directly beneath them. Although no large-scale slope failures have been observed in the Southern Coalfield, tension cracking has been observed at

Feature	Description of natural feature	Predicted subsidence or surface water impact (MSEC 2021; SLR 2021)	Previously observed impacts in other areas (MSEC 2021)
		range of predicted subsidence movements, it is likely that the extraction of the proposed longwalls would result in large surface cracks near the tops and along the sides of these slopes (MSEC 2021). If tension cracks were to develop, as the result of the extraction of the proposed longwalls, it is possible that soil erosion could occur if these cracks were left untreated (MSEC 2021). While in most cases, impacts on steep slopes are likely to consist of surface cracks, there remains a low probability of large-scale downslope movements. Experience indicates that the probability of mining induced large-scale slippages is extremely low due to the significant depth of cover within the Study Area (MSEC 2021).	the tops and along the sides of steep slopes as the result of increased horizontal movements in the downslope direction (MSEC 2021). Cracks resulting from downslope movements at depths of cover greater than 400 m, such as the case in the Study Area, have been observed with typical widths in the order of 25 mm to 50 mm (MSEC 2021). Larger cracks have also been observed at the tops of very steep slopes and adjacent to large rock formations, having typical widths in the order of 100 mm to 150 mm or greater (MSEC 2021).

3 Previous surveys

Previous desktop and field assessment work has been conducted within Appin Areas 7 and 9 just south of the Study Area for previous longwall mining approvals and to satisfy approval conditions in regard to monitoring. Relevant documentation was reviewed as part of this BIA with the results of select key relevant assessments summarised in this report (see sections 3.1 to 3.4 below). Threatened species previously recorded in assessments have generally been supplied to BCD (and its predecessors) for inclusion in the Bionet Atlas of NSW Wildlife threatened species database which has been consulted for this assessment. Relevant assessments conducted within Appin Areas 7 and 9 include:

- Illawarra Coal Bulli Seam Operations Project Terrestrial Flora Assessment (FloraSearch 2009).
- Illawarra Coal Bulli Seam Operations Project – Appendix F - Terrestrial Fauna Assessment (Biosphere Environmental Consultants 2009).
- Appin Area 9 Longwalls 901 to 904 Biodiversity Impact Assessment (Biosis 2012).
- Appin Colliery Area 7 Longwalls 705-710 Impacts of Subsidence on Terrestrial Flora and Fauna (Biosis Research 2008).

3.1 Illawarra Coal Bulli Seam Operations Project – Appendix E - Terrestrial Flora Assessment (FloraSearch 2009)

Flora Search prepared a terrestrial flora and vegetation impact assessment for potential subsidence and surface impacts predicted for the BSO Project.

Six Threatened Ecological Communities (TECs) were recorded within the Study Area:

- O'Hares Creek Shale Forest, Shale/sandstone Transition Forest;
- Shale Sandstone Transition Forest;
- Cumberland Plain Woodland;
- River-flat Eucalypt Forest on Coastal Floodplains;
- Moist Shale Woodland in the Sydney Basin Bioregion; and
- Western Sydney Dry Rainforest in the Sydney Basin Bioregion.

These communities were listed as EECs under the then NSW *Threatened Species Conservation Act 1995* (TSC Act, repealed and replaced by the BC Act) and/or the EPBC Act at the time of the report (2009). The assessment concluded that the proposal was unlikely to have a significant impact on any of these EECs. The impacts of surface cracking as the result of systematic subsidence movements was expected to be isolated and of a minor nature due to the relatively low magnitudes of the predicted strains and the relatively high depths of cover for all EECs.

Across the Woronora Plateau, Nepean River and Razorback Ranges, seven species listed as threatened under the TSC Act, including five that are also listed under the EPBC Act, were recorded during the surveys:

- *Pultenaea aristata*
- *Leucopogon exolasius*
- *Epacris purpurascens* var. *purpurascens*

- *Persoonia hirsuta* subsp*. hirsuta*
- *Persoonia bargoensis*
- *Grevillea parviflora* subsp*. parviflora*
- *Pomaderris adnata.*

An additional 11 threatened flora species were known to occur in or close to the Study Area from previous survey work. Eleven species listed as Rare or Poorly Known in Rare or Threatened Australian Plants (ROTAP) were also identified in the Study Area during the survey. No threatened flora species were recorded by Florasearch (2009) within the Study Area for the current assessment.

With minor impacts to specific locations of threatened plants, mitigated through various avoidance measures, the BSO Project was considered unlikely to have a significant impact on any threatened flora species, populations, ecological communities, or their habitats.

3.2 Illawarra Coal Bulli Seam Operations Project – Appendix F - Terrestrial Fauna Assessment (Biosphere Environmental Consultants 2009)

Biosphere Environmental Consultants (Biosphere 2009) prepared a terrestrial fauna impact assessment for potential subsidence and surface impacts predicted for the BSO Project.

The habitats identified within the Study Area were categorised into nine habitat types: Dry Rainforest, Tall Forest, Open Woodland, Gully Forest, Riparian, Low Woodland Heath, Upland Swamp, Cleared Agricultural Land and Water.

Seventeen threatened species were recorded during the surveys:

- Frogs: Giant Burrowing Frog, Red-crowned Toadlet, Littlejohn's Tree Frog.
- Reptiles: Rosenberg's Goanna, Broad-headed Snake.
- Birds: Eastern Ground Parrot, Gang-gang Cockatoo, Square-tailed Kite, Powerful Owl, Black-chinned Honeyeater.
- Mammals: Spotted-tail Quoll, Southern Brown Bandicoot, Koala, Eastern Pygmy-possum, Grey-headed Flying Fox, Eastern Bentwing-bat, Large-footed Myotis.

Of the threatened fauna recorded by Biosphere (2009), Powerful Owl, Large-footed Myosis and Grey-headed Flying-Fox were recorded in close proximity to the Study Area for the current assessment. Potential adverse impacts of the Project on terrestrial fauna and their habitats were assessed and those relating to subsidence include:

- Surface cracking, changes in pool levels, flooding or scouring, changes in stream alignments, changes in the availability of water due to cracking of rock strata in watercourses, changes in water quality, strata gas emissions and rock falls as a result of mine subsidence.

No significant impacts on threatened fauna species were predicted (Biosphere 2009). The following conclusions were made by Biosphere (2009) in relation to subsidence impacts of the BSO Project:

- Along Navigation Creek, there may be isolated instances of iron staining and spikes in water quality parameters such as iron, transient strata gas emission and induced leakage in pools and farm dams.

- Highly unlikely that there would be any observable effects on stream flow or water levels in the Nepean River within this domain (Appin Area 7).

3.3 Appin Area 9 Longwalls 901 to 904 Biodiversity Impact Assessment (Biosis Research 2012)

BHPBIC commissioned Biosis Research to prepare a BIA to inform the BMP component of the Appin Area 9, Longwalls 901 to 904, Extraction Plan (Biosis Research 2012).

Nine vegetation communities were identified as occurring within the Study Area: Shale Sandstone Transition Forest (High and Low Sandstone Influence), Cumberland Plain Woodland (Shale Hills and Shale Plains Woodland), Moist Shale Woodland, Western Sydney Dry Rainforest, Upper Georges River Sandstone Woodland, Western Sandstone Gully Forest, Riparian Scrub.

No threatened flora were recorded in the Biosis Research (2012) surveys, however eight species were considered to have a medium likelihood of occurring in the Study Area (*Cynanchum elegans, Epacris purpurascens,* var*. purpurascens, Grevillea parviflora* subsp*. parviflora, Persoonia bargoensis, Persoonia hirsuta, Pomaderris brunnea, Pterostylis saxicola, Pultenaea pedunculata*).

Three threatened fauna species were recorded in the Study Area and immediate surrounds by Biosis Research (2012) in Open Woodland, Open Forest or Scrub habitat: Cumberland Plain Land Snail, Brown Treecreeper and Koala. Four additional species, Hooded Robin, Speckled Warbler, Southern Myotis and Varied Sittella had been recorded within the Study Area previously. A further twenty two threatened or migratory fauna were considered to have a medium likelihood or greater of occurring in the Study Area (Spotted Harrier, White-bellied Sea Eagle, Little Eagle, Cattle Egret, Gang-gang Cockatoo, Glossy-black Cockatoo, Black-chinned Honeyeater, Rainbow bee-eater, Diamond Firetail, Scarlet Robin, Little Lorikeet, Swift Parrot, Australian Painted Snipe, Latham's Snipe, Barking Owl, Powerful Owl, Spotted-tail Quoll, Eastern Freetail Bat, New Holland Mouse, Grey-headed Flying-fox, Large-eared Pied-bat, Eastern Bentwing-bat).

Potential impacts as assessed by Biosis Research (2012) were found to be largely consistent with those outlined within the BSO EA.

3.4 Appin Colliery Area 7 - Longwalls 705-710 Impacts of Subsidence on Terrestrial Flora and Fauna (Biosis Research 2008)

Biosis Research Pty Ltd (Biosis) prepared a terrestrial flora and fauna impact assessment for potential subsidence impacts predicted for the proposed longwall mining in Appin Area 7, specifically Longwalls 705-710.

Four TECs were recorded within the Study Area: Cumberland Plain Woodland, Shale Sandstone Transition Forest, River-flat Eucalypt Forest and Moist Shale Woodland. These communities were listed as EECs under the then TSC Act and/or the EPBC Act at the time of the report (2008). The assessment concluded that the proposal was unlikely to have a significant impact on any of these EECs.

Twenty one threatened flora species were considered in the report. No threatened flora species were recorded in the Study Area; however *Pultenaea pedunculata* had previously been recorded in the Study Area. The Study Area also provided potential habitat for three threatened flora species: *Eucalyptus benthamii, Pomaderris brunnea* and *Pterostylis saxicola*. The proposal was considered to have the

potential to alter habitat for these species. The assessment concluded that the proposal was unlikely to have a significant impact on any of these threatened plant species.

The Study Area contained limited potential habitat for a total of 42 threatened and/or migratory animal species. Four of the 42 threatened and/or migratory animal species with potential habitat in the Study Area were considered likely to be dependent on surface water for breeding or foraging: Giant Burrowing Frog, Littlejohn's Tree Frog, Red-crowned Toadlet and Large-footed Myotis. The assessment concluded that the proposal was considered unlikely to have a significant impact on any of these threatened and/or migratory animal species.

As possible impacts from subsidence were likely to be restricted to changes in surface flow and water quality in the Nepean River and its tributaries, only animal species which rely on these natural features for their survival were considered in the detailed impact assessment. Large-footed Myotis forages along the creek lines and pools although the minor changes are not significantly impact the species. There were predicted possibilities of minor rockfalls, surface cracking and erosion events although these impacts are likely to be minor and temporary in nature and are unlikely to alter the species composition of distribution of plant communities in the Study Area.

4 Methods

4.1 Previous survey effort

Previous assessments to support the BSO Approval, including terrestrial flora and fauna assessments (Flora Search 2009; Biosphere 2009), included 42 days of surveys across Woronora plateaux, Nepean River and Razorback ridges, 71 quadrat samples, 92 spot samples and 51 random meanders across vegetated areas. Additional terrestrial assessments for Appin Areas 7 and 9 (Biosis Research 2008; Biosis Research 2012) were undertaken on several occasions between 9 September 2003 and 26 February 2004 with an additional three days in February 2006 (Biosis Research 2008), and over four days in July 2010 (Biosis Research 2012).

The survey effort from the previous surveys conducted within Appin Area 7 and 9 and surrounds encompass the majority of the current Study Area and as such Niche will utilise this data and focus on the areas of modified design for the proposed longwalls.

4.1.1 Survey timing

The current project involved flora and fauna habitat surveys within the Study Area and focused on landscape features and associated biodiversity which may be sensitive to the impacts of subsidence from longwall extraction such as threatened ecological communities, waterways and rocky areas. Survey effort focused on areas within the Study Area which had not been subject to previous survey or had limited survey coverage (Figure 5).

Survey was conducted throughout the Study Area on 12 August 2020 by Niche ecologists Sian Griffiths and Sarah Hart. Field survey effort from previous nearby longwalls was also utilised to supplement the survey data from the current survey. Field survey activities are detailed in the following sections.

4.1.2 Flora and vegetation survey

Flora survey focused on vegetation validation of regional vegetation mapping (DPIE 2013) of TECs within the Study Area and opportunistic threatened plant species searches (Figure 4, Figure 5). This process was completed by undertaking Rapid Data Points to record the following:

- Dominant species present at all strata levels.
- Total projective foliage cover and height at all strata levels.

Species composition and characteristics were then compared with PCT descriptions (DPIE 2021). Boundaries between units and sub units were captured in the field by collecting waypoints and tracks along identified boundaries. Where possible, vegetation patterns within PCTS were also observed from surrounding vantage points using binoculars to aid with identifying consistency of vegetation or otherwise across the PCTs.

Field GPS data was later overlaid onto aerial imagery and boundary mapping was completed with adjustments made if necessary, according to observable colour and texture patterns of vegetation as well as observations of tree canopies, which were used to define the outer-boundaries of the PCTs.

Limitations associated with the selected method include reliance on correct positioning of aerial imagery as well as correct interpretation of canopy shadows. Boundaries between communities are frequently not

discrete, rather these communities' grade into one another. Therefore, there is an element of subjectivity regarding the exact positioning of boundaries dependent upon the observer.

4.1.3 Fauna habitat survey

Fauna survey effort focused on areas susceptible to subsidence impacts and associated fauna. Areas targeted included accessible creek lines and largely undisturbed areas of bushland (Figure 5). No targeted surveys were completed as part of this assessment.

