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Dendrobium Longwall 19A

Terrestrial Ecological Assessment

Accompanying document to Dendrobium Longwall 19A Subsidence Management Plan

Prepared for South32 Illawarra Metallurgical Coal

Prepared by Niche Environment and Heritage | 30 September 2022

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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 Terrestrial Ecological Assessment for the extraction of Longwall (LW) 19A within Dendrobium Area 3A (DA3A). Initial approval to mine Dendrobium Area 3 was granted in 2001 (DA 60-03-2001) and a modification to the consent was granted in 2008. Development consent was granted following the completion of a number of assessments specific to DA3 including a Species Impact Statement (SIS), which was completed in 2007 as part of the modification.

Further to the 2008 approval, a Subsidence Management Plan (SMP), specific to LW19A within DA3A is required to be approved by the New South Wales Department of Planning, and Environment (DPE) prior to any mining of the proposed LW19A. The SMP must be accompanied by a revised terrestrial ecological assessment to address any recent legislative changes, guidelines and research regarding subsidence associated with longwall mining. This report constitutes the revised terrestrial ecological assessment and is specific to LW19A having regard to the proposed mine design and longwall layout as defined by the Mine Subsidence Engineering Consultants (MSEC) subsidence impact assessment.

The SMP involved flora and fauna surveys within DA3A 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 LW19A.

Natural areas and features sensitive to subsidence within the DA3A study area include Wongawilli Creek, Sandy Creek, watercourses, cliffs, rock outcrops, steep slopes and Upland Swamps. Significant conclusions from the MSEC report, relevant to this study include the following:

- The likelihood of fracturing resulting in surface water flow diversions along Wongawilli Creek is low. However, minor fracturing could still occur along the creek, at distances up to approximately 400 m from the proposed longwall.
- It is unlikely that there would be adverse changes in the potential for ponding, flooding, or scouring of the banks along the Wongawilli and Sandy Creek due to the mining-induced tilt. It is possible, however, that there could be some localised changes in the levels of ponding or flooding where the maximum changes in grade coincide with existing pools, steps or cascades along the creek. It is not anticipated that these changes would result in adverse impacts on the creek.
- It is unlikely that adverse impacts would occur along Sandy Creek or Sandy Creek waterfall due to the mining of LW19 and LW19A.
- The potential impacts of increased ponding and scouring of the drainage lines due to tilt are expected to be minor and localised.
- It is expected that fracturing of the bedrock would occur along the sections of the drainage lines that are located directly above LW19 and 19A. Fracturing can also occur outside the extents of the longwall, with minor and isolated fracturing occurring at distances up to approximately 400 m. Surface water flow diversions are likely to occur along the sections of drainage lines that are located directly above and adjacent to the longwalls.
- There are no cliffs identified within the Study Area based on the 35° angle of draw line and the predicted 20 mm subsidence contour. However, there are six clifflines located within the 600 m boundary study area. The two cliffs (DA3-CF7 and DA3-CF17), located above the future LW19 may experience some additional movements due to the mining of the proposed LW19A. The remaining cliffs

located outside the longwall mining area are not expected to experience adverse impacts due to the mining of LW19A.

- It is likely that fracturing and cracking would occur where rock outcrops and steep slopes are located directly above the proposed longwall. The crack widths could be similar to those previously observed at the mine, which were up to approximately 400 mm in width, but typically in the order of 100 mm to 150 mm in width.
- Fracturing of the bedrock could occur beneath swamps within the study area. Fracturing of the bedrock could occur beneath Den34, Den15a, Den15b, Den15c and Den148 where they are located above and adjacent to the mining area. These swamps have layers of organic soil, and, in most cases, cracking would not be visible at the surface within these swamps, except where the depths of bedrock are shallow or exposed. The dilated strata beneath the drainage lines could result in the diversion of some surface water flows beneath parts of the swamps where they are located above and adjacent to the proposed longwall. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation.
- There are no predicted substantial reductions or reversals of stream grade along the drainage lines within the extents of the swamps. However, there are small reductions in stream grade near to Den34 and Den148. There is potential for minor and localised increased ponding upstream of these locations.

Literature review

The findings from the MSEC 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 other work relating to previous approvals and monitoring for underground mining within DA3A and DA3B was reviewed as part of this report with major reports summarised in Section 3.

Summary of methods

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 swamps, watercourses and rocky areas. Survey was conducted between June and August 2022.

Survey activities included vegetation validation of Upland Swamps, and diurnal and nocturnal frog and tadpole searches. A likelihood of occurrence and impact analysis was conducted for threatened species after considering the literature review and survey results.

Summary of results and impact assessment

Ground-truthing of upland swamp community mapping resulted in changes to upland swamp sub-community patterns, swamp boundaries and changes in vegetation communities. Seven Upland Swamps occur within the wider study area with complexity of swamps generally increasing with overall size. Two of the complex larger swamps are within the predicted area of subsidence impacts (35-degree angle of draw study area). Based on previous subsidence monitoring, a maximum impact area for swamps was calculated at 9.53 hectares constituting the Upland Swamps within or along the 35-degree angle of draw study area.

Habitats such as pools, primarily located on Wongawilli Creek (0.8 km) and Sandy Creek (1.2 km), of which 2 km in total crosses the 600 m study area for LW19A, 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.

Four threatened plant species (*Epacris purpurascens var. purpurascens, Pultenaea aristata, Cryptostylis hunteriana* and *Leucopogon exolasius)* were deemed to have habitat in the study area that may be potentially impacted by subsidence, however, impacts for these species are likely to be minimal.

During the field assessment, approximately 79 *Leucopogon exolasius* individuals were identified on sandy alluvium within the riparian corridor of the tributary off Wongawilli Creek that intersects the 600 m study area. This species is often found on rocky sandstone hillsides near creeks, and the impacts of subsidence on this species are not well documented. Given the species affinity to riparian habitats and sandstone substrate, it is assumed that any major bedrock cracking in the locality may impact microhabitats and water availability for the species.

Glossy Black-Cockatoo was recorded in the study area (chewed cones identified within the footprint), however the likelihood of this species or its habitat being impacted by subsidence is low. Nine threatened fauna species are considered to be potentially impacted by subsidence resulting from LW19A comprising:

- Frogs: Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet
- Reptiles: Broad-headed Snake, Rosenberg's Goanna
- Mammals: Large Bentwing Bat, Little Bentwing Bat, Southern Myotis
- Invertebrates: Giant Dragonfly.

From the above species, it is considered that potentially significant impacts could occur for the three frog species and the Giant Dragonfly.

Ongoing monitoring requirements for biodiversity are provided within the recommendations section of the report. Recommendations are focussed on swamp and frog monitoring along watercourses in concert with established programs for measuring physical impacts of subsidence.

Glossary and list of abbreviations

Term or abbreviation	Definition
BC Act	NSW *Biodiversity Conservation Act 2016*
BCD	Biodiversity Conservation Division of DPE (now Biodiversity Conservation and Science, BCS)
DA3	Dendrobium Area 3
DA3A	Dendrobium Area 3A
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DEE	Commonwealth Department of Environment and Energy (now DCCEEW)
DPE	NSW Department of Planning and Environment
EEC	Endangered Ecological Community
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ESSGW	Exposed Sandstone Scribbly Gum Woodland
ha	Hectares
KTP	Key Threatening Process
IMC	South32 Illawarra Metallurgical Coal
Locality	The area within a 10-kilometre radius of the study area
LW	Longwall
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 DPE)
Proposal	the development, activity or proposed action, LW19A
SGPF	Sandstone Gully Peppermint Forest
SIS	Species Impact Statement
SMP	Subsidence Management Plan
Study area	Area potentially directly or indirectly impacted by the proposal
TARP	Trigger Action Response Plan
THPS	Temperate Highland Peat Swamps
TSC Act	NSW *Threatened Species Conservation Act 1995* (repealed by the *BC Act*)
USBT	Upland Swamp: Banksia Thicket
USTTT	Upland Swamp: Tea Tree Thicket
USSHC	Upland Swamp: Sedgeland Heath Complex
USFEW	Upland Swamp: Fringing Eucalypt Woodland

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1 Introduction

1.1 Background and need for the project

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by South32 Illawarra Metallurgical Coal (IMC) to prepare a Terrestrial Ecological Assessment for the extraction of Longwall (LW) 19A within Dendrobium Area 3A (DA3A) (Figure 1). Initial approval to mine Dendrobium Area 3 (DA3) was granted in 2001 (DA 60-03-2001) and a modification to the consent was granted in 2008 (Figure 2). Development consent was granted following the completion of a number of assessments specific to DA3 including a Species Impact Statement (SIS), which was completed in 2007 (Biosis 2007) as part of the modification.

Further to the 2008 approval, a Subsidence Management Plan (SMP) for LW19A within DA3A (Figure 1 and Figure 2) is required to be approved by the New South Wales (NSW) Department of Planning and Environment (DPE) prior to any mining of the proposed LW19A. The SMP must be accompanied by a revised terrestrial ecological assessment to address any recent legislative changes, guidelines and research regarding subsidence associated with longwall mining. This report constitutes the revised terrestrial ecological assessment and is specific to the proposed LW19A in DA3A having regard to the proposed mine design as defined by Mine Subsidence Engineering Consultants (MSEC) subsidence impact assessment (MSEC 2022).

This ecological report has been prepared to meet the relevant sections of the *NSW Department of Primary Industries Guideline for Applications for Subsidence Management Approvals December 2003*.

1.2 Statutory and other approvals

1.2.1 Landscape approval

Approval to mine DA3 was granted by the Department of Planning in 2001. In 2007, IMC applied to modify the approval for Dendrobium Mine pursuant to section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act). A SIS was conducted, and an environmental assessment completed to support the proposal to modify the footprint of DA3.

Since the Dendrobium mine was approved by the Commonwealth of Australia as a controlled action under the *Environment Protection and Biodiversity Act 1999* (EPBC Act) in December 2001, approval within this assessment is not required under the EPBC Act. Threatened species and threatened ecological communities (TECs) listed under the EPBC Act have been considered within this report, however revised impact assessments for species listed under the EPBC Act are not required.

1.3 Timeline and project justification

LW19A is scheduled to be extracted between February 2023 – September 2023.

Mine layouts for DA3A 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 DA3A 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

- Gas drainage, geological and geotechnical issues.

Several layout alternatives for DA3A 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.

These options were reviewed, analysed and modified until an optimised longwall layout in DA3A was achieved. DA3A is part of the overall mining schedule for Dendrobium Mine and has been designed to flow on from (and return to) Areas 1, 2 3A, 3B and 3C to provide a continuous mining operation. There are a number of surface and subsurface constraints within the vicinity of DA3A including major surface water features such as Lake Cordeaux and Wongawilli Creek; and a number of geological constraints such as dykes, faults, and particularly the Dendrobium Nepheline Syenite Intrusion. The process of developing the layout for DA3A has considered predicted impacts on major natural features and aimed to minimise these impacts within geological and other mining constraints. The layouts at Dendrobium Mine have been modified to reduce the potential for impacts to surface features.

The process adopted in designing the DA3A mine layout incorporated the hierarchy of avoid/minimise/mitigate as requested by the DPE and its incorporated Biodiversity Conservation and Science Division (BCS).

1.4 Consultation

IMC have consulted with key Government Agencies (e.g., DPE and WaterNSW) during the development of the SMP.

2 Description of the study area and subsidence predictions

2.1 Study area

One longwall (LW19A) (hereafter referred to as the proposal) has been proposed in the study area. The study area considered within this report (Figure 2) is consistent with the area described in MSEC (2022) as the surface area that could be affected by the mining of the proposed LW19A (area of longwall approximately 24 hectares [ha]) consisting of:

- The 35° angle of draw line from the extents of the proposed LW19A
- The predicted limit of vertical subsidence, taken as the 20 millimetres (mm) subsidence contour, resulting from the extraction of the proposed longwalls
- The natural features located within 600 metres (m) of the extent of the longwall mining area, in accordance with Condition 8(d) of the Development Consent DA 60-03-2001.

The study area at its largest (Figure 2) constitutes approximately 415 ha of largely undisturbed bushland and watercourses of the Cordeaux River Catchment inside the WaterNSW Metropolitan Special Area. The Cordeaux River is part of the Hawkesbury-Nepean Catchment.

Fire roads, easements and active and rehabilitating trails as well as exploration drilling sites occur within the study area and are the primary sources of disturbance. The study area is in WaterNSW controlled land and is contiguous with a large reserve system which includes the Upper Nepean State Conservation Area to the west and the Illawarra Escarpment Area to the east (Figure 1).

2.1.1 Creeks and waterways

The major permanent waterway within the study area, Wongawilli Creek, flows northwards through the western section of the study area and joins the Cordeaux River approximately 11.5 kilometres (km) to the north (Figure 2, Figure 3). Pools and riffle zones in Wongawilli Creek are permanent and naturally develop upstream of rockbars and at areas of sediment and debris accumulations (Figure 3).

Sandy Creek runs parallel to Wongawilli Creek to its east, to the east of the study area (Figure 2). Smaller tributary streams traverse the study area flowing into Wongawilli Creek, Sandy Creek and Lake Cordeaux to the east (outside of the study area). Lake Cordeaux or Cordeaux Dam is one of several large artificial waterbodies in the locality used for drinking water catchment.

A number of waterways throughout the study area have Upland Swamps at their headwaters or along other sections. Swamps within the study area act as a buffer for surface flow allowing for more continuous and even water flows along streams after rain events.

2.2 Predicted mine subsidence for natural features

Subsidence predictions for LW19A within DA3A were investigated and reported by MSEC (2022). Subsidence impacts for natural features prone to subsidence impacts were examined including:

- Major creeks and associated drainage features
- Swamps
- 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 1), as documented in MSEC (2022).

Table 1: Predicted subsidence impacts to natural features and potential biodiversity impacts for LW19A (MSEC 2022 and HGeo 2022)

Feature	Description of natural feature	Predicted subsidence or surface water impact LW19A	Previously observed impacts in other areas
Wongawilli Creek	Wongawilli Creek is a third order perennial stream with a small base flow and increased flows for short periods of time after each significant rain event. The creek generally flows in a northerly direction and drains into the Cordeaux River. Pools in the creek are permanent (based on monitoring to date) and naturally develop behind the rockbars and at sediment and debris accumulations. Wongawilli Creek is situated on the western side of the longwalls in DA3A. The currently active longwalls in DA3B are being mined on the western side of the creek.	Wongawilli Creek is predicted to experience less than 20 mm vertical subsidence, 40 mm upsidence and 40 mm closure due to the extraction of the proposed longwall. It is unlikely that there would be adverse changes in the potential for ponding, flooding, or scouring of the banks along the creek due to the mining-induced tilt. It is possible, however, that there could be some localised changes in the levels of ponding or flooding where the maximum changes in grade coincide with existing pools, steps or cascades along the creek. It is not anticipated that these changes would result in adverse impacts on the creek. It has been assessed that the likelihood of fracturing resulting in surface water flow diversions along Wongawilli Creek, due to the extraction of the proposed LW19A, is low, i.e. affecting less than 10 % of rockbars located within the study area. However, minor fracturing could still occur along the creek, at distances up to approximately 400 m from the proposed longwalls.	Wongawilli Creek was predicted to experience less than 20 mm vertical subsidence, 150 mm upsidence and 210mm closure due to the extraction of the proposed LW6 to LW18, LW19 and LW20-LW21. The extraction of LW6 to LW17 has resulted in one Type 3 impact along Wongawilli Creek. A Type 3 impact is defined as fracturing in a rockbar or upstream pool resulting in reduction in standing water level based on current rainfall and surface water flow. Fracturing was first observed in the bed of Pool 43a after the completion of LW9. This pool is located at distances of 200 m west of LW6 in Area 3A and 410 m east of LW9 in DA3B. Pool water levels below baseline conditions were observed in this pool during low flow conditions (i.e. Type 3 impact) after the completion of LW13. No other fractures have been observed along Wongawilli Creek due to the longwalls extracted in DA3A and DA3B. The longwalls in DA3A and DA3B were set back from Wongawilli Creek so that the predicted closure is less than 200 mm at the mapped rockbars and other stream controlling features. It was assessed that the likelihood of significant fracturing

Feature	Description of natural feature	Predicted subsidence or surface water impact LW19A	Previously observed impacts in other areas
			resulting in surface water flow diversions along Wongawilli Creek would be low.
Sandy Creek and Sandy Creek Waterfall	Sandy Creek is situated on the eastern side of the existing LW6 to LW8 and the proposed LW19A in DA3A. Sandy Creek is situated on the eastern side of DA3A. The thalweg of the creek is located approximately 1200 m from the commencing end of LW19A, at its closest point. Sandy Creek is therefore located well outside the study area based on the 600 m boundary. Sandy Creek Waterfall is situated where Sandy Creek flows into the Cordeaux Reservoir. The centreline of the waterfall is located 1400 m north-east of the commencing end of LW19A. At this distance, the predicted incremental vertical subsidence, upsidence and closure for Sandy Creek Waterfall are negligible.	The maximum predicted incremental vertical subsidence, upsidence and closure for Sandy Creek, due to the mining of LW19 and 19A, are all less than 5 mm. While the creek could experience very low levels of these subsidence effects, it is not expected to experience measurable tilts, curvatures or strains. It is unlikely, therefore, that adverse impacts would occur along Sandy Creek due to the mining of LW19A. Sandy Creek Waterfall is located 1400 m north-east of the commencing end of LW19A. The total closure measured at the waterfall, due to the previous mining of LW6 to LW8 in DA3A is approximately 17 mm. The predicted incremental closure for Sandy Creek Waterfall due to the mining of LW19 and LW19A are less than 2 mm each. These movements are similar to the order of survey tolerance and environmental effects.	The maximum measured total closure across Sandy Creek Waterfall due to the mining of LW6 to LW8 was 14 mm. The greatest closure was measured downstream of the waterfall and across the valley of Lake Cordeaux.
Drainage Lines	SC10 (second order tributary), SC10A, SC10B, SC10C, WC13(A) and WC14 (all first order tributaries) are located within the 600 m buffer. Tributary SC10B crosses the north-east corner of Longwall 19A. The upper reaches of WC13(A) and WC14 are	The drainage lines are located across the study area and, therefore, could experience the full range of predicted subsidence movements.	Impacts have been observed along the drainage lines above and adjacent to the previously extracted LW9 to LW17 in DA3B, including fracturing in the rockbars and exposed bedrock, dilation and uplift of the bedrock, iron staining, surface water

Feature	Description of natural feature	Predicted subsidence or surface water impact LW19A	Previously observed impacts in other areas
	partially located above the proposed LW19A and SC10, SC10C and WC14 are partially located above the future LW19. The drainage lines in the western part of the study area flow into Wongawilli Creek and the drainage lines in the eastern part of the study area flow into Sandy Creek. The drainage lines are first and second order streams. The beds generally comprise exposed bedrock containing rockbars with some standing pools. There are also steps and cascades along the steeper sections. Debris accumulations have formed along the flatter sections that include loose rocks and tree branches.	The potential impacts of increased ponding and scouring of the drainage lines due to tilt are expected to be minor and localised. Impacts resulting from changes in surface water flows due to tilt are expected to be small in comparison with those which occur during natural flooding conditions. It is expected that fracturing of the bedrock would occur along the sections of the drainage lines that are located directly above the proposed LW19A and the adjacent future LW19. Fracturing can also occur outside the extents of the longwalls, with minor and isolated fracturing occurring at distances up to approximately 400 m. Surface water flow diversions are likely to occur along the sections of drainage lines that are located directly above and adjacent to the longwalls.	flow diversions and reduction in pool water levels. These impacts predominately occurred directly above the extracted longwalls. However, fracturing was also observed up to 300 m from the extracted longwalls in DA3B and up to 400 m from extracted longwalls elsewhere in the Southern Coalfield.
Cliffs **"**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)"	There are no cliffs identified within the study area based on the 35° angle of draw line and the predicted 20 mm subsidence contour. There are six cliffs located within the study area based on the 600 m boundary, with DA3-CF7 and DA3-CF8 located on a ridgeline above the eastern end of the future LW19 and DA3-CF16 to DA3-CF18 and DA3-CF24 situated within the valley of Wongawilli Creek. The cliffs have formed predominantly from Hawkesbury Sandstone, with the faces	The cliffs are all predicted to experience incremental vertical subsidence of less than 20 mm due to the mining of LW19A only. While the cliffs could experience very low levels of vertical subsidence due to the mining of LW19A, they are not expected to experience measurable tilts, curvatures, or strains. Cliffs DA3-CF16 to DA3-CF18 and DA3-CF24 are situated within the valley of Wongawilli Creek. While the valleys where the cliffs are located could	It should be noted that there are two levels of cliffs in some locations and, therefore, the total length of clifflines is greater than the total plan length of the ridgeline. The length of ridgeline disturbed due to the extraction of LW1 and LW2 was estimated to be between 7 % and 10 % of the total plan length of ridgeline directly above the longwalls. The length of rockfalls that occurred due to the

Feature	Description of natural feature	Predicted subsidence or surface water impact LW19A	Previously observed impacts in other areas
	being at various stages of weathering and erosion. The cliffs have many overhangs and undercuts that are generally less than 6 m. The minor cliffs within the study area are located within the valleys of Wongawilli Creek and the drainage lines. The lengths of each of the minor cliffs typically range between 20 m and 50 m and have heights up to 10 m. There are also many rock outcrops and rock platforms that are located across the study area. The rock outcrops are generally less than 5 m in height.	experience valley-related effects, the cliffs themselves are unlikely to experience upsidence or compressive strain due to valley closure, as they are located along the valley sides. Cliff DA3-CF7 is located above the eastern end of LW19 and DA3-CF17 is partially located above the western end of that LW. It is possible that isolated rock falls could occur at DA3-CF7 and DA3-CF17, due to the mining of LW19A, where they are located above the previously mined area. Cliffs DA3-CF16 to DA3-CF18 and DA3-CF24 are located outside the mining area. It is unlikely that these cliffs would experience adverse impacts due to the mining of LW19A based on their distances from the longwall and the very low levels of predicted subsidence effects.	extraction of LW1 and LW2 was, however, less than the length of disturbed ridgeline.
Rock outcrops "Exposed rockfaces with heights of less than 10 m or slopes of less than 2 in 1." Steep slopes "*An area of land having a gradient between 1 in 3 (33% or 18.3º) and 2 in 1 (200% or 63.4º)*".	There are rock outcrops located across the study area, primarily within the valleys of Wongawilli Creek and its tributaries and along the ridgelines directly above the mining area. The steep slopes within the study area have been identified within the valleys of Wongawilli Creek and its tributaries and along the ridgelines located directly above the mining area. The natural grades of the steep slopes typically vary up to approximately 1 in 2 (i.e. 27°, or 50 %), with	The rock outcrops and steep slopes are located across the study area and, therefore, are expected to experience the full range of predicted subsidence movements. It is likely that fracturing, and cracking would occur where these features are located directly above the proposed longwalls. The crack widths could be similar to those previously observed in LW1 and LW2.	Surface deformations due to mining in Areas 2, 3A and 3B, include soil cracking and rock fractures with widths less than 50 mm (i.e., 78 % of the cases); however, cracking up to 300 mm also typically occurred. Localised erosion also occurred at several sites causing surface deformations with widths up to 750 mm.

Feature	Description of natural feature	Predicted subsidence or surface water impact LW19A	Previously observed impacts in other areas
	isolated areas with natural grades up to 1 in 1 (i.e. 45° or 100 %).		
Swamps, wetlands and water related ecosystems	There are five swamps (Den15a, Den15b, Den15c, Den34 and Den148) that have been identified partially or wholly within the study area based on the 35° angle of draw line and predicted 20 mm subsidence contour. There are two additional swamps (Den12 and Den96) that are partly or wholly located within the study area based on the 600 m boundary. Den15c, Den148 and Den34 are partially located above the proposed LW19A. The remaining swamps are located outside the extent of the proposed LW19A.	The maximum predicted incremental vertical subsidence for Den12, Den15a, Den15b and Den96 are 30 mm or less. While these swamps could experience very low levels of vertical subsidence due to the mining of LW19A only, they are not expected to experience measurable tilts, curvatures, or strains. The maximum predicted incremental subsidence effects occur at Den148 and Den15c as they are partially located above the tailgate of LW19A. The predicted incremental subsidence effects for Den34 are lower since this swamp is generally located outside the mining area apart from its northern extent. It is considered unlikely that there would be adverse changes in the levels of ponding or scouring for the swamps within the study area based on the predicted vertical subsidence and tilt. Fracturing of the bedrock has been observed in the past, as a result of longwall mining, where the tensile strains have been greater than approximately 0.5 mm/m or where the compressive strains have been greater than approximately 2 mm/m.	The mining of LW9 in Area 3B, located directly above Swamp Den05, resulted in multiple fractures and uplifting at its basal step. Reduction in groundwater levels were also noted. LW4 and LW5 in Area 2 were extracted directly beneath Den01, which is both a headwater and valley infill swamp located along stream A2-14. Cracking was observed within the extent of the swamp in three locations and fracturing was observed in the downstream rockbar. LW7 in Area 3A was extracted directly beneath Den12, which is a headwater swamp located on the valley side of stream WC17. One fracture was identified in a rock outcrop after mining beneath this swamp. Regular monitoring has been undertaken and, to date, no erosion or other physical changes in the swamp have been observed. Four piezometers have been installed in and around the swamp to measure shallow groundwater levels within the sediments above the sandstone bedrock. One of the piezometers has measured a reduction in the groundwater level, two of the piezometers show no change and one is providing poor quality data.

Feature	Description of natural feature	Predicted subsidence or surface water impact LW19A	Previously observed impacts in other areas
		Den34, Den148 and Den15c are partially located above the proposed LW19A and Den12, Den15b and Den148 are partially located above the existing LW7 and LW8. The maximum predicted total compressive strains for these swamps due to the valley-related effects are in the order of 10 mm/m to 20 mm/m. However, the valley-related effects for Den12 and Den15b occur predominately due to the existing LW7 and LW8, rather than the proposed LW19A. It is likely, therefore, that fracturing would occur in the bedrock beneath these swamps, predominately in areas located above and adjacent to the mining area. At Swamps Den15a and Den34, it is possible that a series of smaller fractures, rather than one single fracture, could develop in the bedrock. Fracturing or surface cracking due to mine subsidence are not anticipated at Den96 due to the mining of LW19A. Den12, Den15b, Den15c and Den148 are predicted to experience valley-related effects that could result in the dilation of the strata beneath these swamps, which could result in the diversion of some surface water flows beneath parts of these swamps where they are located directly above the mining area. The drainage lines upstream of these swamps flow during and shortly after rainfall events. Where there is no connective fracturing to any deeper storage, it is likely that surface water	LW9 in Area 3B was extracted directly beneath Den05, which is a valley infill swamp located along the alignment of Donald's Castle Creek. The impacts to this swamp were described in the End of Panel Report (IMC 2014) which states "Site DA3B_LW9_006: Multiple fractures and uplift on DC_RB33 at basal step of Swamp 5; up to 0.015m wide, 2m long and 0.040m of uplift. Exfoliation from the step. Associated flow diversion" and "TARP triggers in relation to shallow groundwater levels (reduction and recession rates) in Swamps 1a, 1b and Swamp 5 were also reported during Longwall 9 extraction".

Feature	Description of natural feature	Predicted subsidence or surface water impact LW19A	Previously observed impacts in other areas
		flows will re-emerge at the limits of fracturing and dilation. Den12 and Den15b are located directly above LW7 and LW8 and, therefore, the potential impacts predominately occur due to these existing longwalls, rather than the proposed LW19A. Only small areas of Den148 and Den15c are located directly above the proposed LW19A.	
Water quality and surface water	• Sandy Creek • Wongawilli Creek • Tributaries • Water quality • Swamps	Estimates based on a regional groundwater model by Watershed (2022) indicate that over the longer term (>40 years) the baseflow components of Wongawilli Creek and Sandy Creek may decline by up to 0.9 and 0.06 megalitres per day (ML/day) (cumulative / whole mine) and up to 0.01 ML/day ML/day (LW19A incrementally) following longwall extraction. This equates to approximately 6% and 1% of the mean flow at the downstream gauges (0.06% and 0.14% incremental). Baseflow reduction would manifest as an increase in low-flow (and no-flow) days during prolonged dry periods. Over the longer term, no-flow days may increase from 44 to 108 days per year in Wongawilli Creek and from 39 to 56 days per year in Sandy Creek (cumulative). Water quality influence due to mining is expected to be minor in stream reaches within subsidence affected areas. Effects	Watercourses that have been affected by subsidence (including WC21, LA4 and DC13 in DA3B) have shown temporary increases in dissolved Fe and Mn, and an increase in pH to near neutral (pH 7) at sampling locations immediately down-gradient of the affected area. The overall salinity of stream waters (as estimated from EC) is controlled largely by rainfall patterns, with EC tending to increase during periods of low rainfall. This reflects evaporative concentration of salts and the relative increase in contribution from groundwater discharge (baseflow). In most cases, there is no discernible change in EC and other water quality parameters at monitoring sites down-gradient of noted effects or impacts. One possible exception is at Donalds Castle Creek (the upper reaches of which cross LWs 9 and 10) in which EC has been elevated for the last two years at the downstream site (DCL3 and at FR6). The anomalous EC trend coincides with the recent drought

Feature	Description of natural feature	Predicted subsidence or surface water impact LW19A	Previously observed impacts in other areas
		are likely to include temporary changes in water salinity, pH and iron content with local transient discolouration of streambeds and rock faces by iron hydroxide. Water quality effects on stored waters of the reservoirs are expected to be negligible and undetectable. Parts of Swamp Den15c and Den148 overlap with the proposed longwall footprint and Swamp Den34 extends within 60 m of the longwall. Based on previous experience at DA3B and subsidence predictions, shallow groundwater levels will likely be affected in Swamp Den15c, Den148 and Den34 that are within 60 m of the LW19A. Shallow groundwater impacts are possible in areas of Swamp 15a that are within 400 m of Longwall 19A. Areas of Swamps Den12, Den15b and Den148 were previously mined under (or were within 60 m of) Longwalls 7, 8 and 19. The remaining swamps are unlikely to be impacted since they are located more than 400 m from the proposed goaf and/or are predicted to experience negligible ground movement related to subsidence and valley closure.	period and will continue to be assessed. Based on previous observations, it is expected that water quality influence due to mining would be minor in stream reaches within subsidence affected areas (SC10 and SC10C; upper reaches of WC14). Local discolouration of streambeds and rock faces by iron hydroxide precipitation can continue for a number of years but is a temporary impact.

2.3 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 impact assessment for the entire DA3 study area has already been completed in the form of a SIS (Biosis 2007), the current assessment is required to ensure that the findings of the SIS remain relevant to LW19A within DA3A, 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.
- Requirement to examine the proposal against the relevant conditions of consent (Condition 5) relating to impacts to Swamp Den15a.

The SIS for DA3, which incorporated the current study area, was completed in 2007 (Biosis 2007). Some data gaps within the SIS have been identified in this study, and appropriate surveys completed to fill 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 (2022) and Section 2.2.

3 Literature review

A significant body of work has been conducted within the DA3 study area for previous approvals for underground mining and to satisfy consent conditions in regard to monitoring for over 15 years. The results of select key relevant assessments have been referred to or summarised in this report. The main relevant documentation as listed below was reviewed as part of this SMP with details provided in proceeding sections of this report:

- Dendrobium Coal Project Species Impact Statement (Biosis 2001a)
- Dendrobium Coal Project: Terrestrial and Aquatic Habitat Assessment (Biosis 2001b)
- Dendrobium Coal Project: Likely Impacts of Subsidence on Terrestrial Ecology (Biosis 2001c)
- Dendrobium Area 3 modification Species Impact Statement (Biosis 2007)
- Terrestrial Flora and Fauna Habitat Assessments accompanying coal exploration activities within DA3B (various companies approximately 1996 – 2011)
- Dendrobium Coal Mine and Elouera Colliery Flora and Fauna Environmental Management Program, Annual Monitoring Report – Spring 2003 to Winter 2006 (Biosis 2007a)
- Dendrobium Area 2 Longwalls 3-5a Impacts of Subsidence on Terrestrial Flora and Fauna (Biosis 2007b)
- Relevant databases (DPE 2022a,b; DAWE 2022; see section 3.7).
- Terrestrial Ecology Assessments as part of previous SMPs for longwalls within DA3A, DA3B and DA3C including annual and end of panel reporting (Niche 2012, Niche 2019c, Niche 2020).
- Geographic review of mining effects on Upland Swamps at Dendrobium Mine (Watershed HydroGeo 2019)
- Dendrobium Next Domain - Biodiversity Assessment Report and Biodiversity Offset Strategy (Niche 2019b)
- Mining Subsidence Engineering Consultants (MSEC) subsidence predictions for Longwall 19A (MSEC 2022)
- Surface water and quality assessment for Longwall 19A (HGEO 2022)
- Long-term monitoring of vegetation and fauna populations, which has been undertaken in Dendrobium Areas 1, 2 and 3, since 2003 (Biosis 2016, 2019; Niche 2021, 2022) (see section 3.4 for summary of latest monitoring results).
- Final Determination for the Key Threatening Process 'Subsidence due to longwall mining'
- Stream and swamp mapping held by IMC.
- Statutory reviews and policy guidelines including:
    - Southern Coalfields Inquiry (DoP 2008)
    - Upland Swamps Environmental Assessment Guidelines (DECCW 2011)
    - Independent Expert Panel for Mining in the Catchment Report: Part 2. Coal Mining Impacts in the Special Areas of the Greater Sydney Water Catchment (IEPMC 2019).

3.1 Dendrobium Area 3 Species Impact Statement

Biosis prepared a SIS in 2007, to support the application to modify the Dendrobium Mine consent (DA-60-03-2001) to incorporate a revised DA3 footprint and longwall layout. The SIS involved an extensive survey and impact assessment of DA3A, DA3B and DA3C.

To assess the impacts of mining in DA3, the maximum subsidence parameters determined from MSEC for DA3A were extrapolated to the entire DA3 footprint.

As such, the consent required that once the mine plans for these areas were finalised any impacts in areas DA3B and DA3C greater than those specified in the SIS, would require a review of the SIS outcomes. The SIS therefore provides the basis against which the proposal should be assessed.

A comparison of the relevant DA3 subsidence parameters used in the SIS (MSEC 2007), against the current MSEC (2020) report is provided below in Table 2. MSEC reports concluded similar potential subsidence impacts. The impact assessments for threatened species in the SIS are similar to those within this report.

Table 2: Subsidence predictions from the Area 3 SIS (2007) compared to MSEC (2022) report for current study area

Subsidence Parameters	MSEC (2007) report for Dendrobium Area 3 used in the SIS	MSEC (2022) report for DA3A
Wongawilli Creek	Longwalls set back from Wongawilli Creek. Wongawilli Creek is unlikely to incur any significant impacts as a result of the extraction of the proposed longwalls. Some minor fracturing could occur. Localised ponding changes may occur due to subsidence induced tilt.	Longwalls set back from Wongawilli Creek. Wongawilli Creek is predicted to experience less than 20 mm vertical subsidence due to the mining of the proposed LW19A. While the creek could experience very low levels of vertical subsidence, it is not expected to experience measurable conventional tilts. That is, the predicted changes in grade along the creek due to the conventional movements are less than 0.5 mm/m (i.e. less than 0.05 %, or 1 in 2000). The maximum predicted incremental upsidence along Wongawilli Creek due to the mining of the proposed LW19A only is 40 mm. The maximum predicted total upsidence along the creek within the study area is 120 mm. It is unlikely that there would be adverse changes in the potential for ponding, flooding, or scouring of the banks along Wongawilli Creek due to the mining-induced tilt. Fracturing could occur along the section of Wongawilli Creek that is located within a distance of approximately 400 m from the proposed longwall. The rate of Type 3 impacts (i.e. fracturing resulting in surface water flow diversions) has been assessed as low, affecting less than 10 % of rockbars and other stream controlling features located within the study area.
Sandy Creek and Sandy Creek Waterfall	It is unlikely that there would be any significant increases in levels of ponding, flooding or scouring of the creek banks. However, it is possible that there could be some very localised increased level of ponding or flooding where the maximum predicted tilts coincide with existing pools, steps or cascades along the creek.	It is unlikely that adverse impacts would occur along Sandy Creek or Sandy Creek Waterfall due to the mining of LW19A.

Subsidence Parameters	MSEC (2007) report for Dendrobium Area 3 used in the SIS	MSEC (2022) report for DA3A
	It is possible that there could be minor fracturing in the beds of Wongawilli and Sandy Creeks as a result of the extraction of the proposed longwalls. Any fracturing that does occur in the beds of these creeks would be expected to be isolated and of a minor nature and not result in any significant surface water flow diversions.	
Cliffs	Predicted to be some impact to between 7% and 10% of the cliff lines that will be directly mined beneath. Cliff lines that will not be directly mined beneath are unlikely to exhibit any significant impacts.	There are no cliffs located directly above the proposed LW19A. However, two cliffs (DA3-CF7 and DA3-CF17) are located above the future LW19, and they could experience some additional movements due to the mining of the proposed LW19A. It is therefore possible that isolated rock falls could occur at DA3-CF7 and DA3-CF17, due to the mining of LW19A, where they are located above the mining area. The remaining cliffs located outside the longwall mining area are not expected to experience adverse impacts due to the mining of LW19A.
Rock outcrops and steep slopes	Percentage of rock outcrops that are likely to be impacted by mining is small – much less than 7% to 10% of the total length of rock outcrops directly mined beneath. Potential DA3 steep slopes are expected to result in cracking of the surface soils and possible downhill movements, similar to Dendrobium Areas 1 and 2. The greatest surface cracking and downhill movements are expected to occur along the steep slopes directly mined beneath and adjacent to ridgelines.	Rock outcrops and steep slopes could experience the full range of predicted subsidence effects. It is likely that fracturing and cracking would occur where these features are located directly above the proposed longwall. The crack widths could be similar to those previously observed at the mine, which were up to approximately 400 mm in width, but typically in the order of 100 mm to 150 mm in width.
Upland Swamps	Swamps directly mined beneath are expected to experience the full range of predicted subsidence and valley related movements.	There are no predicted substantial reductions or reversals of stream grade along the drainage lines within the extents of the swamps. However, there are small reductions in stream grade near

Subsidence Parameters	MSEC (2007) report for Dendrobium Area 3 used in the SIS	MSEC (2022) report for DA3A
	It is unlikely that mine subsidence induced scour effects would affect the swamps in DA3. It is possible that the changes in water level within the swamps could impact on the distribution of local vegetation within the swamps. The surfaces of the swamps are free draining, and it is not anticipated that significant changes in water levels would occur as a result of subsidence induced tilt.	to Den34 and Den148. There is potential for minor and localised increased ponding upstream of these locations. Fracturing of the bedrock could occur beneath Den12, Den15a, Den15b, Den15c and Den148 where they are located above and adjacent to the mining area. These swamps have layers of organic soil and, in most cases, cracking would not be visible at the surface within these swamps, except where the depths of bedrock are shallow or exposed. The dilated strata beneath the drainage lines could result in the diversion of some surface water flows beneath parts of the swamps where they are located above and adjacent to the proposed longwall. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation.

The results of the SIS in regard to ecological impacts, specifically threatened species, included the following:

- Fourteen threatened flora species were considered in the SIS. Two threatened flora species, *Acacia bynoeana* and *Pultenaea aristata* were recorded within DA3. A further nine species were regarded as having potential habitat. Seven-part tests under the *Threatened Species Conservation Act 1995* (TSC Act) (equivalent to the current five-part test under the *Biodiversity Conservation Act 2016* [BC Act]) concluded that the proposed longwall mining activities in DA3 were unlikely to have a significant impact on any threatened flora within the study area.
- Sixty-three threatened fauna were considered in the SIS. Sixteen species were recorded in the DA3 study area including:
    - Littlejohn's Tree Frog (*Litoria Littlejohni*)
    - Giant burrowing Frog (*Heleioporus australiacus*)
    - Red-crowned Toadlet (*Pseudophryne australis*)
    - Gang-gang cockatoo (*Callocephalon fimbriatum*)
    - Glossy black cockatoo (*Calyptorhynchus lathami*)
    - Olive Whistler (*Pachycephala olivacea*)
    - Barking Owl (*Ninox connivens*)
    - Powerful Owl (*Ninox strenua*)
    - Eastern Pygmy-possum (*Cercartetus nanus*)
    - Eastern Freetail Bat (*Mormopterus norfolkensis*)
    - Koala (*Phascolarctos cinereus*)
    - Grey-headed Flying-fox (*Pteropus poliocephalus*)
    - Large Bentwing-bat (*Miniopterus orianae oceanensis*)
    - Large-eared Pied bat (*Chalinolobus dwyeri*)
    - Southern Myotis (*Myotis macropus*)
    - Rosenberg's Goanna (*Varanus rosenbergi*).
- Test of significance assessments (under the TSC Act) concluded that the DA3 mining operations would likely cause a significant impact to local populations of Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Stuttering Frog (*Mixophyes balbus*) and Giant Dragonfly (*Petalura gigantea*). The possible mechanisms of subsidence and physical effects of subsidence were determined to have a direct impact on known and potential habitat for the threatened fauna, which included waterways, Upland Swamps, riparian vegetation, ridge lines and rock overhangs.