4.1.4 Limitations

Survey was conducted during August 2020. Survey focused on biodiversity that could potentially be impacted by subsidence, such as frog habitat and riparian zones sensitive to water loss. Due to the location of the proposed longwalls, access to some private properties was not secured during the current assessment. As such, this constrained the habitat surveys and reduced the capacity to survey the entire Study Area, vegetation was viewed using public vantage points and binoculars to confirm communities with previously mapped areas. Discussions of ecological values for land not ground-truthed, including vegetation mapping and suitable habitat are based on previously published work and interpretation of recent aerial photography.

4.2 Likelihood of occurrence assessment for threatened species

A list of threatened species within the locality (10 km radius) was derived from the following database searches:

- DPIE Bionet Atlas of NSW Wildlife (DPIE 2021) (accessed August 2020).
- EPBC Act Protected Matters Search Tool (Department of the Environment and Energy (DoEE) 2020) (accessed August 2020).

Further records of threatened species were obtained from the previous studies listed in Section 3. The list of potentially impacted species is determined from consideration of the list of threatened species known to occur within the locality. In order to adequately determine the relevant level of assessment for each species, further analysis of the likelihood of those species occurring within the Study Area was undertaken.

Five categories for 'likelihood of occurrence' (Table 4) were attributed to species after consideration of criteria such as known records, presence or absence of important habitat features on the subject site, results of the field surveys and professional judgement. This process was completed for each individual species. Species considered further were those in the 'Known' to 'Moderate' categories and where impacts for the species could reasonably occur from the development (Appendix 1).

Table 4: Likelihood of occurrence methodology

Likelihood rating	Threatened Flora/EEC Criteria	Threatened and Migratory Fauna Criteria
Known	The species/EEC was observed within the Study Area.	The species was observed within the Study Area.
High	It is likely that a species/EEC 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/EEC 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/EEC inhabits the Study Area.	It is unlikely that the species inhabits the Study Area. If present at the site, the species would likely be a transient visitor. The site contains only very common habitat for this species which the species would not rely on for its on-going local existence.
None	The habitat within the Study Area is unsuitable for the species/EEC.	The habitat within the Study Area is unsuitable for the species.

5 Results

5.1 Plant community types

Six PCTs have been mapped as occurring within the Study Area by DPIE (2013) and Niche during the current assessment (Table 5). Regional vegetation mapping was found to be broadly accurate during ground-truthing surveys (Figure 4).

Table 5: Area of vegetation communities within the Study Area

PCT	Keith Formation	Keith Class	Corresponding TEC	BC Act	EPBC Act	Area in Study Area (ha)	Area directly mined beneath (ha)
830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Grassy Woodlands	Coastal Valley Grassy Woodlands	Moist Shale Woodland in the Sydney Basin Bioregion	E	CE	143.07	45.90
835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Forested Wetlands	Coastal Floodplain Wetlands	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E	CE	29.20	13.61
849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Grassy Woodlands	Coastal Valley Grassy Woodlands	Cumberland Plain Woodland in the Sydney Basin Bioregion	CE	CE	26.07	11.39
850 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Grassy Woodlands	Coastal Valley Grassy Woodlands	Cumberland Plain Woodland in the Sydney Basin Bioregion	CE	CE	147.21	55.94
877 Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion	Rainforests	Dry Rainforests	Western Sydney Dry Rainforest in the Sydney Basin Bioregion	E	CE	25.12	3.76
1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Grassy Woodlands	Coastal Valley Grassy Woodlands	Shale Sandstone Transition Forest in the Sydney Basin Bioregion	CE	CE	6.09	1.00
Total vegetation						**376.76**	**131.60**

5.1.1 Plant community type descriptions

All PCT descriptions detailed below have come from the Bionet Vegetation Classification (DPIE 2020).

PCT 830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion

Occurs on protected aspects on steeper shale hills and rises of the southern half of the Cumberland Plain. It differs from the grassy woodlands found in western Sydney by the prevalence of waxy-leaved shrubs and small trees in the understorey and a ground cover of herbs, fleshy twiners and grasses. Some of these species, such as hairy clerodendrum (*Clerodendrum tomentosum*) and slender grape (*Cayratia clematidea*), are hints of the Hinterland Dry Rainforest, a community that occasionally occurs in more protected situations nearby. Across its range in western Sydney the canopy is mostly dominated by forest red gum (*Eucalyptus tereticornis*) and grey box (*Eucalyptus moluccana*).

This unit occurs on the Cumberland Plain Wianamatta shale at elevations between 50 and 300 m above sea level and where mean annual rainfall level reaches between 800 and 900 millimetres. Much of this habitat has been extensively cleared, with remaining stands commonly choked by dense thickets of African olive (*Olea europaea* subsp. *cuspidata*).

PCT 835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion

This community is an open eucalypt forest situated on broad alluvial flats of the Hawkesbury and Nepean river systems. It also forms narrower ribbons alongside streams and creeks that drain the Cumberland Plain. Typically the canopy includes one of either rough-barked apple (*Angophora floribunda*) or broad-leaved apple (*Angophora subvelutina*) and one or both of forest red gum (*Eucalyptus tereticornis*) and cabbage gum (*Eucalyptus amplifolia*). However there are a wide variety of other interesting eucalypts that are highly localised.

The understorey within this riverflat forest is characterised by an occasional sparse to open small tree stratum of paperbark (*Melaleuca* spp.) and wattles (Acacia spp.). A sparse lower shrub layer features blackthorn (*Bursaria spinosa*) at most sites. The ground layer is characterised by an abundant cover of grasses with small herbs and ferns. Cumberland Riverflat Forest occurs at altitudes between one and 160 metres above sea level and with a mean annual rainfall of 750-1000 millimetres.

PCT850 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion

Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion is one of two widespread grassy woodland communities which together are recognised as Cumberland Plain Woodland in the Sydney Basin Bioregion, a Critically Endangered Ecological Community (CEEC). It is an open woodland of grey box (*Eucalyptus moluccana*) and forest red gum *(Eucalyptus tereticornis*) with narrow-leaved ironbark (*Eucalyptus crebra*) also common. Hickory wattle (*Acacia implexa*) occurs amongst the small tree layer, often amongst regrowth stands. This species is one of the more distinctive floristic attributes that helps distinguish between the two components of the CEEC. Other features are similar in that the two woodland units are characterised by an open shrub layer and a grassy ground cover. Fire history can have an important influence on the abundance of shrubs, with density of blackthorn (*Bursaria spinosa*) increasing with time since fire.

The community occupies higher elevations associated with the hills and rises south from Prospect. It is most extensive in Campbelltown and Liverpool local government areas. It extends west across the Razorback range and once dominated the southern half of the Cumberland Plain. It is restricted to mean annual rainfall of between 750 and 900 millimetres and elevations between 50 and 350 metres above sea level (Tozer et al. 2010).

PCT849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion

The gentle topography associated with the shale plains of western Sydney carries an open grassy woodland dominated by grey box (*Eucalyptus moluccana*), forest red gum (*Eucalyptus tereticornis*) and ironbark (*Eucalyptus crebra*/ *Eucalyptus fibrosa*). Cumberland Shale Plains Woodland is the second of the grassy woodlands that comprise the Cumberland Plain Woodland in the Sydney Basin Bioregion CEEC listed under the BC Act and EPBC Act. Like the related community Cumberland Shale Hills Woodland it is typified by a sparse to moderate cover of shrubs and a high cover of grasses and forbs.

The primary habitat for the community as occurring at elevations less than 150 meters above sea level with some sites occurring at higher elevations where the landscape remains gently inclined. Rainfall is restricted to a narrow band between 750 and 950 millimetres per annum (DPIE 2020).

PCT877 Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion

This community occurs on very sheltered clay-rich soils of the undulating hills and ranges of western Sydney and the southern Blue Mountains. Grey myrtle (*Backhousia myrtifolia*) is the most common and abundant rainforest species. Other locally prominent species include fig (*Ficus rubiginosa*), wild quince (*Alectryon subcinereus*) and whalebone tree (*Streblus brunonianus*). The rainforest canopy may include eucalypts (in the Study Area spotted gum (*Corymbia maculata*) is common), wattles and paperbarks. The former is more commonly an emergent layer and the latter prevalent in hillside drainage lines. Several mesic shrubs consistently occur including hairy clerodendrum (*Clerodendrum tomentosum*) and large mock olive (*Notelaea longifolia*). The ground cover is a sparse cover of herbs and ferns.

This rainforest community is also known in the immediate Sydney area as Western Sydney Dry Rainforest and is recognised as a TEC under the BC and EPBC Acts. The community is generally severely disturbed and most stands are now obscured by chronic infestation of African olive (*Olea europaea* subsp. *cuspidata*). It occurs on south-facing aspects generally less than 200 metres in elevation and in zones receiving less than 900 millimetres average annual rainfall.

PCT1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion

Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion is found on the fringes of the Cumberland Plain. It is one of a suite of forests that are associated with the subtle intergrade between clay-rich shale soil and the coarse sandy substrates of the sandstone plateau. The PCT is restricted to the hinterland where mean annual rainfall is relatively low (800-1000 millimetres) and soils have a distinct clay component. It is most extensively distributed on the western edge of the Woronora Plateau and above the Nepean and Georges rivers between Appin and the Holsworthy defence area. It is a moderately tall eucalypt forest with a mixed understorey of sclerophyll shrubs and grasses. Sites invariably have one of two species of ironbark (*Eucalyptus crebra* or *Eucalyptus fibrosa*) present in the canopy along with grey gum (*Eucalyptus*

punctata) and red bloodwood (*Corymbia gummifera*). Spotted gum (*Corymbia maculata*) and blackbutt (*Eucalyptus pilularis*) are included amongst the canopy in the Appin and Wedderburn area respectively. A sparse cover of tall casuarinas (*Allocasuarina littoralis/Allocasuarina torulosa*) is common.

The understorey supports a mix of shrubs that are common on shale substrates such as blackthorn (*Bursaria spinosa*) and those more commonly associated with sandstone soils such as geebungs (*Persoonia* spp.). Beneath this diverse mix of shrubs is a high cover of grass and forbs. The grass layer includes a wide range of species, most of which occur more extensively on the Cumberland Plain.

5.1.2 Threatened ecological communities

All six PCTs identified in the Study Area form part of a TEC (Table 6). These have been identified partially or wholly within the Study Area based on the current layout of the longwalls and within 600m of the extent of the longwall mining area (MSEC 2021) (Figure 4).

Table 6: Threatened ecological communities and corresponding PCTs within the Study Area

Threatened ecological communities	BC Act	EPBC Act
Moist Shale Woodland in the Sydney Basin Bioregion		
PCT830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	E	CE
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions		
PCT835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	E	CE
Cumberland Plain Woodland in the Sydney Basin Bioregion		
PCT849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	CE	CE
PCT850 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	CE	CE
Western Sydney Dry Rainforest in the Sydney Basin Bioregion		
PCT877 Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion	E	CE
Shale Sandstone Transition Forest in the Sydney Basin Bioregion		
PCT1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	CE	CE

5.2 Threatened flora

A total of 22 threatened plant species listed on the EPBC Act and/or BC Act have been previously recorded, or have potential habitat within a 10 km radius of the Study Area (Appendix 1 and Figure 6). Of the 22 threatened species obtained in the database searches, nine species (*Cynanchum elegans, Eucalyptus benthamii, Epacris purpurascens* var*. purpurascens, Grevillea parviflora* subsp*. parviflora, Persoonia bargoensis, Pultenaea pedunculata, Pomaderris brunnea, Pimelea spicata, Pterostylis saxicola*) were considered to have a Moderate to High likelihood of occurrence in the Study Area.

No threatened flora was recorded within the Study Area. Potential impacts to threatened flora are discussed in Section 6.2.

5.3 Fauna habitat

Fauna habitat within the Study Area considered sensitive to subsidence impacts is described below.

5.3.1 Creeks and drainage lines

Two main watercourses within the Study Area include: Navigation Creek and Foot Onslow Creek. Various drainage lines and tributaries of these watercourses occur throughout the Study Area. All creeks and drainage lines within the Study Area are considered to be generally in poor to moderate condition, and provide a range of habitat features including: emergent vegetation, riffles, pools, sandy substrate and rocks. The total length of third order sections of the creeks above the mining areas is 4.4 km (MSEC 2021).

Creek lines are important to particular frog and reptile species including threatened species, with water facilitating the breeding cycle and other lifecycle components of most frogs. The character of drainage lines depends on their size, slope and catchment area, with small ephemeral streams offering important breeding and sheltering habitat for some species while larger permanent streams are preferred by others. Habitat features along the streams include rock pools, riffle zones, gravel beds, woody debris, boulders and aquatic vegetation.

5.3.2 Sandstone outcrops, overhangs and caves

Sandstone outcrops, overhangs and caves are typically important to reptile and bat species. Threatened species that may utilise such features include the Broad-headed Snake and Southern Myotis.

There are seven cliffs that have been identified within the Study Area along the Razorback Range and have formed in the sandstone members of the Wianamatta Group, three of these are directly above the proposed Longwall 710A and Longwall 905, and consequently have the potential for minor fracturing and direct impacts (MSEC 2021).

Caves and overhangs within the Study Area may provide habitat for micro-bats, including threatened species: Eastern Bentwing-bat, Little Bentwing-bat and Southern Myotis. Cave development within the Study Area is poor however, so roosting is likely to be confined to limited areas. No large breeding colonies of cave dependant bats are expected to occur within the Study Area.

5.4 Threatened fauna

A total of 55 threatened fauna species listed on the EPBC Act and or BC Act have been previously recorded, or have potential habitat within a 10 km radius of the Study Area (Appendix 1 and Figure 7). Of the 55 threatened species obtained in the database searches, 28 of these species were determined to have a moderate or high likelihood of occurrence within the Study Area:

- Frogs: *Heleioporus australiacus (*Giant Burrowing Frog), *Litoria Littlejohni* (Littlejohn's Tree Frog).
- Birds*: Callocephalon fimbriatum* (Gang-gang Cockatoo), *Calyptorhynchus lathami* (Glossy Black-Cockatoo), *Chthonicola sagittata* (Speckled Warbler), *Circus assimilis* (Spotted Harrier), *Climacteris picumnus victoriae* (Brown Treecreeper (eastern subspecies)), *Daphoenositta chrysoptera* (Varied

Sittella), *Glossopsitta pusilla* (Little Lorikeet), H*aliaeetus leucogaster* (White-bellied Sea-Eagle), *Hieraaetus morphnoides (*Little Eagle), *Lathamus discolour* (Swift Parrot), *Melanodryas cucullata cucullata* (Hooded Robin (south-eastern form)), *Melithreptus gularis gularis* (Black-chinned Honeyeater), *Ninox connivens* (Barking Owl), *Ninox strenua* (Powerful Owl), *Petroica boodang* (Scarlet Robin), *Rostratula australis* (Australian Painted-snipe) and *Stagonopleura guttata* (Diamond Firetail).

- Mammals: *Chalinolobus dwyeri* (Large-eared Pied-bat), *Dasyurus maculatus* (Spotted-tailed Quoll), *Micronomus norfolkensis* (Eastern Coastal Free-tailed Bat), *Miniopterus australis (*Little Bent-winged Bat), *Miniopterus orianae oceanensis* (Large Bent-winged Bat), *Myotis macropus* (Southern myotis), *Phascolarctos cinereus* (Koala) and *Pteropus poliocephalus* (Grey-headed Flying-fox).
- Invertebrates: *Meridolum corneovirens* (Cumberland Plain Land Snail).

No threatened fauna was recorded within the Study Area, however targeted surveys were not undertaken as part of this assessment. Potential impacts to threatened fauna are discussed in Section 6.4.

5.5 Key threatening processes

There are two KTPs that would potentially be exacerbated by the Proposal, the main known process being listed below:

1. Alteration of habitat following subsidence due to longwall mining.
2. Alteration of the natural flow regimes of rivers, stream, floodplains and wetlands.

There are several other KTPs not relevant to the Proposal (Table 7) as it is unlikely to be exacerbated or greater than current impact as no surface vegetation clearing or disturbance the surface is intended.

Table 7: Key threatening processes

Key Threatening Process	BC Act	EPBC Act equivalent	Exacerbated due to proposal
Aggressive exclusion of birds by noisy miners (*Manorina melanocephala*)	√	√	No
Alteration of habitat following subsidence due to longwall mining	√	x	Yes – see below
Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.	√	x	Yes – see below
Bushrock removal	√	x	No
Clearing of native vegetation	√	√	No
Competition and grazing by the feral European rabbit	√	√	No
Competition and habitat degradation by feral goats	√	√	No
Competition from feral honey bees	√	x	No
Forest Eucalypt dieback associated with over-abundant psyllids and bell miners	√	x	No
Herbivory and environmental degradation caused by feral deer	√	x	No
High frequency fire	√	x	No
Human-caused climate change	√	√	Negligible
Importation of red imported fire ants into NSW	√	√	No
Infection by *Psittacine circoviral* (beak & feather) disease affecting endangered psittacine species	√	√	No
Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis	√	√	No
Infection of native plants by *Phytophthora cinnamomi*	√	√	No

Key Threatening Process	BC Act	EPBC Act equivalent	Exacerbated due to proposal
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	√	x	No
Introduction of the large earth bumblebee (*Bombus terrestris*)	√	x	No
Invasion and establishment of exotic vines and scramblers	√	x	No
Invasion and establishment of Scotch broom	√	x	No
Invasion and establishment of the Cane Toad	√	√	No
Invasion of native plant communities by bitou bush & boneseed	√	x	No
Invasion of native plant communities by exotic perennial grasses	√	(only N. Aust)	No
Invasion of the yellow crazy ant (*Anoplolepis gracilipes*)	√	(only Christmas Island)	No
Invasion, establishment and spread of Lantana (*Lantana camara)*	√	x	No
Invasion by escaped garden plants, including aquatics	√	√	No
Invasion of native plant communities by African Olive (*Olea europaea* L. subsp. *cuspidata*)	√	x	No
Loss of hollow-bearing trees	√	x	No
Loss and/or degradation of sites used for hill-topping by butterflies	√	x	No
Novel biota and their impact on biodiversity	x	√	No
Predation and hybridisation of feral dogs	√	√	No
Predation by the European Red Fox	√	√	No
Predation by feral cats	√	√	No
Predation by the Plague Minnow (*Gambusia holbrooki*)	√	x	No
Predation, habitat degradation, competition and disease transmission by Feral Pigs (*Sus scrofa*)	√	√	No
Removal of dead wood and dead trees	√	x	No

5.5.1 Alteration of habitat following subsidence due to Longwall mining

Alteration of habitat following subsidence due to longwall mining is listed as a KTP under Schedule 4 of the BC Act. This is the most relevant KTP associated with the Project. Subsidence due to longwall mining has been recognised as causing habitat alteration, with species and ecological communities that depend on aquatic and semi-aquatic habitats being particularly susceptible to the impacts of subsidence. Consequently, alteration of habitat following subsidence due to longwall mining has been determined by the NSW Scientific Committee to constitute a KTP (DPIE 2021).

A list of threatened species, populations and TECs potentially impacted by longwall mining is provided in the NSW Scientific Committee Final Determination for this KTP (NSW Scientific Committee 2005). Fauna of relevance to this assessment include: Littlejohn's Tree Frog, Stuttering Frog, Southern Myotis, Red-crowned Toadlet, Grey-headed Flying Fox and Broad-headed Snake. There are no flora listed relevant to this assessment.

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

Alteration of the natural flow regimes of rivers, stream, floodplains and wetlands was listed as a KTP under Schedule 4 of the BC Act. This is a relevant KTP for the proposal as these can be caused by subsidence. Alteration to natural flow regimes can occur through reducing or increasing flows, altering

seasonality of flows, changing the frequency, duration, magnitude, timing, predictability and variability of flow events, altering surface and subsurface water levels and changing the rate of rise or fall of water levels.

5.6 Areas of Outstanding Biodiversity Value (AOBV)

No AOBV have been declared for any ecological values within the Study Area. No AOBV will be impacted by the proposal.

6 Impact assessment

6.1 Potential impacts to vegetation

Vegetation communities which are not dependent on groundwater are unlikely to be impacted by subsidence due to underground mining. This accounts for most of the woodland and forest communities in the Study Area.

Groundwater dependant and riparian vegetation may experience some floristic changes in response to altered groundwater conditions or the release of strata gas, as a result of subsidence.

Riparian vegetation is generally mapped as discrete vegetation communities (e.g. PCT877 and PCT835), these areas display structural and floristic variation within their composite community in response to more frequent contact with shallow groundwater. Riparian vegetation may be potentially impacted by subsidence through water diversion or cracking of bedrock. Should changes in groundwater levels occur, this may impact on the distribution of local vegetation within the riparian vegetation. However, the magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in soils of riparian vegetation.

In the Southern Coalfield, observed impacts to riparian vegetation as a result of subsidence are minor in occurrence. Previous examples of impacts include dieback of riparian vegetation as a result of strata gas releases which occurred nearby Cataract River during the 1990s, and small localised changes to riparian vegetation along a section of the Waratah Rivulet.

Impacts to riparian vegetation associated with the proposal are predicted to be minor in occurrence, being localised if they occurred. Predicted impacts of the proposal on vegetation and TECs are consistent with the predicted impacts from the BSO EA.

6.2 Potential impacts to threatened flora

Nine threatened flora species have been determined to have a moderate to high likelihood of occurring within the Study Area (Appendix 1). However, a limited number have potential habitat likely to be impacted by subsidence (Table 7).

One threatened plant species is known to occur in the Study Area, *Pimelea spicata* (Bionet record, Figure 6). Impacts for this species are likely to be minimal, given its occurrence within drier PCTs that are less reliant on groundwater and surface water flows and hence less likely to be impacted by subsidence.

Impacts of the BSO Project on threatened flora were previously assessed within the BSO Project EA (BHPBIC 2009). Predicted impacts as a result of the current proposal are likely to be minimal. Therefore. the predicted impacts for the current proposal are consistent with the impact predictions of the BSO EA. See details in Table 7 below.

Table 8: Threatened flora with potential to be impacted within the Study Area

Scientific Name	Potential habitat in Study Area	Level of impact according to FloraSearch (2009)	Level of impact according to Biosis (2012)	Level of impact according to Biosis (2008)	Level of impact based on current survey
Cynanchum elegans	Previously recorded in Razorback range. Potential habitat in Western Sydney Dry Rainforest.	Habitat may potentially be subject to mine subsidence related rock falls and land slips. However, the likelihood of rock falls and land slips are reduced due to the high depths of cover above the Bulli Seam in the Razorback Ranges. Significant impact unlikely.	As for BSO EA. Negligible residual risk.	Not considered as no potential habitat present.	Habitat may be impacted by subsidence, but only minimal impacts likely. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Epacis purpurascens var. *purpurascens*	Not previously recorded in Study Area. Open woodland, damp gullies, riparian on shale/ sandstone transition soils.	Habitat could potentially be affected by mechanisms of subsidence. The magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in shale/sandstone transition soils. Therefore, it is unlikely there would be any biologically significant effect on the habitats of threatened shale/sandstone transition species due to soil moisture change. Significant impact unlikely.	As for BSO EA. Negligible residual risk.	Habitat not likely to be impacted by subsidence.	Habitat may be impacted by subsidence, but only minimal impacts likely. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Eucalyptus benthamii	Not previously recorded in Study Area. Potential habitat along larger stretches of Navigation Creek	Not considered.	Not considered.	Habitat could potentially be affected by mechanisms of subsidence. Unlikely to be significantly impacted.	Habitat may be impacted by subsidence, but only minimal impacts likely. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Grevillea parviflora subsp. *parviflora*	Not previously recorded in Study Area. Open woodland on shale/ sandstone transition soils.	Habitat could potentially be affected by mechanisms of subsidence. The magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in shale/sandstone transition soils. Therefore, it is unlikely there would be any biologically significant effect on the habitats of threatened	As for BSO EA. Negligible residual risk.	Habitat not likely to be impacted by subsidence.	Potential habitat occurs within the drier soils of shale/sandstone communities, hence less likely to be impacted by potential hydrological changes due to subsidence. Habitat not likely to be impacted by subsidence.

Scientific Name	Potential habitat in Study Area	Level of impact according to FloraSearch (2009)	Level of impact according to Biosis (2012)	Level of impact according to Biosis (2008)	Level of impact based on current survey
		shale/sandstone transition species due to soil moisture change. Significant impact unlikely.			Predicted impacts as a result of current proposal consistent with predicted impacts in BSO EA.
Persoonia bargoensis	Not previously recorded in Study Area. Open woodland on shale/ sandstone transition soils.	Habitat could potentially be affected by mechanisms of subsidence. The magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in shale/sandstone transition soils. Therefore, it is unlikely there would be any biologically significant effect on the habitats of threatened shale/sandstone transition species due to soil moisture change. Significant impact unlikely.	As for BSO EA. Negligible residual risk.	Habitat not likely to be impacted by subsidence.	Potential habitat occurs within the drier soils of shale/sandstone communities, hence less likely to be impacted by potential hydrological changes due to subsidence. Habitat not likely to be impacted by subsidence. Predicted impacts as a result of current proposal consistent with predicted impacts in BSO EA.
Pimelea spicata	Previously recorded in Study Area. Potential habitat within Cumberland Plain Woodland.	Habitat could potentially be affected by mechanisms of subsidence. The magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in shale/sandstone transition soils. Therefore, it is unlikely there would be any biologically significant effect on the habitats of threatened shale/sandstone transition species due to soil moisture change. Significant impact unlikely.	Not considered.	Habitat not likely to be impacted by subsidence.	Species and its potential habitat occurs within the drier soils of Cumberland Plain Woodland communities, hence less likely to be impacted by potential hydrological changes due to subsidence. Habitat not likely to be impacted by subsidence. Predicted impacts as a result of current proposal consistent with predicted impacts in BSO EA.
Pomaderris brunnea	Not previously recorded in Study Area. Potential habitat along larger stretches of Navigation Creek	Habitat, occurring along the Nepean River, could potentially be affected by subsidence related movements. Deep, loose alluvial soils of active floodplains are mainly wet during flood events and rainfall, and the soil moisture regime is unlikely to be significantly impacted. Due to the design criteria applied to the Nepean River (i.e. avoid significant cracking of rock bars that could result in surface flow diversion and draining of pools) it is highly unlikely the river would be significantly impacted by bedrock tilting, stream realignment or loss of flow to dilated bedrock strata. The alluvial floodplain habitats of *Pomaderris brunnea* are	As for BSO EA. Negligible residual risk.	Habitat could potentially be affected by mechanisms of subsidence. Unlikely to be significantly impacted.	Habitat may be impacted by subsidence, but only minimal impacts likely. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.