It is noted that Upland Swamps within the study area were not a listed TEC at the time of the SIS under either the TSC Act (gazetted in 2012) (now the BC Act) or EPBC Act (gazetted in 2014), the community has since been added to the relevant schedules as an endangered ecological community.

The survey effort and outcomes of the SIS have been summarised in Section 4.1.

3.2 Dendrobium Areas 3A, 3B and 3C Terrestrial Ecological Assessments

Niche was commissioned by IMC to prepare a Terrestrial Ecological Assessments for proposed LWs within DA3A, DA3B and DA3C (Niche 2012, 2019a, 2020).

The assessment involved flora and fauna surveys within DA3A, DA3B and DA3C which focused on landscape features and threatened species sensitive to the impacts of subsidence from extraction of proposed longwalls. Natural areas sensitive to subsidence included: creeks and drainage lines, cliffs, rock outcrops, steep slopes, and Upland Swamps.

One threatened flora population of *Pultenaea aristata* was recorded in an upland swamp in the DA3B study area. The population estimate was greater than a thousand individuals. The SIS also identified a population of *Acacia bynoeana* consisting of approximately 30 individuals within the DA3B study area. A further three threatened plant species (*Epacris purpurascens* var. *purpurascens, Cryptostylis hunteriana* and *Leucopogon exolasius*) were considered to have habitat in the study area. Impacts on these species were assessed within the project's SIS (Biosis 2007) and were considered likely to be minimal. Seven-Part Tests were carried out for these species which concluded that a significant impact was unlikely. The same conclusion was reached in the 2007 SIS (Biosis 2007). Threatened fauna recorded during surveys, including Red-crowned Toadlet, Littlejohn's Tree Frog, Gang-gang Cockatoo, and Grey-headed Flying Fox. Fauna impact assessments were conducted for 31 threatened fauna, including:

- Amphibians: Littlejohn's Tree Frog, Giant Burrowing Frog and Red-crowned Toadlet
- Birds: Barking Owl, Black Bittern (*Ixobrychus flavicollis*), Eastern Bristle Bird (*Dasyornis brachypterus*), Eastern Ground Parrot (*Pezoporus wallicus wallicus*), Grass Owl (*Tyto longimembris*), Gang-gang Cockatoo, Glossy Black Cockatoo, Masked Owl (*Tyto novaehollandiae*), Sooty Owl (*Tyto tenebricosa*), and Powerful Owl
- Mammals: Brush-tailed Rock Wallaby (*Petrogale penicillata*), Eastern Pygmy Possum, Long nosed Potoroo (*Potorous tridactylus tridactylus*), Southern Brown Bandicoot (*Isoodon obesulus*), Spotted tail Quoll (*Dasyurus maculatus*), Squirrel Glider (*Petaurus norfolcensis*), Large Bentwing-bat (*Miniopterus orianae oceanensis*), Little Bentwing-bat (*Miniopterus australis*), Large-eared Pied Bat, Eastern Cave Bat (*Vespadelus troughtoni*), Eastern False Pipistrelle (*Falsistrellus tasmaniensis*), Golden-tipped Bat (*Kerivoula papuensis*), Southern Myotis, Greater Broad-nosed Bat (*Scoteanax rueppellii*) and Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*).
- Reptiles: Broad-headed Snake (*Hoplocephalus bungaroides*) and Rosenberg's Goanna
- Giant Dragonfly.

Test of Significance assessments concluded that the proposed longwalls were likely to have a significant impact on local populations of Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, and Giant Dragonfly. Subsidence impacts were determined as likely for known and potential habitat for these species, as they are reliant upon creeks and drainage lines, Upland Swamps, ridgelines and rock outcrops. The same conclusion was reached in the SIS impact assessments for these species; however, the Stuttering Frog was considered to be significantly impacted within the initial SIS whereas it was considered unlikely to occur in these assessments.

SSTF which was listed as a CEEC under the EPBC Act and TSC Act (repealed and replaced by the BC Act), occurred within the DA3B study area. Mining in DA3B was considered unlikely to result in any physical landscape changes which may impact this community. The assessment concluded that SSTF is unlikely to be significantly impacted by the proposed longwalls.

A number of Upland Swamps (large and small) were recorded within the study areas. The Upland Swamps fit the description of Coastal Upland Swamps in the Sydney Basin Bioregion, which has been listed as an

EEC under the BC Act and EPBC Act since the 2007 SIS. The potential for impact Upland Swamps was considered to be low. A Seven-Part Test for Coastal Upland Swamps in the Sydney Basin Bioregion was conducted and concluded that a significant impact on this community was unlikely, primarily due to the proportion of swamps likely to be impacted compared with swamps within the locality and the severity of impacts predicted.

A number of recommendations were proposed in relation to terrestrial ecological values, and included the following:

- On-going monitoring which is currently being undertaken within DA3 should continue. Monitoring of impacts should follow pre-existing methodology. Monitoring to continue targeted surveys for Littlejohn's Tree Frog, Red-crowned Toadlet and Giant Dragonfly. Upland swamp monitoring transects should continue. Transect and photo point monitoring to be included within upland Swamp 35a as this swamp contains a population of *Pultenaea aristata*. In the event that monitoring reveals impacts greater than predicted or authorised by the approval, modifications to the project and mitigation measures should be considered to minimise impacts.
- Visual comparison of photo point monitoring undertaken at each upland swamp site should also continue from marked monitoring points.
- Mapping of microhabitats such as pools along streams, as currently performed by IMC for DA3B, should be extended to DA3C prior to baseline frog surveys.
- All remediation works should include appropriate measures to minimise environmental impacts. This includes avoiding the spread of Chytrid Fungus following the NPWS guidelines (DECC 2008).
- The implementation of any mitigation measures should include monitoring to confirm the success of any implemented measures.
- Surface cracking within woodland or forested areas where significant fauna entrapment is likely should be mitigated in order to minimise fauna entrapment.

3.3 Dendrobium Terrestrial Ecology Monitoring Program

Annual Reporting (Biosis 2016, Biosis 2019, Niche 2021, Niche 2022) documents the ecological monitoring program undertaken within Dendrobium Areas 2 (11 years), 3A (8-14 years) and 3B (4 years). Subsidence related impacts following mining in these areas include lowering of shallow groundwater in Upland Swamps and loss or alteration in the quality of pool water for first and second order streams.

The following ecological features are monitored as part of the terrestrial ecology program:

- Vegetation within Upland Swamps in DA2, DA3A and DA3B (swamp extent, species composition, total species richness (TSR)
- Littlejohn's Tree Frog along streams in DA3A and DA3B population attributes (number of individual frogs within different life-stages, habitat such as breeding pool characteristics).

As part of the monitoring program, LIDAR mapping of the upland swamp extents is also undertaken. This detailed mapping of the upland swamp boundaries was used in the current assessment.

The following summarises the latest findings of the vegetation monitoring program (Niche 2022):

Upland Swamps

In 2020, visual trends of drying (or areas of die-back) were observed at Impact swamps that have been directly mined beneath during field survey, and in the UAV imagery. The drying of the Impact Upland Swamps over time since impact may be exacerbated by the effect of the most recent drought, though the correlation between impact of mining and drying of the Impact Upland Swamps was evidenced by the statistically significant difference between Control and Impact Upland Swamps over this drought period. The trends in floristic data and LiDAR analysis in 2021 represent in general a continuation of the trends observed in recent years at the impact swamps. Although additional analysis in 2021 is suggestive of changing swamp conditions pre-mining and some limited observations of regeneration in previous areas of drying have been observed.

Cumulative impacts have been observed at a number of Impact Upland Swamps, which show stronger trends of statistically significant decline in TSR over time and statistically significant changes to composition, with 'wetter' species becoming less common post impact, suggesting a loss of species that prefer moist soils. Some swamps show a loss of species over time, with limited recruitment of new species.

Threatened frogs – Littlejohn's Tree Frog (Littlejohn's Tree Frog)

The Control creeks in general have a higher quality of breeding habitat for Littlejohn's Tree Frog and were presumably chosen at the beginning of the monitoring program due to the known population of breeding adult records of Littlejohn's Tree Frog and habitats. The 2021 analysis has identified that where pre-mining frog detection data is available, detection was statistically significantly lower at impact transects than the controls, indicating this disparity in control and impact transect pre-dates mining effects. However, it is also notable that environmental conditions (water levels and absence of flocculant) were also more favourable at the Control transects. Additional analysis in 2021 has identified a statistically significant relationship between flocculant and the detection of the Adult and Eggmass lifecycle stages and that flocculant is more likely to occur at post-mining transects.

The Littlejohn's Tree Frog monitoring (Niche 2022) detailed the following results within the LW19A study area:

- No significant changes in Littlejohn's Tree Frog populations, an increase in tadpoles at SC10(1), and an increase in egg mass at SC10(2) may be due to displacement of breeding adults from impacted areas such as SC10C.
- Subsidence related impacts including cracking of bedrock, lowering of water levels and build-up of iron flocculant have been recorded at sites SC10C, SC10(1), with each of these sites triggering either Level 1 (SC10(1) or Level 3 (SC10C) of the Dendrobium Area 3 Watercourse TARP.

3.4 Geographic review of mining effects on Upland Swamps at Dendrobium Mine

A review of piezometer data used for detection of impacts to swamps throughout the Dendrobium area has been conducted (Watershed HydroGeo 2019) which concluded:

> "*Based on assessments of water levels and recession rates around past mining in Areas 2, 3A and 3B, hydrographs from swamp piezometers within 60 m are likely to exhibit a mining effect and almost certain to exhibit a mining effect when directly mined under, be that through a reduction in*

the water table to below pre-mining levels and/or increased recession (drainage) rate. Effects on swamp water tables have not been observed at distances greater than 60 m from a longwall panel.

When considering piezometers that are lithologically similar, but lying outside of mapped swamp communities, impacts have been observed at 95 and 125 m in two piezometers in Area 3B. Some piezometers within that distance (125 m) have recorded no mining effects."

The above findings are important with regard to assessing the likely extent of impacts to swamp communities.

3.5 Relevant reviews considered in this report

The following reviews have been considered in the current study:

- Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield (Southern Coalfield Inquiry) (DOP 2008)
- The Draft Upland Swamp Environmental Assessment Guidelines, Guidance for the Underground Mining Industry Operating in the Southern and Western Coalfields (DECCW 2011)
- Independent Expert Panel for Mining in the Catchment Report: Part 2. Coal Mining Impacts in the Special Areas of the Greater Sydney Water Catchment (IEPMC 2019).

Key findings of the above reviews (as relevant to this assessment) are shown in Table 3.

Table 3: Key findings of relevant reviews

Southern Coalfield Inquiry
Environmental assessments should include a minimum of 2 years of baseline data, collected at an appropriate frequency and scale provided for significant natural features.
Development of improved regional and cumulative data sets for the natural features of the Southern Coalfield.
Before After Control Impact (BACI) study is considered the most appropriate design for many impact studies. Appropriate replication in both impact (directly above the mine) and control (outside direct impact zone) sites is required in monitoring programs so natural variability can be determined.
Environmental assessments should include identification and assessment of significance for all natural features located within 600 m of the edge of secondary extraction.
Risk Management Zones should be identified for all significant natural features, which are sensitive to valley closure and upsidence, including rivers, significant streams (3rd order or above in the Strahler stream classification), significant cliff lines, significant overhangs and valley infill swamps.
Approved mining within identified Risk Management Zones (and particularly in proximity to highly-significant natural features) should be subject to increased monitoring and assessment requirements which address subsidence effects, subsidence impacts and environmental consequences.
The requirements should also address reporting procedures for back analysis and comparison of actual versus predicted effects and impacts, in order to review the accuracy and confidence levels of the prediction techniques used.

Upland Swamps Environmental Assessment Guidelines (Draft)
All underground mining proposals and operations that have the potential to impact on Upland Swamps demonstrate how they have applied the Upland Swamp Environmental Assessment Guideline.
Impacts to swamps of 'special significance status' are avoided.
Impacts on Upland Swamps (not of special significance status) are minimised as far as possible.
Monitoring undertaken by the underground mining industry to understand subsidence effects, impacts and environmental consequences is greatly improved.
Adaptive management should be implemented to provide a systematic process for continually detecting impacts, validating predictions and improving mining operations to prevent further impacts. Active adaptive management usually involves a comparison of management options and a conscious investment in learning by experimentation.
Effective and rigorous monitoring, evaluation, and reporting on management performance and ecological and hydrological impacts are required to inform the adaptive management process and should be integrated into core management systems in a consistent way across industry.
Management measures are to include contingency plans that allow for any unforeseen circumstances, particularly given the uncertainty inherent in the assessment of subsidence impacts, such as non-systematic subsidence (valley closure and upsidence).
Prior to underground mining proponents preparing an environmental assessment there is a need to gather baseline data. Initial steps in the collection of baseline data on Upland Swamps may include desktop studies to identify the location of the Upland Swamps (e.g. through vegetation mapping) and the identification of key threatening processes and Upland Swamps listed under national and state legislation.
Independent Expert Panel for Mining in the Catchment Report: Part 2. Coal Mining Impacts in the Special Areas of the Greater Sydney Water Catchment (IEPMC 2019)
Longwall mining directly under swamps in the Southern Coalfield can result in significant changes to swamp hydrology and redirection of surface runoff, which the Panel considers are very likely irreversible.
Despite decades of monitoring, mining-induced changes to upland swamp vegetation communities are still not able to be clearly differentiated from natural changes. Vegetation change assessment to date does not provide a clear and timely measure of possible changes in ecosystem functionality of the Upland Swamps. This means that it has been of limited value as a performance indicator. This may be resolved in part by changes in methodology. Quantitative monitoring data should be supplemented by an overview of the whole swamp and assessment of changes in biomass. Use of targeted obligate swamp-dependent species (either plants or animals) may be a more reliable and timely indicator of ecological consequences than measures such as total species richness of vegetation. However, the decadal nature of many changes still remains a barrier to distinguishing between mining induced variations and natural variations.
Existing TARPs define ecosystem functionality predominantly by consequences (vegetation change and erosion) that may take years or decades to be measurable and clearly separable from natural variation. Swamps are groundwater-dependent ecosystems. Therefore, a change in piezometric levels should be the primary gauge of impacts on the ecosystem. If maintenance of ecosystem functionality is to be mandated for any swamp, then piezometric variation must be used not only in TARPs but also in performance measures.
Future swamp monitoring and modelling programs should be designed to: • Provide a hydrological balance for representative swamps, sufficient to identify any mining-induced changes in soil moisture and in baseflow down the exit stream; and to provide vertical leakage rates as inputs to groundwater models, in order to quantify how much of the leakage is diverted back into the catchment or elsewhere.

• Link any changes in swamp vegetation to changes in water table position, soil moisture content and soil organic carbon content. • Identify the presence of and any changes in obligate swamp fauna such as the Giant Dragonfly (*Petalura gigantea*).
Annual performance reports, end-of-panel reports and reports on studies required by development consent conditions, should: • integrate hydrological and ecological impact and consequence assessments • include discussion of the inter-related changes in hydrological and ecological consequences for swamps, rather than having only discrete chapters on each • include results for the entire period of monitoring, rather than just the previous year, that should be assessed, not only for the current mining area but for previous mining domains.
Remediation should not be relied upon for features, including watercourses and swamps, that are highly significant or of special significance (as per the guidance provided by the Planning Assessment Commission Panels for the Metropolitan Coal Project and the Bulli Seam Operations Project).
Consent conditions for Dendrobium Mine issued in 2008 in relation to offsetting impacts on swamps do not appear to have foreseen the scale of impacts occurring today but have been subsequently addressed by a Strategic Biodiversity Offset approved in 2016.
There is very limited, if any, scope for remediating fracture networks beneath swamps. Therefore, in circumstances where it is difficult, if not impossible, to design a viable mining layout that avoids impacting swamps and mining is to proceed, there is little option other than to consider offsets as compensation for the consequences of negative environmental impacts on swamps.
All future mine approvals in the Special Areas should include performance measures related to measured changes in groundwater pressure and/or pressure gradients where these have the potential to impact on surface water diversions or losses.

The proposal is consistent with the recommendations of these reports due to the following proposed actions:

- Subsidence prediction reports and environmental studies have been used to determine potential impacts for DA3A
- Potential impacts to Upland Swamps have been determined
- Long-term monitoring of natural features in DA3 is currently undertaken including Upland Swamps, piezometric variation and targeted surveys of Littlejohns Tree Frog and Giant Dragonfly. It is recommended these programs continue and are expanded to DA3A
- Additional management and mitigation measures have been recommended in this report and the SIS.

3.6 Databases

Databases used in the preparation of this report include:

- NSW Department of Planning and Environment (DPE) BioNet, Atlas of NSW Wildlife and Vegetation Information system (VIS) flora surveys (DPE 2022a) (accessed February 2022)
- Threatened Species Profiles for threatened species, endangered populations and threatened ecological communities (TECs) listed under the BC Act (DPE 2022b)

- Australian Department of Agriculture, Water and the Environment (DAWE) EPBC Act Protected Matters Report (DAWE 2022)
- (accessed February 2022).

Threatened species recorded in previous assessments have been supplied to BCS (and its predecessors) for inclusion in the BioNet Atlas of NSW Wildlife threatened species database which has been consulted for this assessment. Further records of threatened species were obtained from the SIS (Biosis 2007), and from the previous studies listed in Section 3.5.

4 Field survey

4.1 Previous survey effort

This section identifies the extensive surveys which have been conducted within DA3 and surrounds. The survey effort from the SIS (Biosis 2007) and previous surveys within DA3 has been summarised in Table 4.

Table 4: Approximate total hours of SIS survey effort and other previous surveys in DA3

Survey method	Total hours
Vegetation quadrats and transects	44 person hours in SIS, and 373.5 person hours in previous surveys
Vegetation validation and Targeted surveys for threatened plant species	244.5 person hours in SIS and 143 hours in previous surveys
Plot based surveys for *Pultenaea aristata* population count	14 person hours in SIS
Diurnal bird survey	288.5 person hours in previous survey
Nocturnal frog survey	274.8 person hours in previous survey
Bat Detection	68 Trap nights in previous survey
Harp Trap	24 Trap nights in previous survey
Arboreal Elliot Traps (Small)	72 Trap nights in previous survey
Arboreal Elliot Traps (Large)	72 Trap nights in previous survey
Arboreal hair tubes	303 Trap nights in previous survey
Cage traps	360 Trap nights in previous survey
Diurnal bird surveys	13.88 person hours in previous survey
Diurnal herpetofauna Search	44.03 person hours
Diurnal call playback	2.05 person hours in previous survey
Frog habitat search	39.9 person hours
Nocturnal watercourse search	55 person hours in previous survey
Spotlighting	64 person hours in previous survey
Nocturnal call playback	52 person hours in previous survey
Frog call/Song Meter	225 trap nights

Areas previously surveyed within the current study area as part of the SIS (Biosis 2007) and ongoing monitoring (Niche 2022), have been identified in Table 5 and 6.