Scientific Name	Potential habitat in Study Area	Level of impact according to FloraSearch (2009)	Level of impact according to Biosis (2012)	Level of impact according to Biosis (2008)	Level of impact based on current survey
		unlikely to be modified physically or hydrologically by mining related subsidence. However, there is expected to be strata gas emissions from the bedrock in some locations, which may temporarily affect a population of *Pomaderris brunnea*. However, it is expected that regeneration would occur and that local populations would not be placed at risk of extinction. Significant impact unlikely.			
Pterostylis saxicola	Not previously recorded in Study Area. Potential habitat along larger stretches of Navigation Creek	Habitat could potentially be affected by mechanisms of subsidence. Subsidence may affect the species through rock falls, with potential for the collapse of a sandstone shelf to eliminate a local population of the species, which characteristically occurs in small isolated groups on suitable shelves. However, rock falls are usually small, sporadic and isolated in the landscape with higher intensity events being relatively rare. Large cliff instabilities are not expected. Subsidence cracking of cliff top rock shelves may result in loss of water via cracks and accelerated drying out of moss and lichen beds to the detriment of the species, however the species is adapted to moisture stress. The likelihood of cracks on cliff tops coinciding with rock shelves suitable for the species is low, as is the probability that significant additional moisture stress would result. Therefore, it is considered unlikely that cliff top cracking would significantly affect species. Significant impact unlikely.	As for BSO EA. Negligible residual risk.	Habitat could potentially be affected by mechanisms of subsidence. Unlikely to be significantly impacted.	Habitat may be impacted by subsidence, but only minimal impacts likely. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Pultenaea pedunculata	Not previously recorded in Study Area. Open woodland on shale/ sandstone transition soils.	Habitat could potentially be affected by mechanisms of subsidence. The magnitude of the predicted subsidence effects is considered too small to significantly influence the hydrological processes in shale/sandstone transition soils. Therefore, it is unlikely there would be any biologically significant effect on the habitats of threatened shale/sandstone transition species due to soil moisture change. Significant impact unlikely.	As for BSO EA. Negligible residual risk.	Habitat not likely to be impacted by subsidence.	Habitat may be impacted by subsidence, but only minimal impacts likely. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.

6.3 Potential impacts to fauna

Subsidence may have a direct impact on known and potential habitat for threatened fauna such as watercourses, riparian vegetation, rock overhangs, rocky outcrops, cliffs and crevices. Predicted impacts to these habitats are documented in Section 2. Woodland and forest habitat types make up approximately one third of the Study Area. These habitat types which are not dependent on groundwater are unlikely to be impacted by subsidence. Microhabitat features such as tree hollows and exfoliating bark are also unlikely to be impacted by subsidence.

The proposed longwall layouts are set back from the major watercourse near the Study Area including Nepean River, and as such, subsidence impacts within these areas would be limited (MSEC 2021). Watercourses that are directly mined beneath and those within the 35° angle of draw, are likely to have minor bedrock fracturing with associated impacts such as diversion of surface water flows and draining of pooled water (MSEC 2021). During the mining of previous longwalls within Appin Area 7 and 9 ephemeral creeks with comparable predicted subsidence movements to those of third order creeks within the Project Area showed no reported observed fracturing that has resulted in surface water flow diversion (SLR 2021). The assessment by MSEC (2021) found that although fracturing along streams may occur it is unlikely that there would be a significant loss of surface water yield from the catchment.

The iron and manganese precipitates form an organic flocculant which decomposes and decreases dissolved oxygen, which may impact aquatic fauna and insects, although is highly unlikely to be increased by the Project due to potential minor bedrock cracking. Both such impacts (hydrological and water quality) may extend some distance downstream from the zone of fracturing, with the severity of impacts reducing with distance from the zone of fracturing as a result of dilution, particularly in partially ground-water fed systems.

Overall, 4.4 km of mapped watercourses within the 35 degree angle of draw Study Area are potentially susceptible to subsidence impacts (both direct and indirect), however impacts are likely to be confined to features such as standing pools, which make up a small but important proportion of the overall watercourse. An additional 2.5 km of mapped streams occur within 600 m from the proposed Longwalls. In regard to terrestrial fauna, such impacts are of particular relevance to frog species including the threatened species, Littlejohn's Tree Frog and Giant Burrowing Frog and the Red-crowned Toadlet, which are discussed in detail in Section 6.4.

Impacts on cliff lines, rock outcrops and other rocky habitats within the Study Area are likely to be minor, as observed in previous mining areas. No large-scale cliff collapses or slope failures are predicted, though tension cracks may appear in steep slopes, which could result in erosion without rehabilitation. It is expected that the rock outcrops located directly above the proposed longwalls would experience fracturing and, where the rock is marginally stable, this could then result in instabilities (MSEC 2021).

Previous experience in the Southern Coalfield shows the percentage of rock outcrops that experience adverse impacts is small, representing less than 3 % of the total surface area. Such impacts, while having some potential to alter available roosting or sheltering habitat for a range of species, have limited potential to harm or cause widespread mortality to species given the minimal occurrence of rock falls and collapses predicted, as well as the limited importance of any given area of such habitat (i.e. there is no one area considered to be particularly important for the survival of species within the Study Area, such as roosting bats).

6.4 Potential impacts to threatened fauna

Fifty-five threatened fauna were considered during likelihood of occurrence assessment (Appendix 1), 28 of these species were determined to have a moderate or high likelihood of occurrence within the Study Area. Subsidence impacts from the proposed longwalls are likely to be negligible for the majority of these species. (Table 8).

Assessments of significance under the then TSC Act were previously carried out for nine threatened species during the impact assessment for the BSO EA (Biosphere 2009). An assessment of potential impacts from the current proposal for each of the threatened species identified by Biosphere (2009) as likely to be impacted is also provided below in Table 8.

Subsidence impacts from the proposed longwalls are likely to be negligible for the majority of these threatened fauna species. One species, *Myotis macropus* (Southern Myotis) was considered for this assessment due to potential impacts including: death or injury as result of rock fall or collapse and impacts on prey availability due to drying of pools. Although due to the nature and minor subsidence predictions, these potential impacts are unlikely to be significant for the local population of Southern Myotis within the Study Area.

Impacts of the BSO Project on threatened fauna were previously assessed within the BSO Project EA (BHPBIC 2009). Predicted impacts as a result of the current proposal are likely to be minimal. Therefore, the predicted impacts for the current proposal are consistent with the impact predictions of the BSO EA. See details in Table 8 below.

Table 9: Threatened fauna with moderate to high potential for impacts of Study Area due to the proposal

Species	Recent records and habitat in Study Area and locality	Level of impact according to Bioshpere 2009 (TSC Act)	Level of impact according to Biosis 2008, Biosis 2012	Level of impacts based on Current Survey
Amphibians				
Heleioporus australiacus Giant Burrowing Frog	There are no recent records although there is marginal potential habitat within the ephemeral creeks downstream of Nepean River.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The Study Area provides marginal habitat and the impacts to potential habitat would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Litoria Littlejohni Littlejohn's Tree Frog	There are no recent records although there is marginal potential habitat within the ephemeral creeks downstream of Nepean River.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The Study Area provides marginal habitat and the impacts to potential habitat would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Birds				
Callocephalon fimbriatum Gang-gang Cockatoo	There are no recent records although there is potential foraging, nesting and roosting habitat (tree hollows) habitat within the Study Area.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to potential nesting and roosting habitat (tree hollows) in the Study Area would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.

Species	Recent records and habitat in Study Area and locality	Level of impact according to Bioshpere 2009 (TSC Act)	Level of impact according to Biosis 2008, Biosis 2012	Level of impacts based on Current Survey
Calyptorhynchus lathami Glossy-Black Cockatoo	There are no recent records although there is potential foraging, nesting the roosting (tree hollows) habitat within the Study Area.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to potential nesting and roosting habitat (tree hollows) would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Chthonicola sagittate Speckled Warbler	There is a previous record within the Study Area, towards the more vegetated bushland areas in the west. The Study Area provides potential foraging, nesting and roosting habitat (tree hollows).	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to potential nesting and roosting habitat (tree hollows) in the Study Area would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Circus assimilis Spotted Harrier	There are several records within the locality. The potential habitat in the Study Area consists of the grassland habitat adjacent to open woodland.	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	The impacts to potential habitat in the Study Area (grassland habitat adjacent to open woodlands) would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Climacteris picumnus victoriae Brown Treecreeper (eastern subspecies)	There are several records within the locality. The forests and open woodland in the Study Area provide potential habitat for this species.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to open woodland and forest habitats in the Study Area would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.

Species	Recent records and habitat in Study Area and locality	Level of impact according to Bioshpere 2009 (TSC Act)	Level of impact according to Biosis 2008, Biosis 2012	Level of impacts based on Current Survey
Daphoenositta chrysoptera Varied Sittela	There are several records across the Study Area, towards the more vegetated bushland areas in the west. Potential habitat for this species occurs in the open woodland and forest habitats in the Study Area	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	The impacts to open woodland and forest habitats in the Study Area would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Glossopsitta pusilla Little Lorikeet	There are several records within the locality. The Study Area provides potential foraging, nesting and roosting habitat (tree hollows).	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	The impacts to potential nesting and roosting habitat (tree hollows) in the Study Area would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Haliaeetus leucogaster White-bellied Sea-eagle	There are several records within the locality. The Study Area provides potential foraging habitat for this species in the grassland habitat adjacent to open woodland.	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	The impacts to potential habitat in the Study Area (grassland habitat adjacent to open woodlands) would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Hieraaetus morphnoides Little Eagle	There is a previous records within the Study Area, towards the more vegetated bushland areas in the west. Potential	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	The impacts to potential habitat in the Study Area (grassland habitat adjacent to open

Species	Recent records and habitat in Study Area and locality	Level of impact according to Bioshpere 2009 (TSC Act)	Level of impact according to Biosis 2008, Biosis 2012	Level of impacts based on Current Survey
	habitat for this species occurs in the grassland habitat adjacent to open woodlands in the Study Area.			woodlands) would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Lathamus discolour Swift Parrot	There are no recent records although there is potential foraging, nesting and roosting habitat within the Study Area.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to potential nesting and roosting habitat (tree hollows) would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Melanodryas cucullata cucullate Hooded Robin	There are several records within the locality, towards the more vegetated bushland areas in the west. Potential habitat for this species occurs in the open woodland and forests of the Study Area.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to open woodland and forest habitats in the Study Area would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Melithreptus gularis gularis Black-chinned Honeyeater	There are several records within the locality, towards the more vegetated bushland areas in the west. Potential habitat for this species occurs in the open woodland and forests of the Study Area.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to open woodland and forest habitats in the Study Area would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.

Species	Recent records and habitat in Study Area and locality	Level of impact according to Bioshpere 2009 (TSC Act)	Level of impact according to Biosis 2008, Biosis 2012	Level of impacts based on Current Survey
Ninox connivens Barking Owl	There are no recent records although there is potential foraging, nesting and roosting habitat within the Study Area.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to potential nesting and roosting habitat (tree hollows) would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Ninox strenua Powerful Owl	There are no recent records although there is potential foraging, nesting and roosting habitat within the Study Area.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to potential nesting and roosting habitat (tree hollows) would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Petroica boodang Scarlet Robin	There are several records within the locality, towards the more vegetated bushland areas in the west.	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	The impacts to open woodland and forest habitats in the Study Area would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Rostratula australis Australian Painted-snipe	There are no recent records although there is potential riparian or artificial aquatic habitat within the Study Area.	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	The impacts to potential riparian or artificial aquatic habitats would be insignificant across the Study Area. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.

Species	Recent records and habitat in Study Area and locality	Level of impact according to Bioshpere 2009 (TSC Act)	Level of impact according to Biosis 2008, Biosis 2012	Level of impacts based on Current Survey
Stagonopleura guttata Diamond Firetail	There are several records within the locality . There is potential riparian or artificial aquatic habitat within the Study Area.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to potential riparian or artificial aquatic habitats would be insignificant across the Study Area. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Invertebrates			As for BSO EA. Negligible residual risk	
Cumberland Plain Land Snail *Meridolum corneovirens*	There are several records across the Study Area, towards the more vegetated bushland areas in the west.	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	The Study Area provides marginal open woodland habitat, the impacts to potential habitat would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Mammals			As for BSO EA. Negligible residual risk	
Chalinolobus dwyeri Large-eared Pied-bat	There are several records within the locality.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	Potential impacts include death or injury as result of rock fall or collapse and impacts on prey availability due to drying of pools. Impact not likely to be significant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.

Species	Recent records and habitat in Study Area and locality	Level of impact according to Bioshpere 2009 (TSC Act)	Level of impact according to Biosis 2008, Biosis 2012	Level of impacts based on Current Survey
Dasyurus maculatus maculatus Spotted-tailed Quoll	There are no recent records although there is potential open and/or shrubby woodland and forest habitats within the Study Area.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	The impacts to potential open and/or shrubby woodland and forest habitats in the Study Area would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Micronomus norfolkensis Eastern Coastal Free-tailed Bat	There are several records within the locality.	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	Potential impacts include death or injury as result of rock fall or collapse and impacts on prey availability due to drying of pools. Impact not likely to be significant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Miniopterus australis Little Bent-winged Bat	There are several records within the locality.	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	Potential impacts include death or injury as result of rock fall or collapse and impacts on prey availability due to drying of pools. Impact not likely to be significant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.

Species	Recent records and habitat in Study Area and locality	Level of impact according to Bioshpere 2009 (TSC Act)	Level of impact according to Biosis 2008, Biosis 2012	Level of impacts based on Current Survey
Miniopterus orianae oceanensis Large Bent-winged Bat	There are several records within the locality.	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	The Study Area provides cliffs and overhangs, there are no known roosts in the Study Area and the impacts to potential habitat would be insignificant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Myotis macropus Southern Myotis	There is one recent record to the south of the Study Area along an ephemeral creek, a first order stream from the Nepean River.	AoS undertaken. No significant impacts on the species	As for BSO EA. Negligible residual risk	Potential impacts include death or injury as result of rock fall or collapse and impacts on prey availability due to drying of pools. Impact not likely to be significant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.
Koala *Phascolarctos cinereus*	There are recent records along the Nepean and within suburban areas near the Study Area.	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	Subsidence impacts to the Koala are low as the proposal is unlikely to affect the trees that this species utilises and forages in. Impact not likely to be significant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.

Species	Recent records and habitat in Study Area and locality	Level of impact according to Bioshpere 2009 (TSC Act)	Level of impact according to Biosis 2008, Biosis 2012	Level of impacts based on Current Survey
Grey Headed Flying Fox (GHFF) *Pteropus poliocephalus*	There is a large camp to the south-east of the Study Area along the Nepean River (Biosis 2008), and various BioNet records across the current Study Area.	No AoS undertaken. Impacts to habitats are considered highly unlikely	As for BSO EA. Negligible residual risk	Subsidence impacts to the GHFF are low as the proposal is not directly above or within the campsite and unlikely to affect the trees that this species roosts in. Impact not likely to be significant. Predicted impacts for current proposal consistent with predicted impacts in BSO EA.

7 Monitoring and recommendations

7.1 Existing monitoring and requirements

Findings from subsidence monitoring (creeks, cliffs and rock outcrops and steep slopes) are reported in end of panel reports. Terrestrial ecology monitoring for Appin Areas 7 and 9 includes observation and photo point monitoring, along with targeted monitoring should impacts (e.g. dieback) be identified. No quantitative monitoring for terrestrial ecology is in place for Appin Areas 7 or 9.

7.2 Recommendations for future monitoring

Consistent with previous assessments, observational monitoring of vegetation communities within the Study Area would be undertaken as a part of routine landscape and water monitoring programs. Targeted inspection by a qualified ecologist would occur should vegetation health appear to be impacted.

Habitat monitoring along watercourses is undertaken in conjunction with End of Panel Reports or established aquatic monitoring programs for measuring physical impacts of subsidence. Impacts are to be monitored as a part of ongoing observational monitoring to determine any change in extent or degree of impact with regards to frog habitat and watercourses.

8 Conclusion

Impacts on features from subsidence resulting from longwall mining within the Appin Area are largely predictable given a particular longwall mine layout. This is evidenced through identification of reasonably consistent patterns during monitoring of subsidence impacts.

MSEC (2021) have determined it is unlikely that the Nepean River would experience adverse physical impacts due to the mining-induced movements from Longwall 709 to Longwall 711 and Longwall 905. Further, MSEC (2021) determine that it is unlikely there would be large-scale adverse changes in the levels of ponding or scouring of the banks along the creeks and tributaries within the Study Area due to the mining-induced tilt. While in most cases, impacts to steep slopes are likely to consist of surface cracks, there remains a low probability of large-scale downslope movements. Experience indicates that the probability of mining induced large-scale slippages is extremely low due to the significant depth of cover within the Study Area.

Surface water flow diversions could occur along the creeks and tributaries that are located directly above the mining area. 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 creeks and tributaries are ephemeral and, therefore, surface water flows only occur during and for short periods after rain events.

In addition, habitats such as pools, along a combined length of 4.4 km of watercourses within the 35° angle of draw Study Area, are likely to experience subsidence impacts (comprising both direct and indirect impacts). Subsidence impacts to features such as cliffs, overhangs and rocky outcrops have the potential to occur but are likely to have limited impacts on threatened biodiversity within the Study Area due to the small area of predicted impacts.

Impacts of the BSO Project on threatened biodiversity were previously assessed within the BSO Project EA (BHPBIC 2009). Predicted impacts as a result of the current proposal are likely to be minimal. Therefore, the predicted impacts for the current proposal are consistent with the impact predictions of the BSO EA.

Ongoing monitoring requirements for biodiversity are provided within the recommendations section of the report. Recommendations are focussed around habitat monitoring along watercourses in conjunction with End of Panel Reports or established aquatic monitoring programs for measuring physical impacts of subsidence.

9 References

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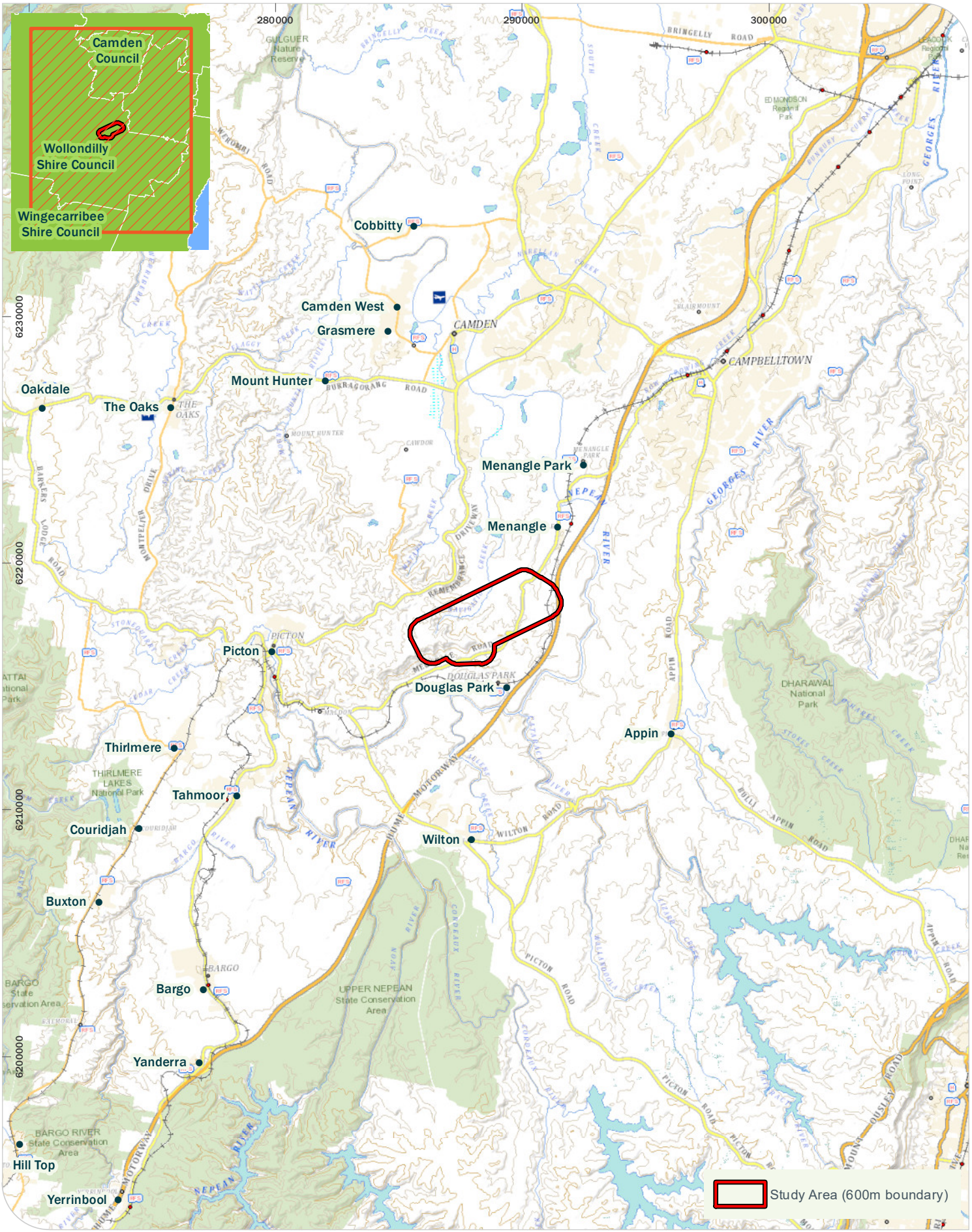
10 Figures



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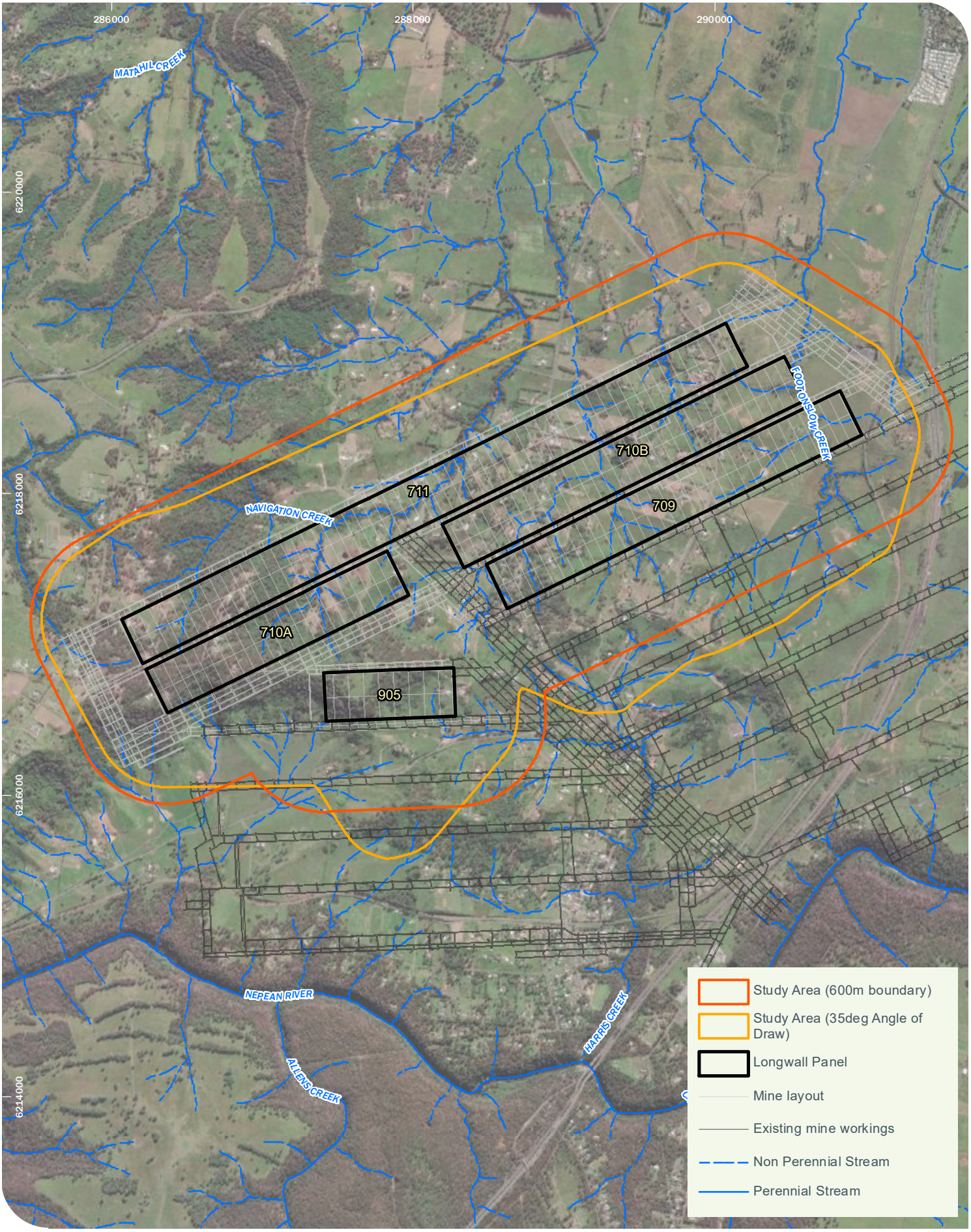
Client: South32 – IMC

Location Map

Appin Mine Biodiversity Impact Assessment

Figure 1



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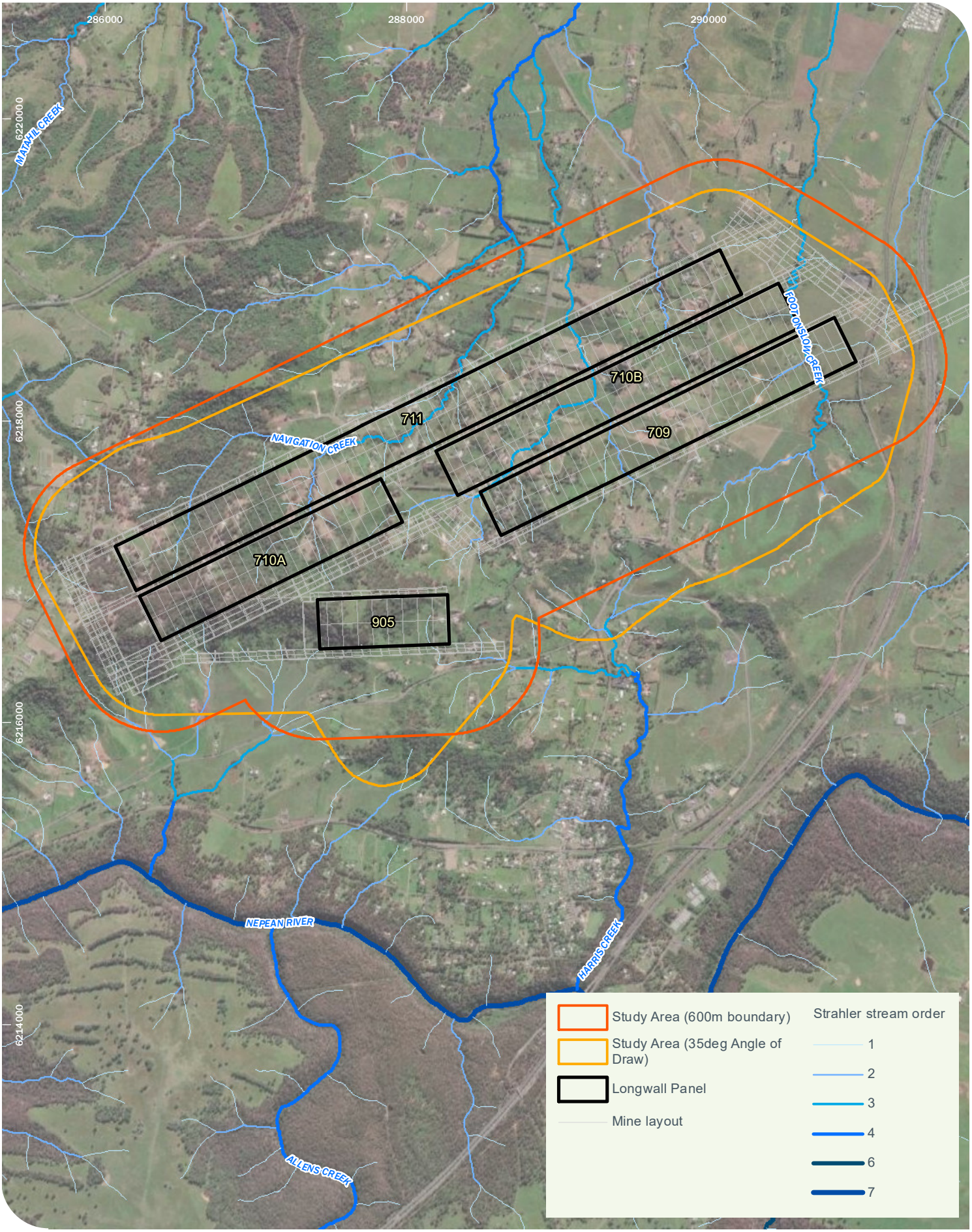
Study Area