Table 5: Previous survey effort of swamps in study area

Site	Swamp characteristics	Position of highest impact area	Previous vegetation survey	Previous fauna survey
Den12	Small simple swamp	600 m study area boundary. Previously mined beneath by LW7 and LW8.	2 x vegetation surveys sites (vegetation validation and	-

Site	Swamp characteristics	Position of highest impact area	Previous vegetation survey	Previous fauna survey
			dominant species observations).	
Den15a	Large complex swamp	Small section of swamp beneath longwall, remainder within Angle of Draw. Feeding tributary (SC10) within Angle of draw.	Fixed swamp monitoring transects (Biosis 2019, Niche 2022). Monitoring undertaken for 8-14 years.	Fixed frog and bird monitoring sites (Biosis 2019, Niche 2022). Monitoring undertaken for 8-14 years. Nocturnal frog habitat search. Spotlighting on foot (mammals, birds' reptiles). Arboreal Elliot Traps/Hair Tubes.
Den15b	Large complex swamp	Within Angle of draw. Previously mined beneath by LW8.	Fixed swamp monitoring transects (Biosis 2019, Niche 2022). Monitoring undertaken for 8-14 years.	Fixed frog, bird, and invertebrate monitoring sites (Biosis 2019, Niche 2022). Monitoring undertaken for 8-14 years. Nocturnal frog habitat search. Spotlighting on foot (mammals, birds' reptiles). Nocturnal call playback frogs.
Den15c	Small simple swamp	Swamp to be mined beneath and within Angle of draw.	-	-
Den34	Small simple swamp	Mined beneath. Feeding tributary (WC13) within the Angle of draw.	1 x vegetation surveys sites (vegetation validation and dominant species observations).	-
Den96	Small simple swamp	Within 600 m boundary.	-	-
Den148	Small simple swamp	Swamp to be mined beneath and within Angle of draw.	1 x vegetation surveys sites (vegetation validation and dominant species observations).	-

Table 6: Previous survey effort of natural features in study area

Stream	Stream order	Position of highest impact area	Previous vegetation survey	Previous fauna survey
SC10	2	Angle of draw. Partially located above LW19.	Fixed vegetation monitoring quadrat (Biosis 2019). Monitoring undertaken for 8-14 years.	Fixed frog and bird monitoring sites (Biosis 2019, Niche 2022). Monitoring undertaken for 8-14 years.
SC10A	1	Angle of draw	-	-
SC10B	1	Upper reaches partially located above LA19A. Remainder within Angle of draw	-	-
SC10C	1	Angle of draw	-	Fixed frog, bird and invertebrate monitoring sites (Biosis 2019, Niche 2022). Monitoring undertaken for 8-14 years.
WC13	2	Upper reaches partially located above LA19A. Remainder within Angle of draw	-	Nocturnal frog habitat search.
WC14	1	Upper reaches partially located above LA19A. Remainder within Angle of draw	-	-
Wongawilli Creek	3	Outside of study area	1 x vegetation surveys sites (vegetation validation and dominant species observations) and 3 x 20 x 20 m quadrats (Q1, Q7 and Q8).	Frog surveys and call play back, bird survey, frog searches, habitat assessments, diurnal herpetofauna search, Anabat, spotlighting, nocturnal call play back for owls, various other surveys.

4.2 Current survey

4.2.1 Survey timing

The current project 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 such as swamps, waterways, and rocky areas. Survey effort focussed on areas within the study

area which had not been subject to previous survey or had limited survey coverage (Figure 4 and Figure 5).

Survey was conducted throughout the study area over two days (16 to 17 June 2022, and 8 August 2022). Field survey activities are detailed in the following sections.

4.2.2 Flora and vegetation survey

Flora survey focused on vegetation validation of Upland Swamps within the study area (Figure 4). A sample of swamps mapped within the Woronora vegetation mapping project (NPWS 2003), Biosis (2019) swamp mapping or identified via aerial photography analysis were visited to confirm the vegetation present and update mapping of swamp boundaries including the swamp community and subcommunity as per NPWS (2003). This process was completed by performing 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 vegetation descriptions. Boundaries between communities and subcommunities were captured in the field by collecting waypoints and tracks along identified boundaries. Where possible, vegetation patterns within swamps were also observed from surrounding vantage points using binoculars to aid with identifying consistency of vegetation or otherwise across the swamp.

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 swamps.

Limitations associated with the selected method include reliance on correct positioning of aerial imagery as well as correct interpretation of canopy shadows. Boundaries between swamp communities and sub-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.

The flora survey included targeted threatened plant species searches within Upland Swamps in the study area.

4.2.3 Fauna survey

Fauna survey effort focused on areas susceptible to subsidence impacts and associated fauna. Areas targeted included Upland Swamps and creek lines (Figure 5). It is noted that most areas of frog habitat have been previously surveyed during annual monitoring of the area.

A summary of the current survey effort is shown in Table 7.

Table 7: Current survey effort

Survey Technique	Habitat	Survey effort (Person hours)	Date
Diurnal frog and tadpole searches	Creeks (SC10 and WC14 tributary off Wongawilli Creek and Sandy Creek)	3 person hours	16/6/2022 17/6/2022
Nocturnal frog searches	WC14 (tributary of Wongawilli Creek), which intersects the LW19A Angle of draw.	8 person hours	8/8/2022
Rapid aquatic habitat assessments	Identify fish habitat, condition assessment, riparian vegetation, presence of frog habitat along tributaries SC10 and WC14.	1 person hours	16/6/2022 17/6/2022 8/8/2022
Threatened flora searches	Across the LW19A Study Area	4 person hours	16/6/2022 17/6/2022
Habitat mapping	Hollow-bearing trees, creeklines, fallen woody debris, ground refugia, rocky outcrops and clifflines.	4 person hours	16/6/2022 17/6/2022
Searches along clifflines and outcrops for Broad-headed Snake	Rock outcrops and clifflines	2 person hours	16/6/2022 17/6/2022
Diurnal 2 ha bird survey	Dusk bird survey within woodland habitat.	1 person hours	8/8/2022

4.2.4 Survey conditions and limitations

Survey was conducted between June and August 2022 (during optimal survey timing). During August 2022 the rain had been steady, with monthly averages above or exceeding monthly averages (Appendix 3) and thus conditions were adequate for frog surveys. The tributary off Wongawilli Creek that was surveyed had moderate to deep pools of water during surveys, and climatic conditions at the time of the assessment were considered mild.

Littlejohn's Tree Frog habitat is well known within DA3A, and thus confirmed and potential habitat has been considered within this report.

4.3 Likelihood of occurrence assessment for threatened species

A list of threatened species within the locality was derived from database searches (DPE BioNet Atlas of NSW Wildlife and EPBC Act Protected Matters Search Tool) (Appendix 1). The list of potentially impacted species is determined from consideration of this list. 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 8) 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 8: 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 Vegetation communities

Six vegetation communities or sub-communities have been mapped as occurring within the study area by NPWS (2003) and Niche during the current project, after confirmation of swamp mapping (Table 9).

Ground-truthing of upland swamp community mapping resulted in changes to upland swamp sub-community patterns, swamp boundaries and changes in vegetation communities (Figure 3, Figure 4).

A number of small swamps were added to vegetation mapping after field observations. Conversely, sections of previously mapped swamps were reclassified as other community types. These areas corresponded with woodland or forest communities with thick understories of banksia thicket. These changes are to be expected since the base mapping of the Upland Swamp Banksia Thicket community unit did not attempt to remove areas of banksia thicket that may occur in other communities such as Exposed Sandstone Scribbly Gum Woodland (see page 200 of NPWS 2003).

Banksia thickets occur moderately frequent throughout the study area in the range of communities present. Often these areas share floristic similarities with simpler swamp types such as areas of banksia thicket (typically dominated by *Banksia marginata*). However, the presence of other diagnostic swamp species that are more reliant on frequently waterlogged soils is lacking or poorly represented in these areas.

Table 9: Area of vegetation communities within the study area (including adjacent swamp areas)

Map Unit (NPWS 2003)	PCT ID	PCT Name	Associated TEC	Area in study area * (ha)
MU26	1250	Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion	No associated TECs	192.90
MU29	1083	Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	No associated TECs	192.06
MU42	978	Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion	Coastal Upland Swamp in the Sydney Basin Bioregion (EEC under the BC and EPBC Act)	18.62
MU43	1804	Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin	Coastal Upland Swamp in the Sydney Basin Bioregion (EEC under the BC and EPBC Act)	3.88
MU44	978	Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion	Coastal Upland Swamp in the	7.47

Map Unit (NPWS 2003)	PCT ID	PCT Name	Associated TEC	Area in study area * (ha)
			Sydney Basin Bioregion (EEC under the BC and EPBC Act)	
MU46	978	Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion	None	1.90

*Note that figures for swamp communities include areas of swamps beyond the study area boundary where any part of the swamp occurs within the boundary. Vegetation calculations are a combination of NPWS (2003) mapped areas and Niche validated mapping for swamp communities. There may be some discrepancies where NPWS (2003) has mapped upland swamp communities and the swamp boundaries have been adjusted as part of the validated swamp mapping undertaken as part of this assessment.

5.2 Upland Swamps within the study area

Seven Upland Swamps occur within the study area based on the 600m boundary (Table 10) (Figure 3 and 4), two large complex swamps and five smaller swamps with single sub-communities, which tend to be drier swamp types (Banksia Thicket ,Mallee Heath). Complexity of swamps generally increased with overall size of the swamp complex. This is likely due to larger swamps having more variable groundwater conditions across the swamp from more frequently waterlogged areas with heavy peat development to less frequently waterlogged areas with less peat development.

The two complex large swamps within the study area (Den15a and Den15b) are located within the predicted area of subsidence impacts (35-degree angle of draw study area) (Figure 3 and 4). There are also three small swamps that are located above LW19A (Den15c, Den34 and Den148) and two small swamps (Den12 and Den96) located within the 600 m boundary study area (Figure 3).

Table 10: Upland Swamps within the study area

Swamp No.	PCT	Swamp community/sub-community (structure)	Area (ha)				
			Total Swamp	600 m boundary	Angle of draw	Groundwater Impact zone	Above proposed longwall
Den12	978	Upland Swamps: Banksia Thicket	5.37	0.10	0	0	0
Den15a	978	Upland Swamps: Banksia Thicket	7.93	6.81	2.04	0	0
	978	Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)	4.40	4.38	1.82	0	0
	978	Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)	2.50	2.49	1.15	0	0
	1804	Upland Swamps: Tea-tree Thicket	2.56	2.56	0.33	0	0
Den15b	978	Upland Swamps: Banksia Thicket	3.25	0.84	0.02	0	0
	1804	Upland Swamps: Tea-tree Thicket	1.04	0.22	0.09	0	0

Swamp No.	PCT	Swamp community/sub-community (structure)	Area (ha)				
			Total Swamp	600 m boundary	Angle of draw	Groundwater Impact zone	Above proposed longwall
	987	Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)	0.57	0.01	0	0	0
	978	Upland Swamps: Sedgeland-Heath Complex (Sedgeland)	0.01	0	0	0	0
Den15c	978	Upland Swamps: Banksia Thicket	0.65	0.65	0.65	0.65	0.33
Den34	978	Upland Swamps: Mallee-Heath	1.90	1.90	1.90	1.02	0.01
	978	Upland Swamps: Banksia Thicket	0.40	0.40	0.39	0	0
	1804	Upland Swamps: Tea-tree Thicket	0.28	0.28	0.28	0	0
Den96	978	Upland Swamps: Banksia Thicket	0.17	0.17	0	0	0
Den148	978	Upland Swamps: Banksia Thicket	0.86	0.86	0.86	0.53	0.23
Total			**31.89**	**21.67**	**9.53**	**2.20**	**0.57**

5.3 Upland swamp community descriptions

5.3.1 PCT 978 - Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion

Extent: PCT 978 occurs on coastal sandstone plateaux on soils with impeded drainage, on seepage and water discharge sites that are periodically waterlogged.

Condition and presence of weeds: PCT978 occurs in the study area as three variants, all of which are considered to be in good condition, with no weeds present:

- Sedgeland-Heath Complex (MU44)
- Banksia Thicket (MU42)
- Mallee Heath (MU46).

None of these areas are to be cleared as part of the proposal, however, may be impacted by subsidence.

Conservation status: This PCT aligns to Coastal Upland Swamp in the Sydney Basin Bioregion listed as Endangered under the BC Act and EPBC Act. However, the Mallee Heath variant is not included in the TEC listing.

Variants:

The following vegetation communities grow within Coastal Upland Swamps and are associated with PCT978 in the study area:

- Banksia Thickets: develops on the edge of larger swamps, often occupying the highest parts of swamp topographical sequences. Its soils are predominantly drier and sandy, yet they have intermediate levels

of total phosphorus, conductivity and exchangeable cations. Its higher levels of organic matter might be explained by a greater rate of litterfall, rather than by a slower rate of decay due to poor aeration (Keith and Myerscough 1993). *Banksia ericifolia* subsp. *ericifolia* and *Hakea teretifolia* are the dominant diagnostic species of this assemblage.

- Sedgeland-Heath Complex: comprises of three communities, Cyperoid Heath, Restioid Heath and Sedgeland, have been described by Keith (1994):
  - Cyperoid Heath prefers the wetter locations on organic sandy soils (Young 1986) within the Coastal Upland Swamp complex, though it is replaced by Tea-tree Thicket in drainage lines. Sedges from the Cyperaceae family, including *Gymnoschoenus sphaerocephalus* and *Lepidosperma limicola*, dominate Cyperoid Heath. Low shrubs of *Banksia robur* and *Leptospermum juniperinum* occur patchily.
  - Restioid Heath occupies relatively drier sites within the swamp complex, with sedges from the Restionaceae family forming the dominant ground cover. Species include *Leptocarpus tenax*, *Empodisma minus* and *Lepyrodia scariosa*. A low spreading shrub layer of *Banksia oblongifolia* and *Hakea teretifolia* is common. Restioid heath occupies higher parts of the topographical sequence where soils are periodically dry, preventing the accumulation of large amounts of peat. This, and their low clay content, provide few exchange sites for mineral nutrients which are leached downslope, perhaps to be adsorbed in soils with higher clay and organic fractions.
  - Sedgeland occurs on the perimeter of larger Coastal Upland Swamps or on gently sloping 'hanging swamps' in the headwaters of sandstone gully lines. Similar to Restioid Heath, Sedgeland occupies higher parts of the topographical sequence where soils are periodically dry, preventing the accumulation of large amounts of peat. A thick, low cover of sedge species spreads across the extent of the community. Species such as *Leptocarpus tenax*, *Schoenus brevifolius, Schoenus paludosum* and *Lepyrodia scariosa* are frequently recorded. A number of sparsely scattered low shrubs such as *Sprengelia incarnata, Epacris obtusifolia* and *Symphionema paludosum* are also found.
- Mallee-Heath is not described by Keith and Myerscough (1993), however it is described as part of the Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments mapping project (NPWS 2003). The vegetation unit is distributed on drier gradients with the Coastal Upland Swamp Complex in the Avon and Nepean Catchments, and only occasionally in the north near Maddens Plains. *Eucalyptus stricta* occurs in dense clumps amongst a low cover of shrubs such as *Banksia ericifolia* subsp. *ericifolia*, *B. paludosa* subsp. *paludosa*, *Allocasuarina nana*, *Petrophile sessilis* and *Leptospermum attenuatum* with ground cover typical of Restioid Heath.

Characteristic species used for identification of PCT:

Niche typically recorded the following species within PCT978: *Banksia ericifolia* subsp. *ericifolia* and *Hakea dactyloides* and *Dillwynia floribunda.* Common understorey species recorded by Niche include: *Empodisma minus, Dampiera stricta, Entolasia stricta, Selaginella stricta* and *Leptocarpus tenax* and *Lepyrodia scariosa.*

Justification of evidence used to identify the PCT: The stated distribution and habitat information for the PCT, as given in the DPE VIS Community Profile Report (DPE 2022a), is highly consistent with the geographic location, habitat and floristics of the PCT at the study area. The key matching characteristics are:

- its occurrence on humic sandy loams in headwater valleys on sandstones of the Woronora plateaux at altitudes of 50-600 m.
- its open to dense shrub canopy with a dense groundcover of sedges and forbs.
- its occurrence on coastal sandstone plateaux.

5.3.2 PCT 1804 - Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin

Extent: PCT 1804 is restricted to the coastal zone where mean annual rainfall exceeds 1200 millimetres or greater. Some examples are found in drier zones (to 1000 millimetres per annum) however invariably these are drainage line swamps. Outside of the Sydney metropolitan area this community extends south from the hinterland of the Central Coast to the southern Woronora Plateau and Jervis Bay.

Condition and presence of weeds: PCT 1804 occurs in the study area as one variant, which is considered to be in good condition, with no weeds present:

- Tea-tree Thicket (MU 43).

These areas would not be cleared as part of the proposal, however may be impacted by subsidence.

Conservation status: This PCT aligns to Coastal Upland Swamp in the Sydney Basin Bioregion listed as Endangered under the BC Act and EPBC Act.

Variants:

Tea-tree Thicket: occupies major seepage zones of large swamps, which typically have deep, highly organic waterlogged soils. In general, levels of soil nutrients are highest in Tea-tree Thicket compared to the other Coastal Upland Swamp vegetation. Keith and Myerscough (1993) note that waterlogging is continuous and peat development is greatest in Tea-tree Thicket. Young (1986) showed that the soils, termed 'organic fines', have a high silt/ clay content in their mineral fraction, as well as a high organic carbon content. Their high nutrient status may therefore be explained by a large input of nutrient ions from runoff and downwash, and by the abundance of clay and organic particles which provide a large number of exchange sites for mineral cations. Tea-tree Thicket has a tall to short, relatively dense shrub stratum with *Leptospermum juniperinum, Leptospermum grandifolium, Melaleuca squarrosa, Baeckea linifolia* and *Banksia robur*, and a tall, very dense stratum of ferns; Gleichenia spp., and sedges *Gahnia sieberiana* and *Baumea teretifolia*.

Characteristic species used for identification of PCT:

Niche recorded the following species within Coastal Upland Swamps Tea-tree Thicket: *Leptospermum juniperinum, Leptospermum trinervium, and L. polygalifolium* subsp. *polygalifolium*, *Acacia rubida, Banksia ericifolia* subsp. *ericifolia* and *Melaleuca squarrosa*. All these species are diagnostic species discussed in NPWS (2003).

The thickets of the Tea-trees ranged from may being sparse to absent depending on water table fluctuation and long-term fire history. Occasional individuals of *Banksia robur* and *Conospermum ellipticum* are present in the sparse low shrub layer. Other ground covers included *Lepidosperma laterale, Baumea teretifolia* and *Tetrarrhena juncea*.

Justification of evidence used to identify the PCT: The stated distribution and habitat information for the PCT, as given in the DPE VIS Community Profile Report (DPE 2022a), is highly consistent with the geographic location, habitat and floristics of the PCT at the study area. The key matching characteristics are:

- It is a wet heath-open sedgeland community that has a sparse to dense heath layer.
- The upper stratum usually includes one or more species of banksia, hakea or tea-tree. However it is the distinctive broad hairy leaves of the low-growing shrub swamp banksia (*Banksia robur*) that helps distinguish this community from those in drier locations on the sandstone plateau.
- Typically this community occupies zones in or proximate to drainage lines where water seepage is more constant than it is in more elevated parts of the swamp.
- Soils are peaty and regularly waterlogged.
- A diverse and abundant cover of sedges and ferns is present in the ground layer. Dense patches of pouched coral fern (*Gleichenia dicarpa*) often adjoin drainage lines.

5.4 Upland swamp – TEC classification

5.4.1 BC Act/ EPBC Act

The majority of Upland Swamps within the study area are considered to fit the NSW and Commonwealth determination descriptions of Coastal Upland Swamps in the Sydney Basin Bioregion, which is listed as an EEC under the NSW BC Act and the Commonwealth EPBC Act. Point 7 of the Final Determination (NSW Scientific Committee 2012) states Coastal Upland Swamp in the Sydney Basin bioregion includes mapping units: Upland Swamps Banksia Thicket (MU42), Upland Swamps Tea-tree Thicket (MU43) and Upland Swamps Sedgeland-Heath Complex (MU44) of NPWS (2003). All three of these communities occur within the Upland Swamps in the study area (Figure 3). Upland Swamps: Mallee-Heath (MU46) is not included in the definition for the EEC.

The approximate area of EEC Coastal Upland Swamps within the wider study area, which includes the totality of a swamp where any part of the swamp is within 600 m of the proposed longwalls is 29.97 ha (Table 10).

5.5 Threatened flora

A total of 27 threatened plant species listed on the EPBC Act and or BC Act have been previously recorded or have potential habitat within a 5 km radius of the study area (Appendix 1 and Figure 6). Of the 27 threatened species obtained in the database searches, 10 species (*Acacia bynoeana, Cryptostylis hunteriana, Epacris purpurascens* var. *purpurascens, Grevillea parviflora* subsp. *parviflora, Grevillea raybrownii, Leucopogon exolasius, Melaleuca deanei, Persoonia acerosa, Persoonia hirsuta* and *Pultenaea aristata*) were considered to have a Moderate to High likelihood of occurrence in the study area.