Appin Mine Biodiversity Impact Assessment

Figure 2



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0 600

m

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Watercourses

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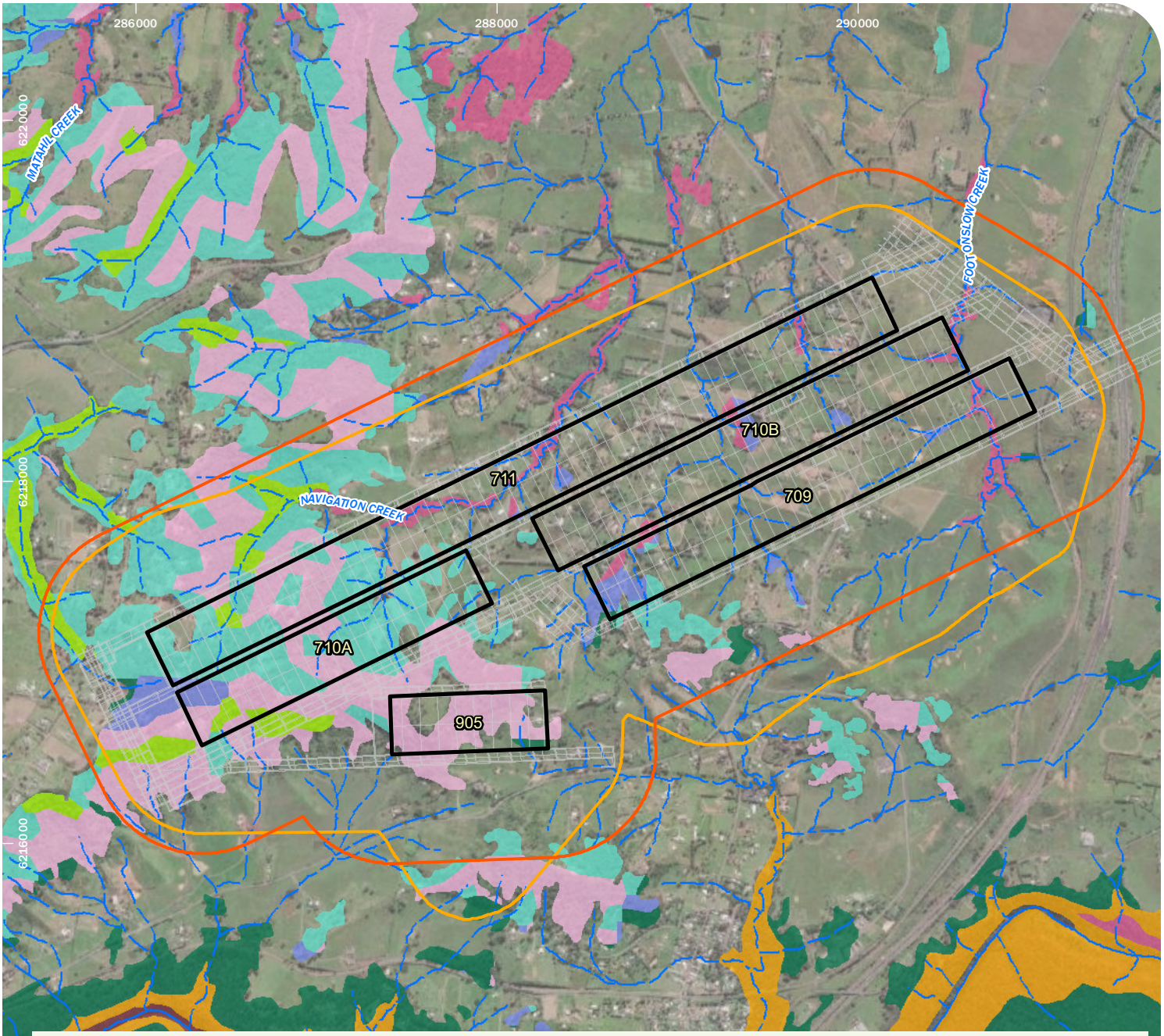
Figure 3

v2.0



Study Area (600m boundary)

Study Area (35deg Angle of Draw)

Longwall Panel

Mine layout

Non Perennial Stream

Perennial Stream

Cumberland Plain West (OEH 2013)

- 830: Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
- 835: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- 849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- 850: Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
- 877: Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
- 1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion
- 1292: Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion
- 1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion

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Vegetation

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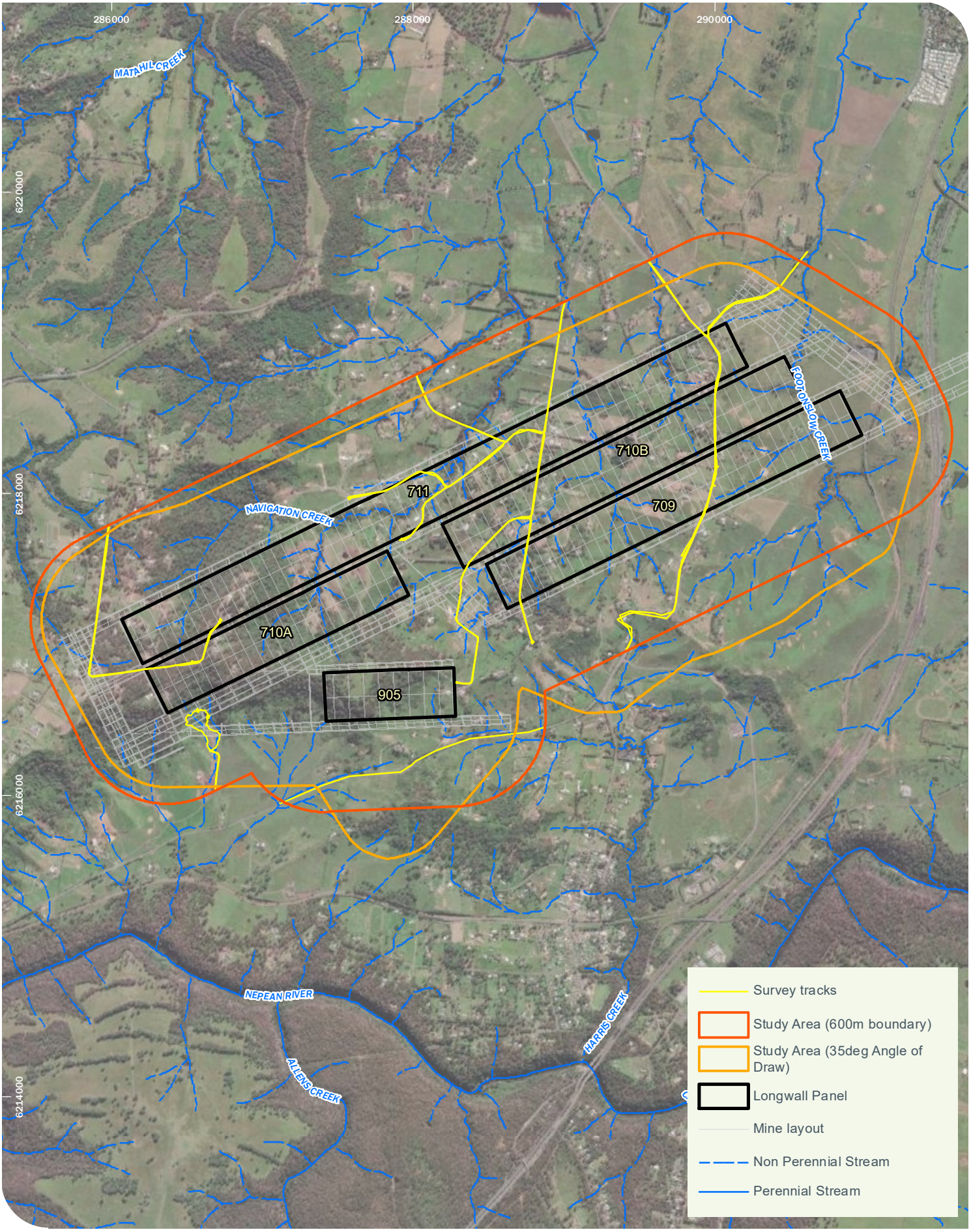
Figure 4



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Survey Effort

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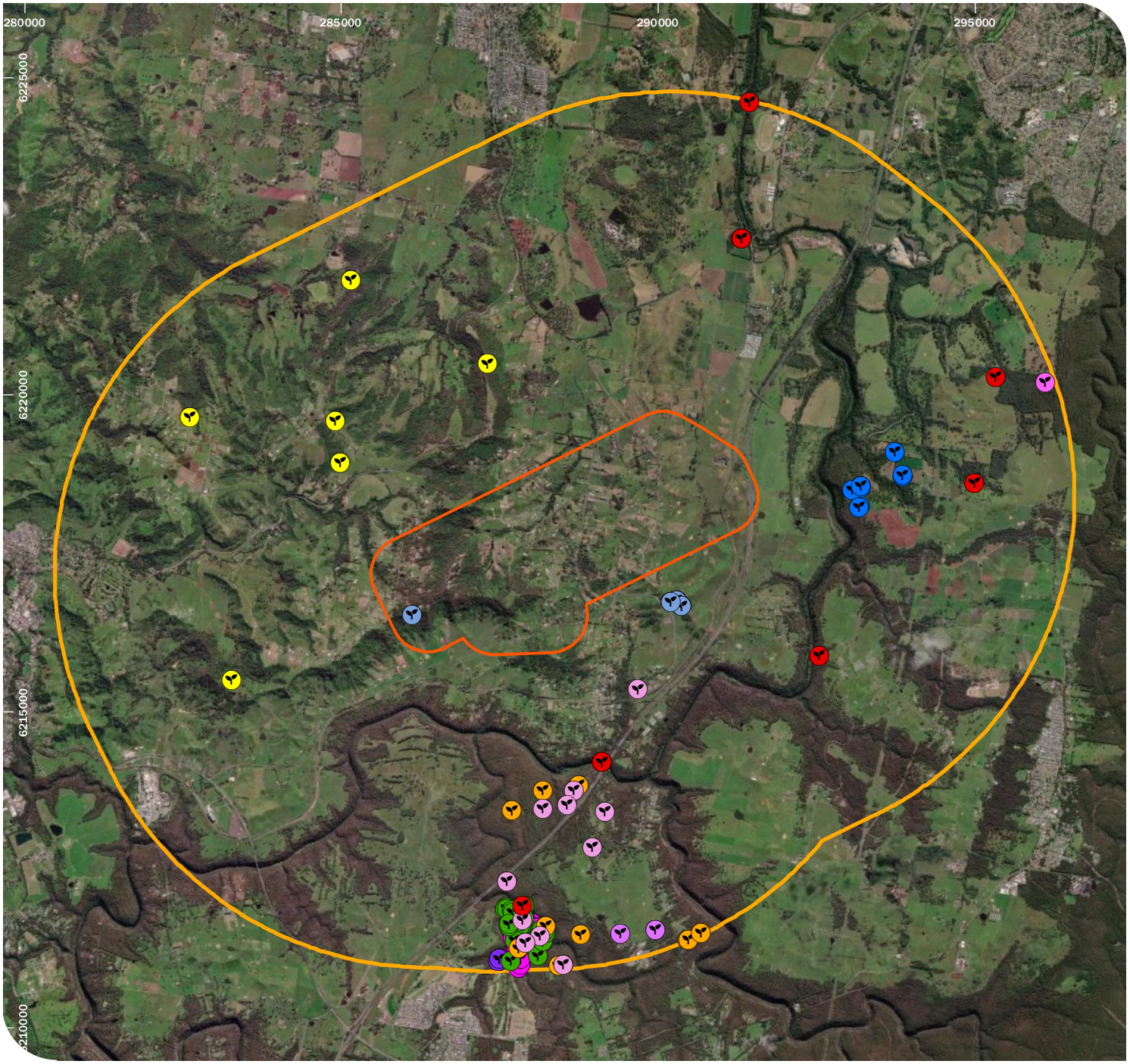
Figure 5



Study Area (600m boundary)

5 km search

Flora

- Acacia bynoeana
- Cynanchum elegans
- Epacris purpurascens var. purpurascens
- Galium australe
- Grevillea parviflora subsp. parviflora
- Isotoma fluviatilis subsp. fluviatilis
- Melaleuca deanei
- Persoonia bargoensis
- Pimelea curviflora var. curviflora
- Pimelea spicata
- Pomaderris brunnea
- Pultenaea pedunculata

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0 2

km

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Threatened Flora within 5 km of the Study Area

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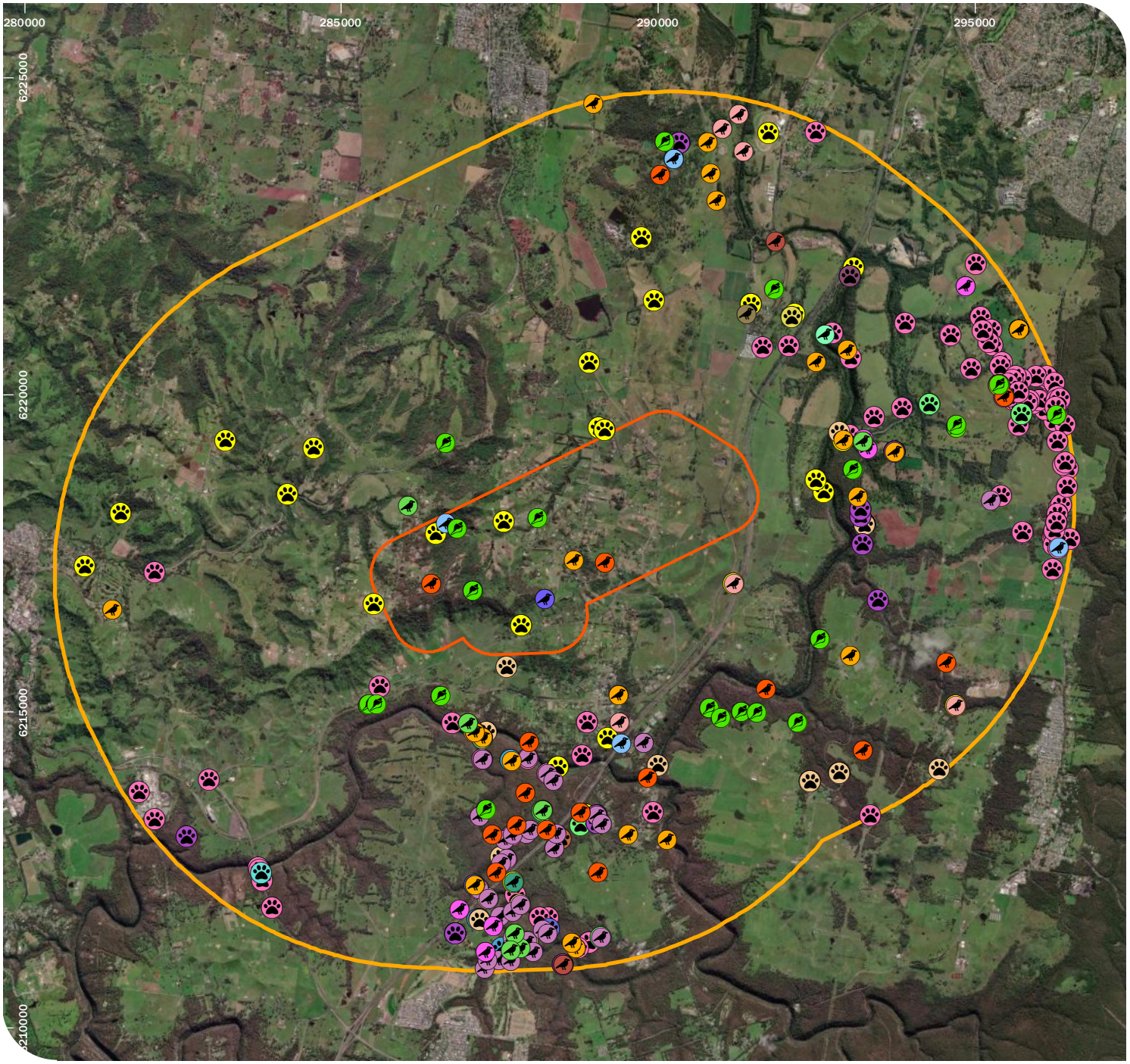
Sensitive species not displayed

Figure 6



Study Area (600m

5 km search

Gastropoda

- Cumberland Plain Land Snail

Aves

- Black-chinned Honeyeater (eastern subspecies)
- Brown Treecreeper (eastern subspecies)
- Diamond Firetail
- Dusky Woodswallow
- Hooded Robin (south-eastern form)
- Little Eagle
- Little Lorikeet
- Regent Honeyeater
- Scarlet Robin
- Speckled Warbler
- Spotted Harrier
- Varied Sittella
- White-bellied Sea-Eagle
- White-throated Needletail

Mammalia

- Eastern Coastal Free-tailed Bat
- Eastern False Pipistrelle
- Greater Broad-nosed Bat
- Greater Glider
- Grey-headed Flying-fox
- Koala
- Large Bent-winged Bat
- Large-eared Pied Bat
- Little Bent-winged Bat
- Southern Myotis
- Squirrel Glider
- Yellow-bellied Sheathtail-bat

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0 2

km

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Threatened Fauna within 5 km of the Study Area

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Sensitive species not displayed

Figure 7

11 Appendices

Appendix 1: Threatened species likelihood of occurrence tables

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
Amphibians						
Heleioporus australiacus	Giant Burrowing Frog	V	V	-	The Giant Burrowing Frog has been recorded breeding in a range of water bodies associated with more sandy environments of the coast and adjacent ranges from the Sydney Basin south the 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.	Moderate
Litoria aurea	Green and Golden Bell Frog	E	V	-	Inhabits a very wide range of water bodies including marshes, dams and streams, particularly those containing emergent vegetation such as bull rushes or spike rushes. 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
Litoria littlejohni	Littlejohn's Tree Frog	V	V	-	Occurs in wet and dry sclerophyll forests and heathland associated with sandstone outcrops between 280 and 1000 m 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.	Moderate
Litoria raniformis	Southern Bell Frog	E	V	-	A highly adaptable and wide-ranging large frog found in a very wide range of habitats to the west of the Great Dividing Range in SW NSW. This includes permanent and ephemeral black box-lignum-nitre goosefoot swamps, lignum-typha swamps and river red gum swamps or billabongs along floodplains and river valleys as well as irrigated rice crops and farm dams in agricultural environments. They prefer areas with emergent aquatic vegetation that they can use for shelter and for basking sites. Individuals can be found sheltering and overwintering under debris or in vegetation immediately adjacent to the breeding sites.	Low
Mixophyes balbus	Stuttering Frog	E	V	-	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

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
Pseudophryne australis	Red-crowned Toadlet	V	-		Occurs on wetter ridge tops and upper slopes of sandstone formations on which the predominant vegetation is dry open forests and heaths. This species typically breeds within small ephemeral creeks that feed into larger semi-perennial streams. After rain these creeks are characterised by a series of shallow pools lined by dense grasses, ferns and low shrubs 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.	Moderate
Birds						
Anthochaera phrygia	Regent Honeyeater	CE	E,M	-	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. The distribution of the species has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. 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
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V	-	-	Dusky woodswallows are widespread in eastern, southern and south western Australia. The species occurs throughout most of New South Wales, but is sparsely scattered in, or largely absent from, much of the upper western region. Most breeding activity occurs on the western slopes of the Great Dividing Range. Primarily inhabit dry, open eucalypt forests and woodlands, including mallee associations, with an open or sparse understorey of eucalypt saplings, acacias and other shrubs, and ground-cover of grasses or sedges and fallen woody debris.	Moderate
Botaurus poiciloptilus	Australasian Bittern	E	E	-	The Australasian Bitterns is widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly 53ubulate53 and spikerushes.	Low
Calidris ferruginea	Curlew Sandpiper	E	-	-	The Curlew Sandpiper is distributed around most of the coastline of Australia. It occurs along the entire coast of NSW, particularly in the Hunter Estuary, and sometimes in freshwater wetlands in the Murray-Darling Basin. It generally occupies littoral and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats of sheltered coasts. It also occurs in non-tidal swamps, lakes and lagoons on the coast and sometimes the inland	Low
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	-	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	Moderate

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
					woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas. It requires tree hollows in which to breed.	
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-	-	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.	Moderate
Chthonicola sagittata	Speckled Warbler	V	-	-	The Speckled Warbler lives in a wide range of eucalypt dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy.	High
Circus assimilis	Spotted Harrier	V	-	-	The Spotted Harrier occurs throughout the Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Individuals disperse widely in NSW and comprise a single population. Occurs in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands.	Moderate
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	-	-	Found in eucalypt woodlands (including box-gum woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and river red gum forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer; fallen timber is an important habitat component for foraging; also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains.	Moderate
Daphoenositta chrysoptera	Varied Sittella	V	-	-	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.	High
Falco hypoleucos	Grey Falcon	E	-	-	Usually restricted to shrubland, grassland and wooded watercourses of arid and semi-arid regions, although it is occasionally found in open woodlands near the coast. Also occurs near wetlands where surface water attracts prey.	Low
Glossopsitta pusilla	Little Lorikeet	V	-	-	Distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range in NSW, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri. Mostly occur in dry, open eucalypt forests and woodlands. They feed primarily on nectar and pollen in the tree canopy. Nest hollows	Moderate

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
					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.	
Haliaeetus leucogaster	White-bellied Sea-Eagle	V	M	-	Inhabits coastal and near coastal areas, building large stick nests, and feeding mostly on marine and estuarine fish and aquatic fauna.	Moderate
Hieraaetus morphnoides	Little Eagle	V	-	-	Most abundant in lightly timbered areas with open areas nearby. Often recorded foraging in grasslands, crops, treeless dune fields, and recently logged areas. May nest in farmland, woodland and forest in tall trees.	High
Lathamus discolor	Swift Parrot	E	E	-	The Swift Parrot occurs in woodlands and forests of NSW from May to August, where it feeds on eucalypt nectar, pollen and associated insects. 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.	Moderate
Lophoictinia isura	Square-tailed Kite	V	-	-	Typically inhabits coastal forested and wooded lands of tropical and temperate Australia. In NSW it is often associated with ridge and gully forests dominated by *Eucalyptus longifolia, Corymbia subulata, E. elata or E. smithii*. Individuals appear to occupy large hunting ranges of more than 100km^2. They require large living trees for breeding, particularly near water with surrounding woodland forest close by for foraging habitat. Nest sites are generally located along or near watercourses, in a tree fork or on large horizontal limbs.	Low
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	-	-	Occupy a wide range of eucalypt woodlands, Acacia shrublands and open forests. The Hooded Robin is widespread, found across Australia, except for the driest deserts and the wetter coastal areas – northern and eastern coastal Queensland and Tasmania. However, it is common in few places, and rarely found on the coast. It is considered a sedentary species, but local seasonal movements are possible. The south-eastern form (subspecies *cucullata*) is found from Brisbane to Adelaide and throughout much of inland NSW, with the exception of the extreme north-west, where it is replaced by subspecies *picata*. Two other subspecies occur outside NSW.	Moderate
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	-	-	In NSW it is widespread, with records from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. It is rarely recorded east of the Great Dividing Range, although regularly observed from the Richmond and Clarence River areas. It has also been recorded at a few scattered sites in the Hunter, Central Coast and Illawarra regions, though it is very rare in the latter.	Moderate

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
Micronomus norfolkensis	Eastern Freetail-bat	V	-		Most records are from dry eucalypt forests and woodlands to the east of the Great Dividing Range. Appears to roost in trees, but little is known of this species' habits	Moderate
Ninox connivens	Barking Owl	V	-		Generally found in open forests, woodlands, swamp woodlands and dense scrub. Can also be found in the foothills and timber along watercourses in otherwise open country.	Moderate
Ninox strenua	Powerful Owl	V	-	-	Occupies wet and dry eucalypt forests and rainforests. Can occupy both un-logged and lightly logged forests as well as undisturbed forests where it usually roosts on the limbs of dense trees in gully areas. It is most commonly recorded within red turpentine in tall open forests and black she-oak within open forests. Large mature trees with hollows at least 0.5 m deep are required for nesting. Tree hollows are particularly important for the Powerful Owl because a large proportion of the diet is made up of hollow-dependent arboreal marsupials. Nest trees for this species are usually emergent with a diameter at breast height of at least 100 cm.	Moderate
Numenius madagascariensis	Eastern Curlew	-	CE, MA, M	-	A primarily coastal distribution. Found in all states, particularly the north, east, and south-east regions including Tasmania. Rarely recorded inland. Mainly forages on soft sheltered intertidal sand flats or mudflats, open and without vegetation or cover. Breeds in the northern hemisphere.	Low
Petroica boodang	Scarlet Robin	V	-	-	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.	Moderate
Pezoporus wallicus	Eastern Ground Parrot	V	-		Currently inhabits south-eastern Australia from southern Queensland through NSW to western Victoria. In NSW populations have been recorded on the north coast (Broadwater, Bundjalung, Yuraygir NPs); Myall Lakes on the central coast; south coast, particularly Barren Grounds NR, Budderoo NP, the Jervis Bay area, Nadgee NR, Morton and Ben Boyd NP. The Ground Parrot occurs in high rainfall coastal and near coastal low heathlands and sedgelands, generally below one metre in height and very dense (up to 90% projected foliage cover).	Low
Rostratula australis	Painted Snipe	E	E, MA	-	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.	Low