During the field assessment, approximately 79 *Leucopogon exolasius* individuals were identified on sandy alluvium within the riparian corridor of the tributary off Wongawilli Creek (WC14) that intersects the 600 m study area, and on the north-west facing ridgeline within the LW19A footprint (Figure 4). This species is found on rocky sandstone hillsides near creeks, and the impacts of subsidence on this species are not well documented. However, based on the species ecology it may be less likely to be reliant on groundwater and less likely to be impacted by subsidence.

No other threatened flora was recorded within the study area.

Potential impacts to threatened flora are discussed in Section 6.3.

5.6 Threatened fauna

A total of 56 threatened fauna species listed on the EPBC Act and or BC Act have been previously recorded or have potential habitat within a 5 km radius of the study area (Appendix 1 and Figure 7).

The previous SIS survey recorded 139 fauna, including 32 threatened fauna within DA3.

Fauna surveys were undertaken across the entire 600 m buffer study area, targeting habitat types such as Upland Swamps, creeks and drainage lines and cliff habitat (west of the study area along Wongawilli Creek). Threatened fauna were recorded during the current survey as detailed in Table 11.

Table 11: Threatened fauna recorded during current survey

Threatened species	Observation details	Date
Littlejohn's Tree Frog	Observations of tadpoles were made from the following locations: • WC13 (50 individuals observed across 4 pools small and med/large with tadpoles of various stages include close to metamorphic). • Swamp Den15a (approximately 170 individuals observed in three separate pools along edge of swamp. • WC14 of Wongawilli Creek (20 individuals across three pools), that intersects the LW19A Angle of draw.	12/12/2019 8/8/2022
Glossy Black-cockatoo	Two individuals observed at WC13 Crushed Allocasuarina cones found during diurnal surveys.	12/12/2019 16/6/2022

5.7 Fauna habitat

Fauna habitat within the study area considered prone to subsidence impacts is summarised below in Table 12.

Table 12 Fauna habitat prone to subsidence

Habitat type	Associated PCTs	General description	Fallen logs and other woody debris	Foraging resources	Hollow-bearing trees and/or nest	Aquatic habitat	Other foraging/ sheltering/ nesting resources	Photo
Sandstone outcrops, rockbars, and overhangs	1250 and 1083	Sandstone outcrops, overhangs and caves are typically important to reptile and bat species. Threatened reptiles that may utilise such features include the threatened Broad-headed Snake. These species rely on these habitats for over-wintering, thermoregulation, and shelter, and as a refuge for juveniles and prey species. Caves and overhangs within the study area may provide habitat for micro-bats, including threatened species: • Large Bentwing-bat • Little Bentwing-bat • Southern Myotis. Cave development within the study area is poor however, so roosting is	N/A	N/A	N/A	N/A	Sandstone outcrops were not very common throughout the study area, but where they were present included exfoliated surfaces and crevices.	 **Plate 1 Rockbar**

Habitat type	Associated PCTs	General description	Fallen logs and other woody debris	Foraging resources	Hollow-bearing trees and/or nest	Aquatic habitat	Other foraging/ sheltering/ nesting resources	Photo
		likely to be confined to limited areas. No large breeding colonies of cave dependant bats are expected to occur within the study area.						
Creeks and drainage lines	All PCTs	Major watercourses within and adjoining the DA3A study area include Wongawilli Creek and Sandy Creek. Various drainage lines and tributaries of these watercourses occur throughout the study area. 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	Present	Present	Present	All creeks and drainage lines within the study area are considered to be generally in good condition, and they provide a range of habitat features including emergent vegetation, riffles, pools, sandy substrate, and rocks.	Other habitat features along the streams include rock pools, riffle zones, gravel beds, woody debris, boulders, and aquatic vegetation.	 **Plate 2 tributary off Wongawilli Creek**

Habitat type	Associated PCTs	General description	Fallen logs and other woody debris	Foraging resources	Hollow-bearing trees and/or nest	Aquatic habitat	Other foraging/ sheltering/ nesting resources	Photo
		streams are preferred by others.						
Upland Swamp habitat	1803 and 1804	Swamp habitat supports a wide variety of birds, mammals, amphibians, reptiles, invertebrates (e.g. Giant Dragonfly) and stygofauna (fauna reliant on Groundwater Dependant Ecosystems [GDEs]). A number of threatened frogs (e.g. Giant Burrowing Frog, Little John's Tree Frog and Red-crowned Toadlet) have also been previously recorded in this habitat type.	Limited fallen woody debris due to absence of canopy.	Limited – occurrence of Hakea, Banksia and *Leptospermum* spp., which are used as foraging resources at certain times of the year.	Absent	GDE, however, also influenced by surface water runoff. Soak habitat which provides habitat for a range of insects, amphibians, reptiles, birds, and mammals. Upland Swamps within the study area also provide an important role in regulating flows along particular watercourses within the study area.	Dense sedge layer, ground cover, which also provides refuge and nesting/breeding opportunities for fauna such as small mammals and amphibians.	 **Plate 3 Coastal Upland Swamp**

5.8 Key threatening processes

Key-threatening processes (KTP) relevant to the proposal include:

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

5.8.1 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 NSW BC Act. This is the most relevant KTP associated with the proposal.

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

A list of threatened species, populations and TECs potentially impacted by longwall mining is provided in the Final Determination for this KTP (NSW Scientific Committee 2005). Flora of relevance to this assessment include: *Acacia baueri* subsp*. aspera, Epacris purpurascens* var*. purpurascens, Leucopogon exolasius, Melaleuca deanei, Persoonia acerosa* and *Pultenaea aristata.* Fauna include: Eastern Pygmy Possum, Southern Brown Bandicoot, Giant Burrowing Frog, Black Bittern, Littlejohn's Tree Frog, Stuttering Frog, Southern Myotis, Red-crowned Toadlet, Grey-headed Flying Fox, Giant Dragonfly, Broad-headed Snake and Rosenberg's Goanna.

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

Alteration of the natural flow regimes of rivers, stream, floodplains and wetlands is listed as a KTP under Schedule 4 of the BC Act. This is a relevant KTP associated with the proposal, which is 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.

5.9 Critical habitat or Areas of Outstanding Biodiversity Value (AOBV)

Areas of Critical Habitat under the NSW TSC Act have been replaced by AOBVs with the introduction of the NSW BC Act. No AOBVs have been declared for any ecological values within the study area. No AOBVs 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 the woodland and forest communities in Table 9 (PCTs 1250 and 1083).

Groundwater dependant and riparian vegetation may experience some floristic changes in response to changed groundwater conditions, as a result of subsidence.

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

In the Southern Coalfield, observed impacts to riparian vegetation as a result of subsidence are minor in occurrence. Furthermore, limited impacts to riparian vegetation have been observed in Dendrobium Mine (Biosis 2016). Previous examples of impacts include dieback of riparian vegetation as a result of methane 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.

Groundwater dependant ecosystems (typically comprising Upland Swamps within the locality) on the other hand are prone to groundwater changes as a result of subsidence. Potential impacts are discussed below.

6.2 Potential impacts to Upland Swamps

The study area contains a mixture of headwater swamps and valley infill swamps. If all seven swamp areas within and adjacent to the 600 m study area boundary are considered, 21.67 ha of Upland Swamps including complex swamps with wetter sub-units have some potential for impact. However, the areas bounded by 600 m (especially if adjacent swamp areas are included) is considered a conservative approach to determining areas of potential impacts.

The majority of impacts to Upland Swamps will take place where they occur within the groundwater impact zone (2.2 ha) and above the proposed longwall (0.57 ha of Upland Swamps). The severity and risk of impacts will reduce with distance from longwalls up to the 35° angle of draw study area, which includes the 20 mm subsidence contour (9.53 ha of Upland Swamp within 35° angle of draw study area). Beyond the 35° angle of draw study area, impacts to features such as swamps and watercourses are expected to be minor or negligible. A recent assessment at Dendrobium Mine concluded that hydrological change in Upland Swamps is not evident in shallow groundwater piezometers located more than 60 m from the extracted longwall margin (Watershed HydroGeo 2019). Where streams flowing into swamps are located above or in close proximity to longwalls this may have impacts on swamps downstream of impacted streams.

Den15c is located partially above the north-eastern corner of LW19A, a total of 0.33 ha (Figure 3). Den34 (0.01 ha) and Den148 (0.23 ha) are also located partly above LW19A (Figure 3). Approximately 9.53 ha of Upland Swamps occur within the 35° angle of draw study area. These areas are likely to experience a range of subsidence impacts (see Table 13). Upland Swamps located within the wider study area based on the 600 m boundary (Figure 3) equate to 21.67 ha, which may experience some minor or negligible impacts depending on the distance from the proposed longwall.

To assess the potential impacts of subsidence on Upland Swamps, a review of MSEC (2022) subsidence predictions and previous literature on monitoring of swamp subsidence impacts from the locality has been completed, with a summary provided in Table 13. The MSEC (2022) report has predicted potential subsidence impacts within swamps located within the 35° angle of draw study area constituting of five swamps, with parts of the large complex swamps (Den15a and Den15b) being mined beneath by LW19. It is expected that fracturing of the bedrock beneath six of the swamps within the study area would occur as the result of the proposed longwall (MSEC 2022). Should changes in groundwater levels within the Upland Swamps occur, this may impact on the distribution of local vegetation within the swamps as well as potential for downstream impacts to associated watercourses.

Table 13: Impact predictions for Upland Swamps within and adjacent to the study area

Site	Swamp characteristics	Position	Subsidence predictions (MSEC 2022)	Predicted impacts
Den12	Medium sized simple swamp. Northern tip of swamp adjacent to WC17.	Within the 600 m boundary. Directly above LW7 and LW8, 580 m north-west of LW19A	Swamp Den12 is located above the previously extracted LW7 and LW8. Unlikely that there would be adverse changes in the levels of ponding or scouring for swamp Den12 based on the predicted vertical subsidence and tilt. It is likely that fracturing would occur in the bedrock beneath Den12 predominately in areas located above and adjacent to the mining area. Fracturing would only be visible at the surface where the bedrock is exposed, or where the thickness of the overlying soil is relatively shallow. Valley-related effects could result in the dilation of the strata beneath this swamp. The dilated strata beneath the drainage lines upstream of Den12, could result in the diversion of some surface water flows beneath parts of these swamps where they are located directly above the mining area. The drainage lines upstream of this swamp flows during and shortly after rainfall events. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation. Den12 is located directly above LW7 and LW8 and, therefore, the potential impacts predominately occur due to these existing longwalls, rather than the proposed LW19A.	Monitoring of the impacts of LW7 in DA3A, which was extracted directly beneath Swamp Den12, revealed one fracture in a rock outcrop after mining beneath this swamp. Regular monitoring has been undertaken and, to date, no erosion or other changes have been observed (MSEC 2022). Unlikely to be measurable additional impacts (after impacts from LW7 and LW8) to this swamp or associated species including threatened species from the current proposal. Monitoring of impacts likely to be confounded from previous direct undermining (LW7 and LW8). A known population of Littlejohn's Tree Frog occurs along WC17 downstream, of swamp Den12.
Den15a	Large complex swamp with pools observed within or on edges of swamp. Swamp follows alignment of watercourse SC10.	Partially within angle of draw. Feeding tributary (SC10) within angle of draw.	Den15a is located outside and adjacent to the mining area. Unlikely that there would be adverse changes in the levels of ponding or scouring for swamp Den15a based on the predicted vertical subsidence and tilt. It is likely that fracturing would occur in the bedrock beneath Den15a predominately in areas located above and adjacent to the mining area. It is possible that a series of	Possible ecological impacts including changes in vegetation and threatened species habitat (predominantly for Littlejohn's Tree Frog) for the area of swamp directly adjacent the proposed longwall. Long term monitoring of this swamp shows a statistically significant decline in total species richness over time since approximately 2017, five

Site	Swamp characteristics	Position	Subsidence predictions (MSEC 2022)	Predicted impacts
			smaller fractures, rather than one single fracture, could develop in the bedrock. Fracturing would only be visible at the surface where the bedrock is exposed, or where the thickness of the overlying soil is relatively shallow. Valley-related effects could result in the dilation of the strata beneath this swamp. The dilated strata beneath the drainage lines upstream of Den15a, could result in the diversion of some surface water flows beneath parts of these swamps where they are located directly above the mining area. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation. rockbar	years since the swamp was impacted by mining (within the risk management zone). Swamp composition has also been changing statistically significantly over this time period with 'wetter' species becoming less common post impact, suggesting a loss of species that prefer moist soils. A trending decline in swamp extent and in each subcommunity has occurred when compared to 2014. These impacts are likely to be exacerbated by the mining of LW19A. A large population of Littlejohn's Tree Frog is known to occur within areas of this swamp and associated drainage lines and pools. Breeding habitat for this population may be impacted through reductions in water retention from pools after fracturing. Swamp is large and complex and contributes significantly to biodiversity values given its size, complexity and available pooling habitat.
Den15b	Large complex swamp with pools observed within or on edges of swamp. Swamp follows alignment of watercourse SC10C.	Within angle of draw. Directly above LW7 and LW8, 430 m north-east of LW19A.	Swamp Den15b is located above the previously extracted LW7 and LW8. Unlikely that there would be adverse changes in the levels of ponding or scouring for swamp Den15b based on the predicted vertical subsidence and tilt. It is likely that fracturing would occur in the bedrock beneath Den15b predominately in areas located above and adjacent to the mining area. Fracturing would only be visible at the surface where the bedrock is exposed, or where the thickness of the overlying soil is relatively shallow. Valley-related effects could result in the dilation of the strata beneath this swamp. The dilated strata beneath the drainage lines upstream of Den15b, could result in the	Possible ecological impacts including changes in vegetation and threatened species habitat (predominantly for Littlejohn's Tree Frog). Long term monitoring of this swamp indicates a statistically significant decline in total species richness over time since approximately 2013, one year since the swamp was mined beneath. A statistically significant change in composition is observed since 2012. As swamp species appear to be dying out with limited recruitment of new species, the swamp may be experiencing some degree of die-back. A trending decline in swamp extent has occurred since 2014, driven mainly by declines in the Banksia Thicket subcommunity and to a lesser degree the Tea-tree Thicket subcommunity.

Site	Swamp characteristics	Position	Subsidence predictions (MSEC 2022)	Predicted impacts
			diversion of some surface water flows beneath parts of this swamps where it is located directly above the mining area. The drainage lines upstream of this swamp flows during and shortly after rainfall events. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation. Den15b is located directly above LW7 and LW8 and, therefore, the potential impacts predominately occur due to these existing longwalls, rather than the proposed LW19A.	A population of Littlejohn's Tree Frog is known to occur within areas of this swamp and associated drainage lines and pools. Breeding habitat for this population may be impacted through reductions in water retention from pools after fracturing. Areas may trend towards Fringing Eucalypt Forest if changes are long-term. Swamp is large and complex and contributes significantly to biodiversity values given its size, complexity and available pooling habitat. Monitoring of impacts from LW19A are likely to be confounded from previous direct undermining (LW7 to LW8).
Den15c	Small simple swamp occurring along SC10B.	Directly above the tailgate of LW19A near the eastern end.	Unlikely that there would be adverse changes in the levels of ponding or scouring for swamp Den15c based on the predicted vertical subsidence and tilt. Fracturing of the bedrock could occur beneath Den15c where it is located above and adjacent to the mining area. This swamp has layers of organic soil and, in most cases, cracking would not be visible at the surface within these swamps, except where the depths of bedrock are shallow or exposed. The dilated strata beneath the drainage lines could result in the diversion of some surface water flows beneath parts of the swamp where it is located above and adjacent to the proposed longwall. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation.	Possible ecological impacts including changes in vegetation and threatened species habitat. However, swamp is small and simple.
Den34	Small simple swamp occurring along WC13.	Generally outside the mining area but the northern extent above the	Unlikely that there would be adverse changes in the levels of ponding or scouring for swamp Den34 based on the predicted vertical subsidence and tilt. Den34 could experience valley-related effects due	Possible ecological impacts including changes in vegetation and threatened species habitat. However, swamp is small and simple. Observations of

Site	Swamp characteristics	Position	Subsidence predictions (MSEC 2022)	Predicted impacts
		maingate of LW19A.	to the mining of the existing, future and proposed longwalls in DA3A. It is likely that fracturing would occur in the bedrock beneath Den34, predominately in areas located above and adjacent to the mining area. It is possible that a series of smaller fractures, rather than one single fracture, could develop in the bedrock.	Littlejohn's Tree Frog were made approximately 200 m downstream of the swamp and the species may occur within the swamp and downstream pools.
Den96	Small simple swamp, no mapped pools or watercourses adjacent.	Outside the mining area, 400 m east of LW19A.	Unlikely that there would be adverse changes in the levels of ponding or scouring for swamp Den96 based on the predicted vertical subsidence and tilt. Fracturing or surface cracking due to mine subsidence are not anticipated at Den96 due to the mining of LW19A.	Unlikely to be measurable impacts to this swamp or associated species including threatened species.
Den148	Small sized simple swamp, occurring along WC14.	Directly above LW19 and LW19A.	Part of Den148 is partially located above the tailgate of the proposed LW19A. Fracturing is likely to occur in the bedrock beneath this swamp where it is located above and adjacent to the proposed longwall. There are no predicted reversals of stream grade along drainage lines nor within the extents of the swamp as a result of subsidence induced tilt. Predicted upsidence could result in the dilation of the strata beneath this swamp. The dilated strata beneath the drainage lines could result in the diversion of some surface water flows beneath parts of the swamp where they are located above or adjacent to the proposed longwall. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation. Den148 is located near the bases of drainage line WC14, and this swamp could experience valley-	Possible ecological impacts including changes in vegetation and threatened species habitat. However, swamp is small and simple.

Site	Swamp characteristics	Position	Subsidence predictions (MSEC 2022)	Predicted impacts
			related effects due to the mining of the existing, future and proposed longwalls in DA3A.	

6.3 Potential impacts to threatened flora

Eleven threatened flora species have been determined to have a moderate to high likelihood of occurring within the study area (Appendix 4). However, a limited number have potential habitat likely to be impacted by subsidence.

Threatened flora likely to be impacted by subsidence Table 14), include those associated with ground water dependent habitats, such as Upland Swamps and riparian vegetation. Ridgeline and woodland dependent threatened flora are unlikely to be significantly impacted by subsidence mechanisms.

Leucopogon exolasius is known to occur in the study area. An additional three species (*Epacris purpurascens* var*. purpurascens, Pultenaea aristata* and *Cryptostylis hunteriana*) are considered to have habitat within the study area that may be potentially impacted by subsidence. Each of these species has potential habitat within Upland Swamps or creek line vegetation communities, however none of these species are reliant on such habitat and occur throughout a range of other habitats within the study area.

Impacts from the current proposal on threatened flora have been assessed within the project's SIS and are likely to be minimal as a result of the current proposal. Impacts to *Leucopogon exolasius* recorded in the study area are likely to be minimal and not result in death of individuals or loss of population, given the species has been recorded on slopes and ridgelines upslope of riparian habitats, which suggests not dependent on groundwater or surface flows.

Table 14: Threatened flora with potential to be impacted within the study area

Botanical name	Potential habitat in study area	Potential to be impacted by subsidence	Seven-Part Test undertaken in SIS (Biosis 2007)
Cryptostylis hunteriana	Not previously recorded in study area. Potential habitat includes Upland Swamps, creek lines and ridge lines.	Yes. Upland Swamps and creek line habitat may be impacted by subsidence mechanisms.	Yes. No significant impact concluded.
Epacris purpurascens var. *purpurascens*	Not previously recorded in study area. Potential habitat includes Upland Swamps, creek lines and ridge lines.	Yes. Upland Swamps and creek line habitat may be impacted by subsidence.	Yes. No significant impact concluded.
Leucopogon exolasius	Previously recorded in the study area on ridgetop, as well as riparian habitat (WC14). Ridgetop habitat not likely to be impacted by subsidence. Potential habitat includes creek lines. Vegetation communities include SGPF and SRS.	Yes. Creek line habitat may be impacted by subsidence mechanisms.	Yes. No significant impact concluded.
Pultenaea aristata	Not previously recorded in study area.	Yes. Upland Swamps and creek line habitat may be impacted by subsidence mechanisms.	Yes. No significant impact concluded.