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
Rostratula australis	Australian Painted Snipe	E	E, M	-	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.	Moderate
Stagonopleura guttata	Diamond Firetail	V	-	-	Feeds exclusively on the ground, on ripe and partly-ripe grass and herb seeds and green leaves, and on insects (especially in the breeding season). Found in grassy eucalypt woodlands, including box-gum woodlands and snow gum woodlands. Also occurs in open forest, mallee, natural temperate grassland, and in secondary grassland derived from other communities.	Moderate
Invertebrates						
Meridolum corneovirens	Cumberland Plain Land Snail	E	-	-	Primarily inhabits Cumberland Plain woodland (an EEC). This community is a grassy, open woodland with occasional dense patches of shrubs. Lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish.	High
Synemon plana	Golden Sun Moth	E	CE	-	The Golden Sun Moth's NSW populations are found in the area between Queanbeyan, Gunning, Young and Tumut. Occurs in natural temperate grasslands and grassy box-gum woodlands in which groundlayer is dominated by wallaby grasses Austrodanthonia spp.	Low – outside of known populations
Mammals						
Cercartetus nanus	Eastern Pygmy-possum	V	-		Inhabits rainforest through to sclerophyll forest and tree heath. Banksias and myrtaceous shrubs and trees are a favoured food source. Will often nest in tree hollows, but can also construct its own nest. Because of its small size it is able to utilise a range of hollow sizes including very small hollows. 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.	Low
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	-	Located in a variety of drier habitats, including the dry sclerophyll forests and woodlands to the east and west of the Great Dividing Range. 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.	Moderate
Dasyurus maculatus maculatus	Spotted-tailed Quoll	V	E	-	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.	Moderate

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	-	-	Inhabit sclerophyll forests, preferring wet habitats where trees are more than 20 m high. 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.	Low
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E	-	-	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
Micronomus norfolkensis	Eastern Freetail-bat	V	-	-	Most records are from dry eucalypt forests and woodlands to the east of the Great Dividing Range. Appears to roost in trees, but little is known of this species' habits.	Moderate
Miniopterus australis	Little Bentwing-bat	V	-	-	Coastal north-eastern NSW and eastern Queensland. Little Bent-wing 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 Bent-wing Bat has a preference for moist eucalypt forest, rainforest or dense coastal banksia scrub where it forages below the canopy for insects.	Moderate
Miniopterus orianae oceanensis	Large Bentwing-bat	V	-	-	Large Bent-wing 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.	Moderate
Myotis macropus	Southern Myotis	V	-	-	The Large-footed Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. 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.	High
Petauroides volans	Greater Glider	-	V	-	The Greater Glider occurs in eucalypt forests and woodlands. The Greater Glider occurs in eucalypt forests and woodlands. The species nests in hollows and are typically found in older forests. Generally the home range for the greater glider is between 0.7-3 hectares and tends to have a population density of 0.01-5 individuals per hectare. The home ranges of females can overlap with males and females however for the males the home ranges never overlap.	Low
Petrogale penicillata	Brush-tailed Rock-wallaby	E	V	-	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

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
Phascolarctos cinereus	Koala	V	V		Inhabits eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall .	Moderate
Pseudomys novaehollandiae	New Holland Mouse	-	V	-	The New Holland Mouse currently has a disjunct, fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. Across the species' range the New Holland Mouse is known to inhabit open heathlands, open woodlands with a heathland understorey, and vegetated sand dunes.	Low
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	-	This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, melaleuca swamps and banksia woodlands. Bats commute daily to foraging areas, usually within 15 km of the day roost although some individuals may travel up to 70 km.	High
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-	-	Prefer moist gullies in mature coastal forests and rainforests, between the Great Dividing Range and the coast. They are only found at low altitudes below 500 m. 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.	Low
Reptiles						
Hoplocephalus bungaroides	Broad-headed Snake	E	V	-	Mainly occurs in association with communities occurring on Triassic sandstone within the Sydney Basin. Typically found among exposed sandstone outcrops with vegetation types ranging from woodland to heath. Within these habitats they generally use rock crevices and exfoliating rock during the cooler months and tree hollows during summer (Webb 1998).	Low
Varanus rosenbergi	Rosenberg's Goanna	V	-		This species is a Hawkesbury-Narrabeen sandstone outcrop specialist. Occurs in coastal heaths, humid woodlands and both wet and dry sclerophyll forests.	Low
Fish						
Macquaria australasica	Macquarie Perch		E	E	Recent research indicates that there may be at least two distinct forms of Macquarie Perch, one from the western rivers (Murray-Darling Basin form) and one from the eastern rivers (the Shoalhaven and Hawkesbury-Nepean systems) (the coastal form). The species has also been stocked or translocated into a number of reservoirs including Talbingo, Cataract and Khancoban reservoirs and translocated into streams including the Mongarlowe River. Macquarie Perch are found in both river and lake habitats; especially the upper reaches of rivers and their tributaries	Low

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
Prototroctes maraena	Australian Grayling	-	V	-	Historically, this species occurred in coastal streams from the Grose River Valley, southwards through NSW, Vic. And Tas. It also occasionally occurred high upstream in the Snowy R. A single juvenile specimen was collected from Lake Macquarie in 1974 . This species spends only part of its lifecycle in freshwater. The Tambo River population inhabits a clear, gravel-bottomed stream with alternating pools and riffles, and granite outcrops. It has also been associated with clear, gravel-bottomed habitats in the Mitchell & Wonnangatta Rivers but was present in a muddy-bottomed, heavily silted habitat in the Tarwin R.	Low
Plants						
Acacia bynoeana	Bynoe's Wattle	E	V	-	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.	Low
Caladenia tessellata	Thick-lip Spider Orchid	E	V	-	The Tessellated Spider Orchid is found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil. Known from the Sydney area (old records), Wyong, Ulladulla and Braidwood in NSW. Populations in Kiama and Queanbeyan are presumed extinct.	Low
Callistemon linearifolius		V	-		Recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. Recorded in 2000 at Coalcliff in the northern Illawarra. For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River. Grows in dry sclerophyll forest on the coast and adjacent ranges.	Low
Commersonia prostrata	Dwarf Kerrawang	E	E	-	Occurs on sandy, sometimes peaty soils in a wide variety of habitats: snow gum woodland at Rose Lagoon; blue leaved stringybark open forest at Tallong; and in brittle gum low open woodland at Penrose; scribbly gum – swamp mahogany ecotonal forest at Tomago.	Low
Cryptostylis hunteriana	Leafless Tongue-orchid	V	V	-	Does not appear to have well defined habitat preferences and is known from a range of communities, including swamp-heath and woodland. The larger populations typically occur in woodland dominated by Scribbly Gum (*Eucalyptus sclerophylla*), Silvertop Ash (*E. sieberi*), Red Bloodwood (*Corymbia gummifera*) and Black Sheoak (*Allocasuarina littoralis*); appears to prefer open areas in the understorey of this community and is often found in association with the Large Tongue Orchid (*C. 60ubulate*) and the Tartan Tongue Orchid (*C. erecta*).	Low
Cynanchum elegans	White-flowered Wax Plant	E	E	-	Recorded from rainforest gullies scrub and scree slopes from the Gloucester district to the Wollongong area and inland to Mt Dangar.	Moderate

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
Epacris purpurascens var. *purpurascens*		V	-		Recorded from Gosford in the north, to Narrabeen in the east, Silverdale in the west and Avon Dam vicinity in the South. Found in a range of habitat types, most of which have a strong shale soil influence.	Moderate
Eucalyptus benthamii	Camden White Gum	V	V	-	Occurs on the alluvial flats of the Nepean River and its tributaries. There are two major subpopulations: in the Kedumba Valley of the Blue Mountains National Park and at Bents Basin State Recreation Area. Several trees are scattered along the Nepean River around Camden and Cobbitty. At least five trees occur on the Nattai River in Nattai National Park. Requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Occurs in open forest.	Moderate
Genoplesium baueri	Bauer's Midge Orchid	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
Grantiella picta	Painted Honeyeater	V	V	-	Inhabits Boree/ Weeping Myall (*Acacia pendula*), Brigalow (*A. harpophylla*) and Box-Gum Woodlands and Box-Ironbark Forests. A specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias. Prefers mistletoes of the genus Amyema.	Low
Grevillea parviflora subsp. *parviflora*	Small-flowered Grevillea	V	V	-	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	Moderate
Gyrostemon thesioides		E	-	-	Grows on hillsides and riverbanks and may be restricted to fine sandy soils Within NSW, has only ever been recorded at three sites, to the west of Sydney, near the Colo, Georges and Nepean Rivers. The most recent sighting was of a single male plant near the Colo River within Wollemi National Park. The species has not been recorded from the Nepean and Georges Rivers for 90 and 30 years respectively, despite searches. Also occurs in Western Australia, South Australia, Victoria and Tasmania.	Low
Haloragis exalata subsp. exalata	Square Raspwort	V	V	-	Occurs in 4 widely scattered localities in eastern NSW. It is disjunctly 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
Leucopogon exolasius	Woronora Beard-heath	V	V		Grows in woodland on sandstone. Restricted to the Woronora and Grose Rivers and Stokes Creek, Royal National Park.	Low

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
Persoonia bargoensis	Bargo Geebung	E	V	-	The Bargo Geebung occurs in woodland or dry sclerophyll forest on sandstone and on heavier, well drained, loamy, gravelly soils of the Wianamatta Shale and Hawkesbury Sandstone. It favours interface soil landscapes such as between the Blacktown Soil Landscape and the complex Mittagong Formation soils (Lucas Heights Soil Landscape) with the underlying sandstone (Hawkesbury Soil Landscape and Gymea Soil Landscape). Some of the vegetation the species occurs within would be recognised as the Shale/Sandstone Transition Forest.	Moderate
Persoonia hirsuta	Hairy Geebung	E	E	-	Distributed from Singleton in the north, along the east coast to Bargo in the south and the Blue Mountains to the west. A large area of occurrence, but occurs in small populations, increasing the species's fragmentation in the landscape. Found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone. Usually present as isolated individuals or very small populations. Probably killed by fire (as other Persoonia spp. are) but will regenerate from seed.	Low
Persoonia nutans	Nodding Geebung	E	E	-	Confined to aeolian and alluvial sediments and occurs in a range of sclerophyll forest and woodland vegetation communities, with the majority of individuals occurring within Agnes Banks woodland or Castlereagh Scribbly Gum woodland. Restricted to the Cumberland Plain in western Sydney, between Richmond in the north and Macquarie Fields in the south.	Low
Pimelea spicata	Spiked Rice-flower	E	E	-	In both the Cumberland Plain and Illawarra environments this species is found on well-structured clay soils. On the Cumberland Plain sites it is associated with Grey Box communities (particularly Cumberland Plain Woodland variants and Moist Shale Woodland) and in areas of ironbark.	Known. Previous record in Study Area (Figure 6).
Pomaderris brunnea	Brown Pomaderris	V	V	-	The species is expected to live for 10 - 20 years, while the minimum time to produce seed is estimated to be 4 - 6 years. Found in a very limited area around the Colo, Nepean and Hawkesbury Rivers, including the Bargo area. It also occurs at Walcha on the New England Tableland and in far eastern Gippsland in Victoria.	Moderate
Pomaderris adnata		E	-		Known only from one site at Sublime Point, north of Wollongong. Occurs near the edge of the plateau behind the Illawarra escarpment. Associated vegetation is silver-top ash - red bloodwood forest. Soil is a sandy loam over sandstone.	Low
Pomaderris cotoneaster	Cotoneaster Pomaderris	E	E	-	Cotoneaster Pomaderris has a very disjunct distribution and has been recorded in a range of habitats in predominantly forested country. The habitats include forest with deep, friable soil, amongst rock beside a creek, on rocky forested slopes and in steep gullies between sandstone cliffs.	Low
Pterostylis saxicola	Sydney Plains Greenhood	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.	Moderate

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Habitat	Likelihood of Occurrence
Pultenaea aristata		V	V		Grows in moist, dry sclerophyll woodland to heath on sandstone, specifically the drier areas of Upland Swamps. Restricted to the Woronora Plateau, a small area between Helensburgh, south of Sydney, and Mt Keira above Wollongong.	Low
Pultenaea pedunculata		E	-	-	*Pultenaea pedunculata* occurs in a range of habitats. NSW populations are generally among woodland vegetation but plants have also been found on road batters and coastal cliffs. It is largely confined to loamy soils in dry gullies in populations in the Windellama area.	Moderate
Syzygium paniculatum	Magenta Lilly Pilly	E	V	-	Found only in NSW, in a narrow, linear coastal strip from Bulahdelah to Conjola State forest. On the south coast the species occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral rainforest. On the central coast it occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities	Low
Thelymitra kangaloonica	Kangaloon Sun Orchid	CE	CE	-	Thelymitra sp. Kangaloon is only known to occur on the southern tablelands of NSW in the Moss Vale - Kangaloon - Fitzroy Falls area at 550-700 m above sea level. It is known to occur at three swamps that are above the Kangaloon Aquifer. It is found in swamps in sedgelands over grey silty grey loam soils	Low
Thesium australe	Austral Toadflax	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

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

Fauna that are exclusively dependant on marine environments, including near shore environments, were not included in the assessment due to lack of suitable habitat.

Habitat descriptions taken from the relevant profiles on the OEH Threatened Species website unless otherwise stated.

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