Botanical name	Potential habitat in study area	Potential to be impacted by subsidence	Seven-Part Test undertaken in SIS (Biosis 2007)
	Potential habitat includes Upland Swamps and creek lines.		

6.4 Potential impacts to fauna

Subsidence may have a direct impact on known and potential habitat for threatened fauna such as watercourses, Upland Swamps, riparian vegetation, rock overhangs, rocky outcrops, cliffs and crevices. Predicted impacts to these habitats are documented in Table 1.

Woodland and forest habitat types make up the majority 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.

The proposed longwall layout has been set back from major watercourses within the study area including Wongawilli Creek and Sandy Creek, and as such, subsidence impacts within these areas would be limited (MSEC 2022).

A number of mapped watercourses occur within the 35-degree angle of draw study area, which are 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. Watercourses that are directly mined beneath and those within the 35° angle of draw, are likely to have bedrock fracturing with associated impacts such as diversion of surface water flows and draining of pooled water. In addition to hydrological impacts, secondary impacts on water quality, such as increased concentrations of iron and manganese precipitates are likely to occur as a result of bedrock fracturing and increased groundwater input to the streams. The iron and manganese precipitates form an organic flocculant which decomposes and decreases dissolved oxygen, which may impact aquatic fauna and insects. 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 groundwater fed systems.

Within the Dendrobium mining domain, the above-mentioned aquatic impacts are considered the most significant impact to fauna. In regard to terrestrial fauna, such impacts are of particular relevance to frog species including the threatened species Red-crowned Toadlet, Littlejohn's Tree Frog and Giant Burrowing Frog, which are discussed in detail in Section 6.5.

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. Small rock outcrops are expected to experience minor impacts. 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).

6.5 Potential impacts to threatened fauna

Fifty-six threatened fauna were considered during likelihood of occurrence assessment (Appendix 1). Thirty-nine 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. Nine threatened species are considered to be potentially impacted by subsidence impacts resulting from the proposal (Table 15).

Assessments of significance under the BC Act were carried out for 30 threatened species during the project SIS, with significant impacts considered to potentiality occur for six species comprising:

- Frogs: Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet and Stuttering Frog
- Reptiles: Broad-headed Snake
- Invertebrates: Giant Dragonfly.

The results of the assessments of significance considering DA3 are considered relevant to the current project, with the exception of the Stuttering Frog. The Stuttering Frog is not likely to be present in the study area as it has not been recorded during the present study or during extensive survey programs targeting threatened frog species conducted in adjacent areas with the same habitats (Biosis 2019, Niche 2022). The very few recent records of the Stuttering Frog located from the Sydney Basin and southwards have all been associated with large permanent streams lined by wet sclerophyll or rainforest vegetation that tends to form a dense enclosing canopy over the stream area. This habitat is very limited or absent from the study area and surrounds.

An assessment of potential impacts from the current proposal for each of the identified threatened species likely to be impacted is provided below in Table 15.

Table 15: Threatened fauna with moderate to high likelihood of occurrence and potential for impacts due to the proposal

Species	Recent records and habitat in study area	Potential impact to species or potential habitat in study area	Assessment of significance undertaken in SIS and result (Biosis 2007)	Current conservation and impact status
Amphibians				
Giant Burrowing Frog	Species was recorded during SIS and subsequent monitoring surveys in DA3A and DA3B (Biosis 2019; Figure 7). Records are sporadic due to difficulty of detection. Not recorded during current survey but assumed to be present due to difficulty of detection.	Potential impacts include changes to flow regimes, loss of surface flow and water retention within breeding pools. Changes in Upland Swamps are likely to impact the species via influencing downstream pool availability or permanency or through changes in sheltering habitat within swamps.	Yes. Significant impact determined.	Conservation listing status of species has not changed since original SIS. Habitat has been shown to be impacted during monitoring of subsidence impacts within DA3A and DA3B as predicted within SIS. Access constraints and detectability make it difficult to judge severity of impacts on population via effective monitoring. Impacts detected for Littlejohn's Tree Frog for permanent pools are likely relevant for Giant Burrowing Frog.
Littlejohn's Tree Frog	Recorded throughout DA3A-3C during SIS. Recorded within current study in several watercourses and downstream of Upland Swamps (Figure 5). Likely to be present in other watercourses throughout study area where appropriate breeding habitat is present. Within the study area, the species relies upon semi-permanent pools for tadpole development. Maturation times for tadpoles	Potential impacts include changes to flow regimes, loss of surface flow and water retention within breeding pools. Changes in Upland Swamps are likely to impact the species via influencing downstream pool availability or permanency or through changes in sheltering habitat within swamps.	Yes. Significant impact determined.	Conservation listing status of species has not changed since original SIS. Habitat has been shown to be impacted during monitoring of subsidence impacts within DA3A and DA3B as predicted within SIS. Monitoring within DA3B indicates that abundance of species is likely to have declined due to subsidence impacts such as reduced water retention in pools (Biosis 2016).

Species	Recent records and habitat in study area	Potential impact to species or potential habitat in study area	Assessment of significance undertaken in SIS and result (Biosis 2007)	Current conservation and impact status
	have been observed to take around four months (Anstis 2002), although this is variable in the field depending on factors such as weather. Pools of sufficient depth and hydroperiod within the catchment area were almost exclusively located along second order or higher streams or else first order streams where headwater swamps are positioned upstream. Larger, faster flowing streams such as Wongawilli Creek are less likely to support breeding.			No prior threatened frog monitoring has occurred along WC14, within the LW19A Angle of draw, However, the species was identified during the current assessment. Sandy Creek (SC10) frog monitoring sites occur within the 600 m buffer of LW19A. Monitoring at SC10 commenced in 2006, with the extraction of Longwall 7 occurring within the transects RMZ in 2011 and Longwall 8 undermining the transect in 2012. No lifecycle stages were recorded in 2021, which also occurred in 2019 and 2017. A statistically significant difference in detection of adults was identified between the pre-mining period and mined under periods (p-value <.0001). Transect SC10C also recorded an increase in adults during the single year of within RMZ monitoring, as did SC10(2). While all counts were statistically significantly higher at Control sites than the Impact site, this occurred both before and after mining (Niche 2022).

Species	Recent records and habitat in study area	Potential impact to species or potential habitat in study area	Assessment of significance undertaken in SIS and result (Biosis 2007)	Current conservation and impact status
Red-crowned Toadlet	Recorded during the SIS at five sites in DA3 including upland Swamp 10, and a drainage line near upland Swamp Den15b. Recorded in DA3B in 2012 surveys (Niche 2012) and during follow-up monitoring (e.g. Biosis 2016). Recorded in DA3C along WC20.	Yes, potentially impacted. Given its habitat preferences appear to be largely dependent upon surface water runoff and seepage rather than ground water and requirements for semi-permanent pools, it is considered that this species is less sensitive to impacts from subsidence in comparison with other species such as Littlejohn's Tree Frog. Nonetheless, changes in hydrology related to cracking of bedrock underlying streams providing habitat for the Red-crowned Toadlet have the potential to influence moisture levels and retention of moisture within small pools, soaks and leaf litter environments on which Red-crowned Toadlets rely to complete their lifecycle. While some records of the species in the local area are adjacent to swamps, it is not considered that swamps play a particularly important role in providing appropriate breeding or sheltering habitat.	Yes. Significant impact determined.	Conservation listing status of species has not changed since original SIS. There has been limited monitoring to specifically assess impacts to Red-crowned Toadlet due to subsidence within the Dendrobium area. Monitoring has focussed upon the Littlejohn's Tree Frog which is likely to be more prone to subsidence impacts and more effectively monitored due to a conspicuous, relatively lengthy tadpole phase. Impacts detected for Littlejohn's Tree Frog along smaller streams are likely relevant for Red-crowned Toadlet.
Reptiles				

Species	Recent records and habitat in study area	Potential impact to species or potential habitat in study area	Assessment of significance undertaken in SIS and result (Biosis 2007)	Current conservation and impact status
Broad-headed Snake	Not previously recorded in study area. Potential habitat includes ridgeline and creek lines. Vegetation communities include SGPF and ESSGW.	Yes, potentially impacted. Impacts to any potential habitat is likely to be limited, based on previous observations of subsidence within adjacent mined areas and predictions of subsidence for the current proposal. That is, predictions of subsidence impacts such as rock-falls are limited in their extent (MSEC 2022). This factor, coupled with the requirement that subsidence would need to be coincident with sheltering habitat for the Broad-headed Snake which is quite limited, and that deleterious impacts would need to then result, leads to a prediction of minimal impacts for this species.	Yes. No significant impact determined.	Conservation listing status of species has not changed since original SIS. Limited monitoring has been undertaken for this species. The species is difficult to detect and monitoring which includes lifting of preferred rock plates is potentially harmful to the species. It is not known if this species has been impacted by subsidence from mining within the Dendrobium Area, however given the limited extent of reported rock-falls, impacts are likely to be minimal and difficult to detect.
Rosenberg's Goanna	Previously recorded by Biosis (2007) within DA3. Potential habitat includes Upland Swamps, ridgelines and creek lines. Vegetation communities include: SGPF and upland swamp communities.	Yes, potentially impacted. Potential impacts include: death or injury resulting from rock fall or collapse. Impacts to any potential habitat is likely to be limited, based on previous observations of subsidence within adjacent mined areas and subsidence predictions for the current	Yes. No significant impact determined.	Conservation listing status of species has not changed since original SIS. Limited monitoring has been undertaken for this species. It is not known if this species has been impacted by subsidence from mining within the Dendrobium Area, however given the

Species	Recent records and habitat in study area	Potential impact to species or potential habitat in study area	Assessment of significance undertaken in SIS and result (Biosis 2007)	Current conservation and impact status
		proposal. That is, predictions of subsidence impacts such as rock-falls are limited in their extent (MSEC 2022). This factor, coupled with the requirement that subsidence would need to be coincident with sheltering habitat for the Rosenberg's Goanna and that deleterious impacts would need to then result, leads to a prediction of minimal impacts for this species.		limited extent of reported rock-falls, impacts are likely to be minimal and difficult to detect.
Mammals				
Large Bent-wing Bat	Recorded in study area with probable certainty during the SIS. Potential habitat includes the entire study area, however only specific features likely to be impacted.	Yes, potentially impacted. Potential impacts include: death or injury resulting from rock fall or collapse, possible changes in availability of breeding and roosting habitat. Maternity caves would not occur within the study area. If roosting occurs within the study area, it is unlikely to be widespread or significant. Minimal impacts (from subsidence of features such as cliffs and overhangs) are expected to occur given the limited propensity of roosting within the study area and the limited area of impact	Yes. No significant impact determined.	Conservation listing status of species has not changed since original SIS. Monitoring has not been undertaken for this species. It is not known if this species has been impacted by subsidence from mining within the Dendrobium Area, however given the limited extent of reported rock-falls and cliff failures, impacts are likely to be minimal and difficult to detect.

Species	Recent records and habitat in study area	Potential impact to species or potential habitat in study area	Assessment of significance undertaken in SIS and result (Biosis 2007)	Current conservation and impact status
		predicted to occur for possible roost habitats.		
Little Bent-wing Bat	Recorded in study area with probable certainty during the SIS. Potential habitat includes the entire study area, however only specific features likely to be impacted.	Yes, potentially impacted. Potential impacts include death or injury as result of rock fall or collapse, possible changes in availability of breeding and roosting habitat.	Yes. No significant impact determined.	Conservation listing status of species has not changed since original SIS. Monitoring has not been undertaken for this species. It is not known if this species has been impacted by subsidence from mining within the Dendrobium Area, however given the limited extent of reported rock-falls and cliff failures, impacts are likely to be minimal and difficult to detect.
Southern Myotis	Recorded in study area during the SIS. Potential habitat includes larger watercourses with pools and standing water and adjacent vegetation.	Yes, potentially impacted. Potential impacts include death or injury as result of rock fall or collapse and impacts on prey availability due to drying of pools.	Yes. No significant impact determined.	Conservation listing status of species has not changed since original SIS. Monitoring has not been undertaken for this species. It is not known if this species has been impacted by subsidence from mining within the Dendrobium Area, however given the limited extent of reported rock-falls and cliff failures, impacts are likely to be minimal and difficult to detect. Drying of pools may impact on prey availability, but this impact is

Species	Recent records and habitat in study area	Potential impact to species or potential habitat in study area	Assessment of significance undertaken in SIS and result (Biosis 2007)	Current conservation and impact status
				considered likely to be minimal given that the larger watercourses adjoining the study area (such as Wongawilli Creek and Sandy Creek) are unlikely to be impacted by LW19A.
Invertebrates				
Giant Dragonfly	One possible sighting in swamp Den15a (upper section) (Invertebrate Identification Australasia 2019) (Figure 7). The lower section of swamp Den15a was determined to be unsuitable habitat (Invertebrate Identification Australasia 2019). No other swamps within the study area have known sightings of the species. Potential habitat includes Upland Swamps. Swamps that were recorded as being suitable habitat for *P. gigantea* were those swamps that had a high groundwater level with permanent wet areas that could include active soaks/seepage zones, exposed pools and streams evident during the dry periods and a deep peat layer (Invertebrate Identification Australasia 2019). The swamps also usually contained characteristic	Yes, potentially impacted. Potential impacts include loss of upland swamp habitat as a result of subsidence. The critical factor governing the presence of *P. gigantea* is the permanent shallow groundwater level (Invertebrate Identification Australasia 2019). Once the groundwater level drops below the depth of the larval burrows (> 70cm) and the peat dries the habitat, potentially a population in a specific swamp is lost (Invertebrate Identification Australasia 2019).	Yes. Significant impact determined.	Conservation listing status of species has not changed since original SIS. Swamps with preferred breeding habitat for this species, based on the presence of moist swamp subcommunities (Den15a and Den15b) occur within the angle of draw and may be impacted by subsidence as a result of LW19A. Additional swamps with preferred foraging habitat (i.e. within 500 m of a swamp with breeding habitat) for this species occur within the angle of draw study area and the 600 m study area. Minimal impacts are expected to occur for foraging habitat within dryer swamp types.

Species	Recent records and habitat in study area	Potential impact to species or potential habitat in study area	Assessment of significance undertaken in SIS and result (Biosis 2007)	Current conservation and impact status
	saturated soil vegetation such as *Banksia robur*, *Melaleuca sp*, *Gahnia sp*. *Lomandra sp* and the pouched Coral Fern (*Gleichenia dicarpa*) (Invertebrate Identification Australasia 2019).			

6.6 Consent conditions specific to the current proposed longwall

Condition 5, schedule 3 of the consent conditions require that:

> *5. The Applicant must ensure that subsidence does not cause erosion of the surface or changes in ecosystem functionality of Swamp 15a and that the structural integrity of its controlling rockbar is maintained or restored to the satisfaction of the Secretary.*

The terms 'ecosystem functionality' and 'controlling rockbar' are not defined in the condition of consent. DPE also note in their Reasons for Approval of Longwall 19 SMP "It must be noted that this performance measure was not imposed in order to prevent any impact on Swamp 15a. Pages 22-24 of the Department's Assessment Report for Mod 6 make this quite clear. South32's then-proposed mine plan for Area 3A included two longwalls (then termed LW9 and LW10) that would directly undermine Swamp 15a. This proposal was not limited by the consent in any way." In addition, the Department has had regard to the discussion on Swamp 15a within its Assessment Report for Mod 6. It is clear that that report was considering Swamp 15a as a totality, most obviously because it gave approval to South32's then intention to directly undermine the swamp with two 249 m longwall panels (the then LW9 and LW10).

Ecosystem Functionality is defined in the approved Longwall 19 Swamp Impact Monitoring, Management and Contingency plan (SIMMCP, Section 2.11.1, South32 2019) as:

> *ecosystem function of swamps is measured via the following attribute: the size of the groundwater dependent communities contributing to the swamps. Specifically, any changes in the proportion of Banksia Thicket, Tea-tree Thicket and Sedgeland-heath Complex within the monitored swamps.*

DPE advised the intent of the performance measure relating to ecosystem functionality for swamps was more general in intent; basically, the swamp will remain a swamp (South32 2019). Detailed swamp mapping will be updated as mining approaches each swamp. Mapping of Swamp Den15a as part of the current assessment, prior to the mining of LW19A, shows the following areas of each sub community (total swamp area):

- PCT 978 (Restioid Heath) 2.50 ha
- PCT 978 (Cyperoid Heath) 4.4 ha
- PCT 978 (Banksia Thicket) 7.93 ha
- PCT 1804 (Tea-tree Thicket) 2.56 ha.

The Final determination for Coastal Upland Swamp (NSW Scientific Committee 2012) includes a definition of ecological function in stating that:

> *Coastal Upland Swamp in the Sydney Basin Bioregion is eligible to be listed as an Endangered Ecological Community as, in the opinion of the Scientific Committee, it is facing a very high risk of extinction in New South Wales in the near future, as determined in accordance with the following criteria:*
>
> *…*
>
> ***Clause 19 Reduction in ecological function of ecological community***

The ecological community has undergone, is observed, estimated, inferred or reasonably suspected to have undergone or is likely to undergo within a time span appropriate to the life cycle and habitat characteristics of its component species:

(b) a large reduction in ecological function, as indicated by any of the following:

(d) change in community structure,

(e) change in species composition,

(f) disruption of ecological processes,

(h) degradation of habitat,

(i) fragmentation of habitat.

Changes in community structure and species composition have been noted in the ongoing monitoring (Biosis 2019, Niche 2022) for swamp Den15a and Den15b, with changes in structure being more pronounced in mined sites than control sites. Potential changes to ecosystem functionality to Swamp Den15a from LW19A include changes to groundwater levels from potential fracturing of bedrock (as predicted by MSEC 2022), which may lead to further changes to community structure and species composition.

Disruption of ecological processes (through changes to water table and recession rates) have also been noted historically (Watershed 2019) and have the potential to impact swamp Den15a and Den15b post mining of LW19A. Recent historic analysis completed by Watershed (2019) of Dendrobium Coastal Upland Swamps and swamp piezometers following longwall mining was undertaken to determine the distance at which piezometers have indicated an impact [1] to water table and recession rates. Based on assessments of water levels and recession rates around past mining in DA2, DA3A and DA3B, it was concluded by Watershed (2019) that hydrographs from swamp piezometers within 60 m are likely to exhibit a mining effect and almost certain to exhibit a mining effect when directly mined under, be that through a reduction in the water table to below pre-mining levels and/or increased recession (drainage) rate. Effects on swamp water tables were not reported at distances greater than 60 m from a longwall panel. If the Watershed (2019) findings are applied to the proposed LW19A, there is limited potential to cause changes to ecosystem functionality to parts of Swamp Den15a, given Den15a occurs 60 m south-east of LW19A, ie. outside of the groundwater impact zone (Figure 3). Predicted fracturing of bedrock within the swamp (MSEC 2022) is likely to lower the capacity for shallow groundwater retention within a small part of the swamp. Monitoring of swamps that have been mined under has demonstrated similar levels of groundwater recharge but decreased retention of groundwater (e.g. HGEO 2017). Changes in groundwater retention is likely to disrupt ecological processes, however Longwall 19A is not likely to change the ecosystem functionality across the whole of swamp Den15a (in relation to the intent of this performance measure as detailed above), i.e. swamp Den15a will likely remain functioning as a swamp.

[1] As discussed in Watershed (2019) "in other studies at Dendrobium, the definition of 'impact' is consistent with the SIMMCP regarding how an impact or environmental consequence of mining is classified:

1) A shallow groundwater level within swamp sediments lower than the baseline level at any monitoring site within a swamp (in comparison to control swamps).
2) A rate of shallow groundwater level reduction post-mining that exceeds the rate of shallow groundwater level reduction during the baseline period at any monitoring site (measured as average mm per day during the recession curve).

In some instances, both the above modes of impact may be observed at a single site, and in others, just one might be identified from the water level record".

The controlling rockbar for Swamp Den15a is defined in the approved Longwall 19 SIMMCP (South32 2019) as the downstream rockbar where it meets Sandy Creek (SC10-RB15A), which is located outside of the 600 m study area boundary (MSEC 2022, see drawing MSEC1234-09) (Figure 3). The controlling rockbar is therefore not predicted to be impacted by the mining of LW19A. Rockbars associated with Den15a along SC10 are located above the future LW19 to the north of the proposed LW19A, however none are located directly above the proposed LW19A. These rockbars are predicted to experience up to 30 mm vertical subsidence, 150 mm upsidence and 250 mm closure (MSEC 2022). These rockbars within Swamp Den15a (Figure 3) are considered to be the high points at the downstream margins of each swamp section. The watercourse mapping included in Figure 3 (provided by IMC) is useful in indicating where the main rockbars occur, with the rockbars extending from the mapped watercourse areas along the downslope margin of the swamp sections. Impacts to these rockbars may also impact on the ecosystem functionality of Swamp Den15a, through reductions in water retention within the swamp, potentially leading to changes in community structure and species composition to a drier vegetation community type.

MSEC (2022) includes a discussion on the previous experience of mining beneath swamps at Dendrobium Mine, relating to the reported physical impacts, which include surface cracking and fracturing of bedrock at the swamps (though it should be noted that these swamps were completely mined beneath, which is not the case for LW19A and Swamp Den15a):

- DA2 - Cracking was observed within the extent of Swamp Den01 in three locations and fracturing was observed in the downstream rockbar after the extraction of LW4 and LW5 directly beneath this swamp. Impacts included reductions in groundwater levels in the soil and the upstream hillslope aquifer, however the groundwater levels respond to significant recharge events. Based on the observations to date, there has been no erosion or other physical changes observed within Swamp Den01 resulting from the mining in Area 2.

- DA3A - One fracture was identified in a rock outcrop in Swamp Den12 after the extraction of LW7 directly beneath the swamp. No erosion or other changes have been observed through regular monitoring. One of four installed piezometers has measured a reduction in the groundwater level within the sediments above the sandstone bedrock.

- DA3B - Multiple fractures and uplift on the basal step of Swamp 5 and exfoliation from the step after extraction of LW9 directly beneath the swamp. Associated flow diversion was recorded, along with reduction and recession rates in relation to shallow groundwater levels in Swamps 1a, 1b and Swamp 5. Impacts were also observed to the swamps due to the extraction of LW10 to LW14 including groundwater levels lower than baseline and recession rates greater than baseline for Swamps Den03, Den05, Den10, Den11, Den13 and Den14. Soil moisture levels below baseline were also reported in Swamps Den05, Den11 and Den23.

Given that Swamp Den15a is not being mined beneath and is outside of the 60 m groundwater impact zone, potential changes in ecosystem functionality due to LW19A are considered to be low. The likelihood of changes in ecosystem functionality of mapped sections of Swamp Den15a decreases with increasing distance from LW19A. The controlling rockbar is not likely to be impacted, given it occurs outside of the 600 m study area boundary, therefore the potential for impact to areas of Swamp Den15a upstream of the controlling rockbar is low.

It should be noted that Condition 5 required protection **or restoration** of the controlling rockbar and that grouting of discrete rockbars would be undertaken if fracturing and flow diversion occurred, as was undertaken in the Georges River where West Cliff Mine extracted longwalls directly under the Georges River.

The SIMMCP (Section 5.4.1, South32 2019) states:

> *Where the bedrock base of any significant permanent pool or controlling rockbar within Wongawilli Creek or Donalds Castle Creeks are impacted from subsidence and where there is limited ability for these fractures to seal naturally they will be sealed with an appropriate and approved cementitious (or alternative) grout.*

7 Monitoring and recommendations

7.1 Existing monitoring and requirements

A terrestrial ecology monitoring program within Dendrobium began in 2003. Details of the current monitoring program for DA3B are contained in Niche (2022) *Dendrobium Terrestrial Ecological Monitoring Program Annual Report for 2021*. Findings from each year of terrestrial ecology monitoring are reported in Annual Environmental Management Reports and End of Panel Reports.

Related monitoring programs include monitoring of abiotic parameters which are key predictors of biodiversity impacts, such as soil moisture, shallow groundwater levels and recharge rates, rainfall and temperature.

Prior to the proposed mining, a SIMMCP and Watercourse Impacts Monitoring Management and Contingency Plan is to be implemented to the satisfaction of the Secretary as per Schedule 3 Condition 6 of the Development Consent. It is to be prepared in consultation with BCS, WaterNSW and DPE.

7.2 Recommendations for future monitoring

Terrestrial ecology monitoring for DA3A should continue to be based on existing methodologies within Niche (2022) to ensure consistency of data capture to allow for ongoing comparisons with monitoring conducted to date. Improvements and additions to these programs are however recommended as required, based on evolving understanding of the effectiveness of the monitoring program and new technologies.

It is recommended the following be continued or included in the terrestrial ecology monitoring program for DA3A:

- Monitoring of Upland Swamps should continue to follow the methodology outlined in Niche (2022) which is consistent with Keith *et al.* (2006).
- Visual comparison of photo point monitoring undertaken at each upland swamp site should continue from marked monitoring points.
- Mapping of upland swamp boundaries within DA3A should be refined prior to baseline surveys. Recent methods including the use of drones is likely to achieve better accuracy and consistency for mapping of swamp boundaries and overcome current identified limitations (see section 4.2.2).
- Mapping of microhabitats such as pools along streams, as currently performed by IMC for DA3B and DA3C, should be extended to DA3A prior to baseline frog surveys.
- Frog monitoring in DA3A (and other areas) should include rainfall or hydrometric trigger values for surveys to allow for greater consistency between years which would aid in comparison of results (pre versus post mining and impact versus control).
- A baseline survey focussed on tadpole survey for Littlejohn's Tree Frog and aural detection of Red-crowned Toadlet should be conducted after sufficient rainfall and within the appropriate season.
- Targeted surveys for the Giant Dragonfly should be included in swamp monitoring.
- Analysis of swamp monitoring data should incorporate any changes in piezometric levels at or near the swamps.
- Monitoring programs should continue to be based on BACI design.

- Swamp and watercourse monitoring should categorise impact sites based on their distance from longwalls, distinguishing between sites above longwalls, sites less than 60 m from longwalls and sites outside the 35° angle of draw.
- All remediation works that are undertaken near waterways, must take appropriate measures to minimise environmental impacts. This includes avoiding the spread of Chytrid Fungus following the NPWS guidelines.
- The implementation of mitigation measures should also be followed by monitoring to confirm the success or otherwise of any implemented measures.
- Methods should seek to identify any significant (e.g. greater than 10 mm) surface cracking within the study area so that monitoring and mitigation measures to minimise fauna entrapment (if identified as occurring) can be undertaken.

8 Conclusion

Impacts on features from subsidence caused by longwall mining within the Dendrobium domain are largely predictable given a particular longwall mine layout. This is evidenced through identification of reasonably consistent patterns during monitoring of subsidence impacts undertaken for DA2, DA3A and DA3B (e.g. MSEC 2022; Watershed HydroGeo 2022). Subsidence predictions for the proposed LW19A within DA3A are consistent with previous subsidence predictions for DA3 in their nature.

Monitoring of impacts to natural features such as swamps, watercourses and cliffs in DA3A and DA3B (e.g. Biosis 2016, HGEO 2017, Niche 2022) supports past subsidence predictions. Monitoring results have highlighted a high likelihood of impacts to watercourses and swamps through a reduced capacity for water recharge and permanency within the shallow groundwater table and within features such as pools along watercourses. Such impacts can be confidently predicted above and in close proximity to longwalls but become less apparent with distance from longwalls. For example, a recent review of monitoring (Watershed HydroGeo 2019) indicates that hydrographs from swamp piezometers within 60 m of longwalls at Dendrobium are likely to exhibit a mining effect and almost certain to exhibit a mining effect when directly mined under, be that through a reduction in the water table to below pre-mining levels and/or increased recession (drainage) rate. Conversely, effects on swamp groundwater have not been observed at distances greater than 60 m from a longwall panel.

Where subsidence impacts do occur, deleterious effects to particular threatened species such as Littlejohn's Tree Frog have been highlighted as highly likely or definitive in some areas. However, clear patterns regarding the significance and severity of impacts to biodiversity values such as swamps and target threatened species have at times been difficult to illustrate confidently due to other impacts such as drought operating concurrently with subsidence impacts (e.g. Biosis 2016).

Review of the SIS predictions with regard to subsidence impacts on threatened biodiversity along with other relevant studies and surveys conducted as part of the current project support the findings of the *Dendrobium Area 3 Species Impact Statement* (Biosis 2007) with few departures. Since the SIS (2007), Upland Swamps of the study area have been listed as an EEC within NSW under the TSC/BC Acts and nationally under the EPBC Act. In addition, whereas the original SIS highlighted significant impacts for the Stuttering Frog (on a precautionary basis) sufficient data now exists to assess with relatively high confidence that the species does not occur within the study area.

Seven Upland Swamps occur within the 600 m study area boundary. A maximum of 9.53 ha of swamps within the study area may be impacted via subsidence from the proposal, as they occur within the 35-degree angle of draw). In addition, habitats such as pools, along 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.

It is recommended that subsidence monitoring programs including biodiversity monitoring continue. Recommendations in regard to biodiversity monitoring have been included within this report.

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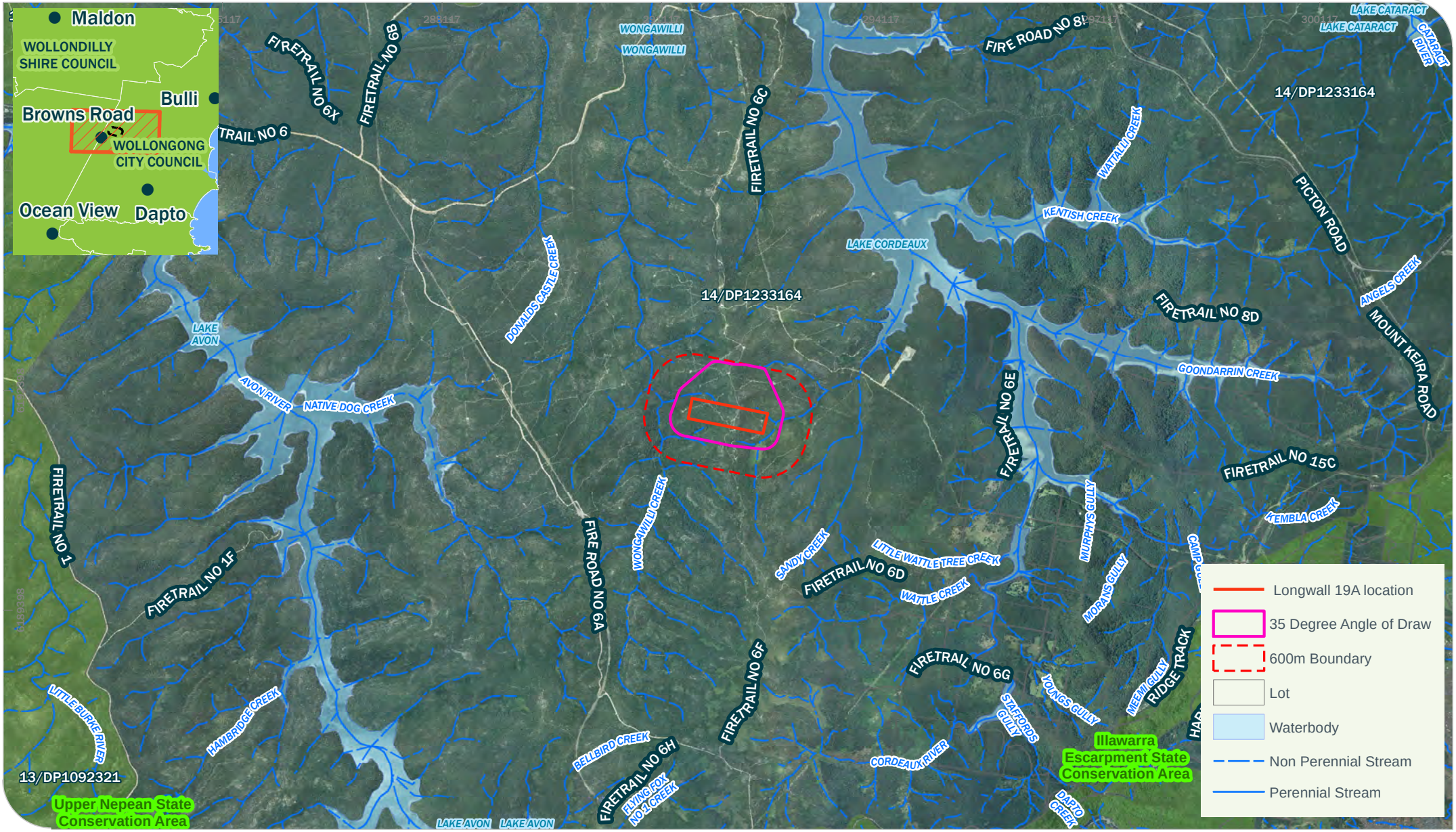
Figures



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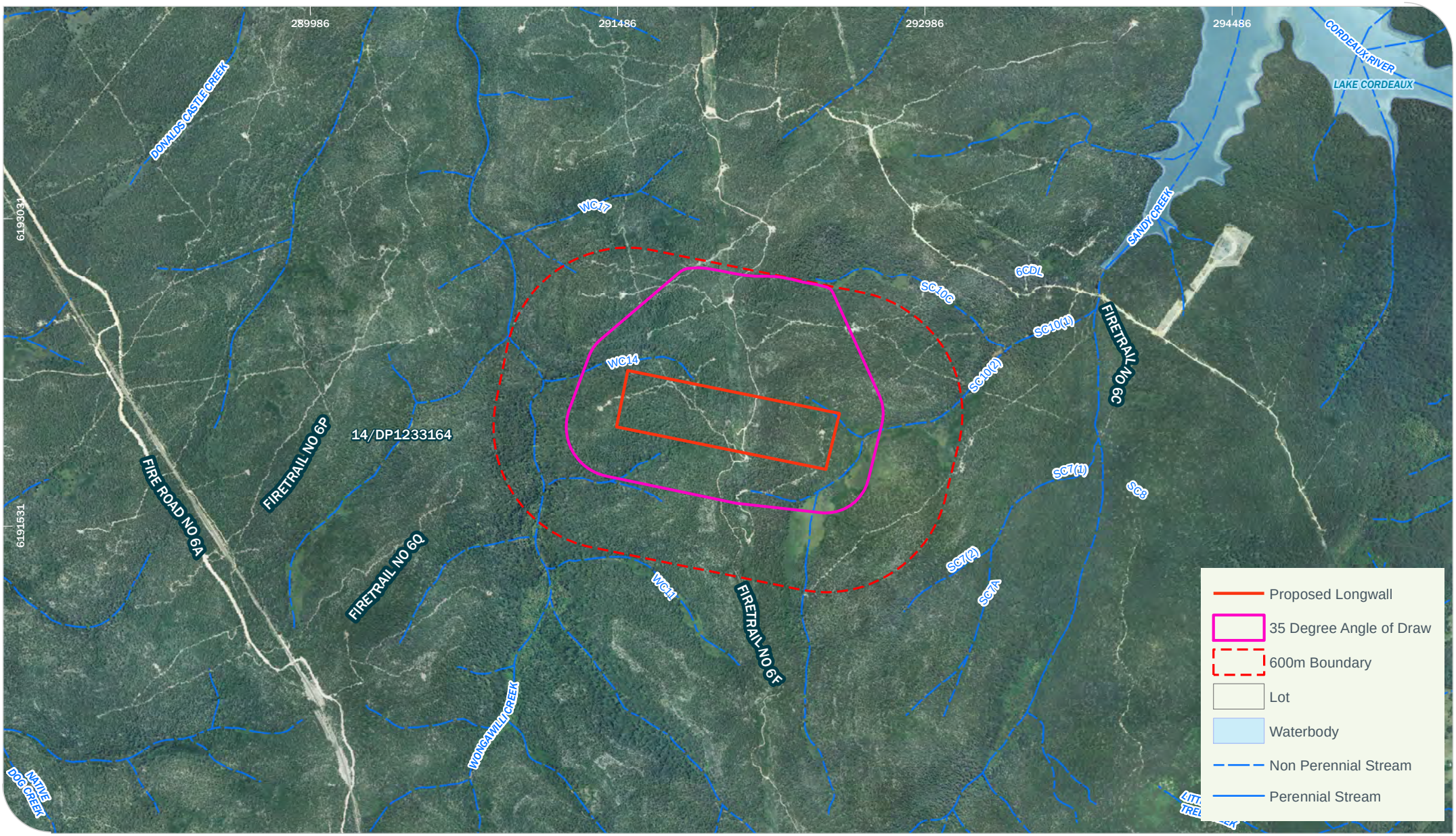
Location Map
Longwall 19A SMP

Figure 1



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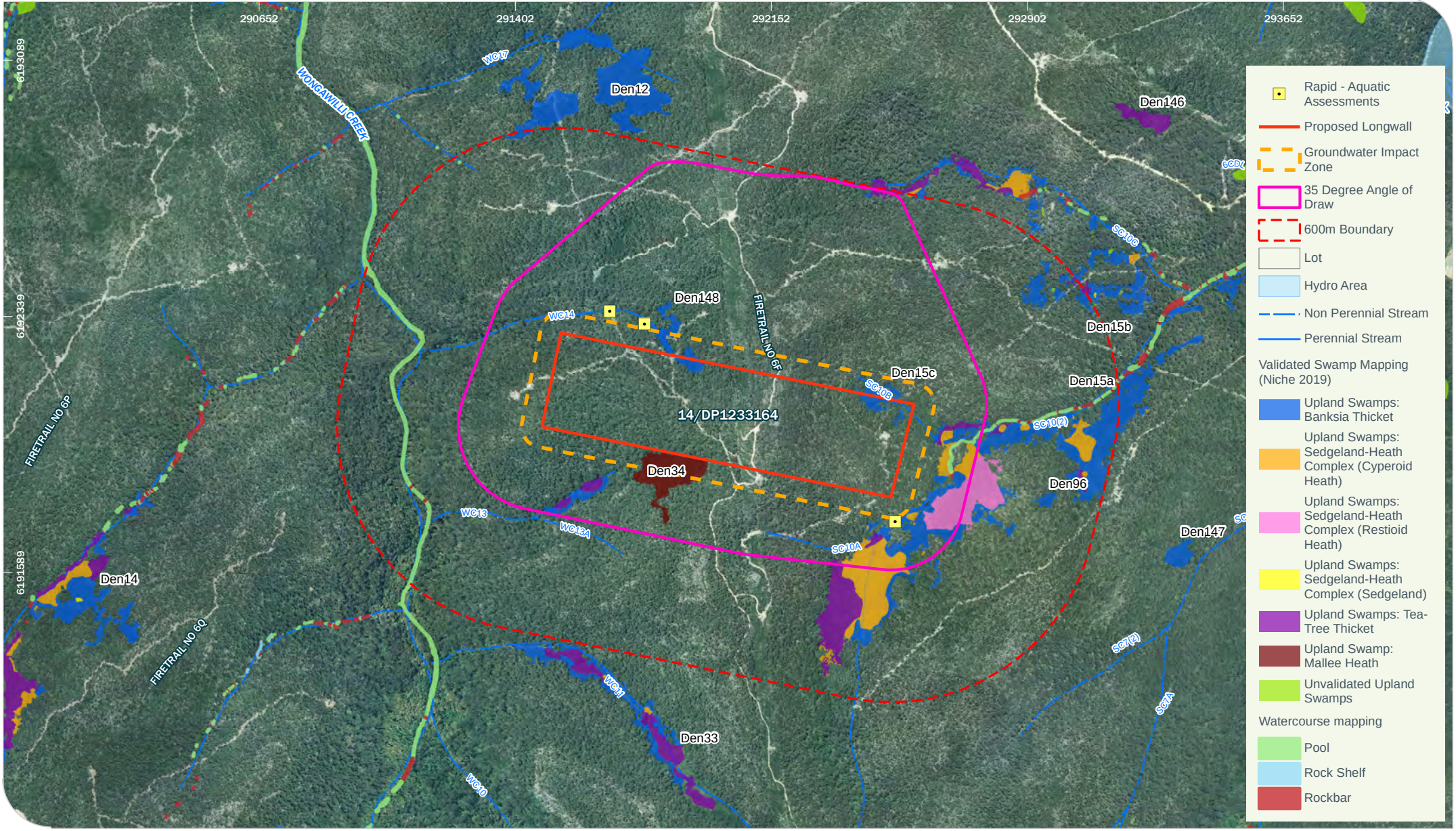
Site Map
Longwall 19A SMP

Figure 2



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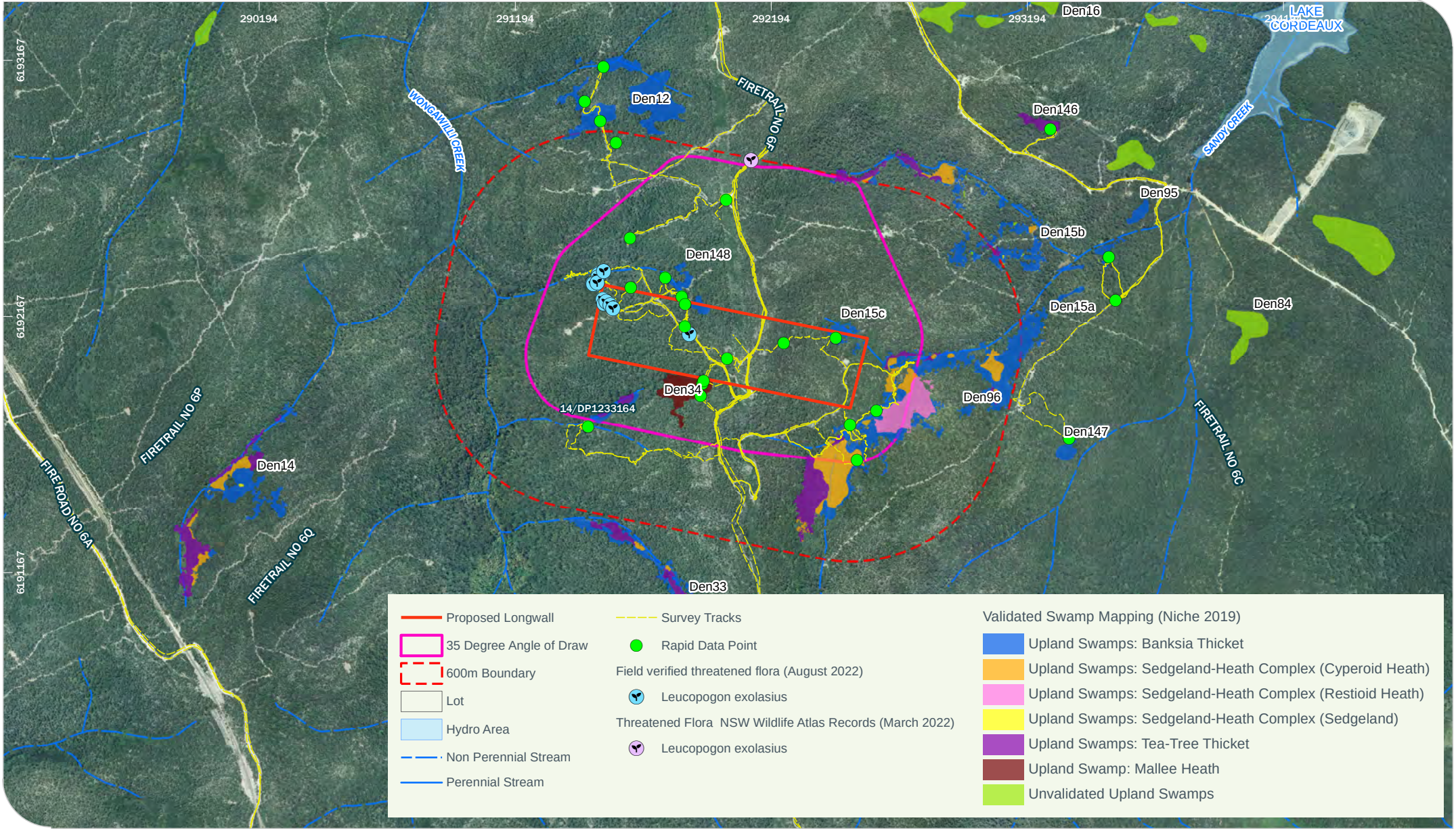
Watercourses and Swamps
Longwall 19A SMP

Figure 3



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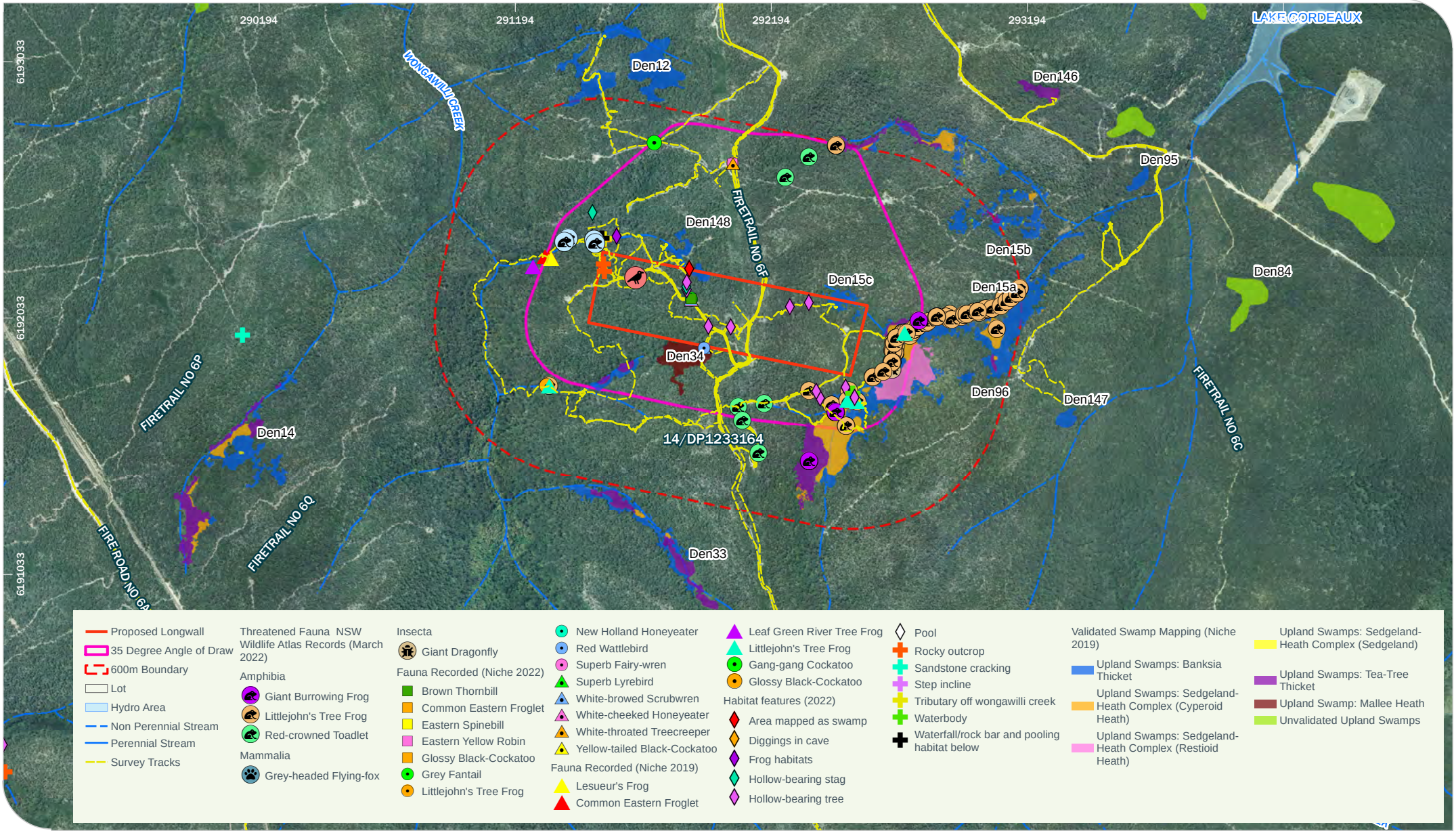
Flora Survey Methods and Results
Longwall 19A SMP

*Sensitive species not displayed

Figure 4



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Client: South 32- Illawarra Metallurgical Coal

Fauna Survey Methods and Results
Longwall 19A SMP

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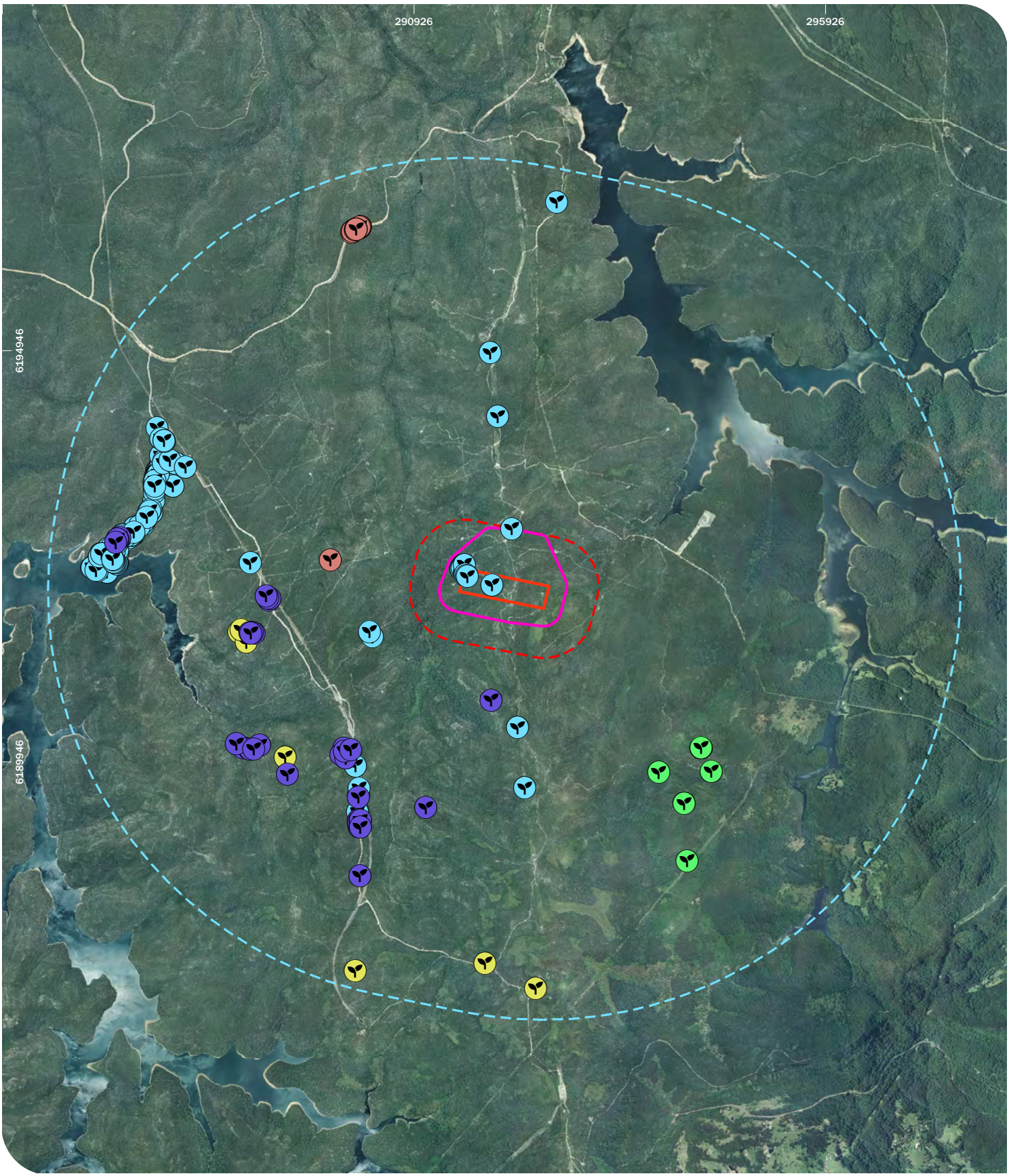
Figure 5



Proposed Longwall
35 Degree Angle of Draw
600m Boundary
5km Buffer

Flora
Acacia bynoeana
Grevillea raybrownii
Leucopogon exolasius
Pultenaea aristata
Rhodamnia rubescens

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GDA 1994 MGA Zone 56

Threatened Flora within 5km of LW19A

Longwall 19A SMP - Terrestrial Ecology Assessment

*Sensitive species not displayed

Niche PM: Sian Griffiths
Niche Proj. #: 7167
Client: Illawarra Metallurgical Coal

Figure 6

NSW Office of Environment and Heritage's BioNet Atlas, which holds the data from a number of custodians. Data Obtained DD/MM/YYYY.

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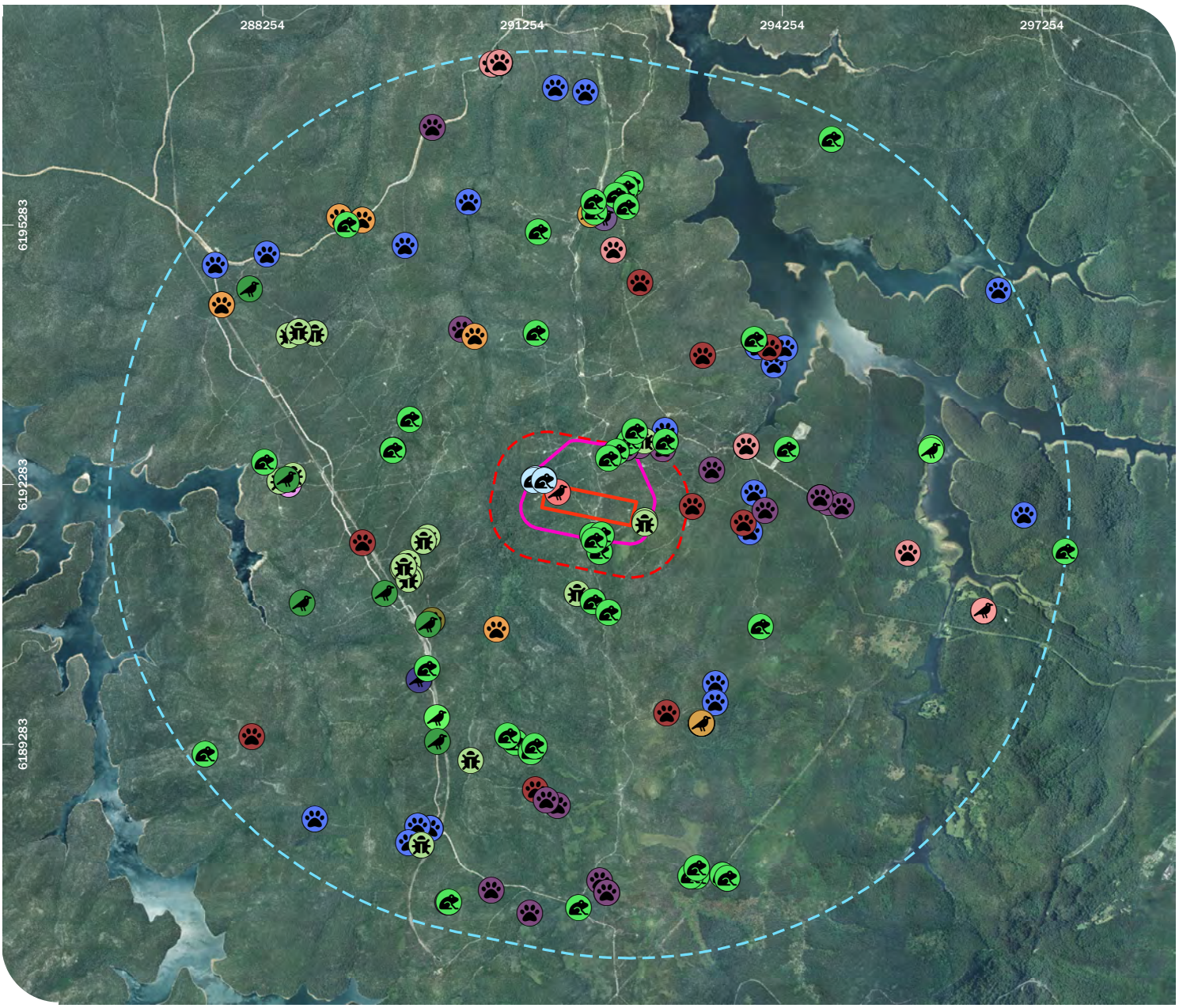

- Proposed Longwall
- 35 Degree Angle of Draw
- 600m Boundary
- 5km Buffer

Gastropoda

Amphibia

- Green and Golden Bell Frog
- Red-crowned Toadlet
- Wallum Froglet
- Littlejohn's Tree Frog

Aves

- Australasian Bittern
- Black Bittern
- Black-browed Albatross
- Black-chinned Honeyeater (eastern subspecies)
- Black-tailed Godwit
- Broad-billed Sandpiper
- Bush Stone-curlew
- Curlew Sandpiper
- Diamond Firetail
- Dusky Woodswallow
- Eastern Curlew
- Flame Robin
- Flesh-footed Shearwater
- Freckled Duck
- Gould's Petrel
- Great Knot
- Greater Sand-plover
- Grey-headed Albatross
- Lesser Sand-plover
- Little Eagle
- Little Lorikeet
- Little Tern
- Magpie Goose
- Pied Oystercatcher
- Red Knot
- Regent Honeyeater
- Sanderling
- Scarlet Robin
- Sooty Oystercatcher
- Sooty Tern
- Superb Fruit-Dove
- Terek Sandpiper
- Varied Sittella
- Wandering Albatross
- White-bellied Sea-Eagle
- White-fronted Chat
- White-fronted Chat population in the Sydney Metropolitan Catchment Management Area
- Glossy Black-Cockatoo

Insecta

- Giant Dragonfly

Mammalia

- Australian Fur-seal
- Dugong
- Eastern Bentwing-bat
- Eastern False Pipistrelle
- Eastern Freetail-bat
- Eastern Pygmy-possum
- Grey-headed Flying-fox
- Humpback Whale
- Koala
- Large-eared Pied Bat
- Little Bentwing-bat
- Long-nosed Bandicoot population in inner western Sydney
- New Zealand Fur-seal
- Rufous Bettong
- Southern Myotis
- Southern Right Whale
- Spotted-tailed Quoll
- Squirrel Glider
- Yellow-bellied Sheathtail-bat

Reptilia

- Green Turtle
- Leatherback Turtle
- Loggerhead Turtle

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GDA 1994 MGA Zone 56

Threatened Fauna within 5km of LW19A

Longwall 19A SMP - Terrestrial Ecology Assessment

*Sensitive species not displayed

Niche PM: Sian Griffiths
Niche Proj. #: 7167
Client: Illawarra Metallurgical Coal

Figure 7

NSW Office of Environment and Heritage's BioNet Atlas, which holds the data from a number of custodians. Data Obtained DD/MM/YYYY.

Appendices

Appendix 1: Threatened species likelihood of occurrence tables

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
Amphibians						
Heleioporus australiacus	Giant Burrowing Frog	V	V	Prefers hanging swamps on sandstone shelves adjacent to perennial non-flooding creeks (Daly 1996, Recsei 1996). Can also occur within shale outcrops within sandstone formations. In the southern part of its range can occur in wet and dry forests, montane sclerophyll woodland and montane riparian woodland (Daly 1996). Individuals can be found around sandy creek banks or foraging along ridge-tops during or directly after heavy rain. Males often call from burrows located in sandy banks next to water (Barker 1995).	Known	High – due to rock fracture, surface water flow diversions and reduction in pool water levels.
Litoria aurea	Green and Golden Bell Frog	E	V	Inhabits marshes, dams and stream-sides, particularly those containing bullrushes (Typha spp.) or spikerushes (Eleocharis spp.). Optimum habitat includes water-bodies that are un-shaded, free of predatory fish such as Plague Minnow (*Gambusia holbrooki*), have a grassy area nearby and diurnal sheltering sites available.	None	None
Litoria Littlejohni	Littlejohn's Tree Frog	V	V	Occurs in wet and dry sclerophyll forests associated with sandstone outcrops between 280 and 1000 m on the eastern slopes of the Great Dividing Range (Barker 1995). Prefers rock flowing streams, but individuals have also been collected from semi-permanent dams with some emergent vegetation (Barker 1995). Forages both in the tree canopy and on the ground, and has been observed sheltering under rocks on high exposed ridges during summer. It is not known from coastal habitats.	Known. Previously recorded in Swamps Den15a, Den15b, tributaries SC10 and WC14 in the study area.	High – due to rock fracture, surface water flow diversions and reduction in pool water levels.
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 rainfall these creeks are characterised by a series of shallow pools lined by dense grasses, ferns and low shrubs (Thumm 1997).	High	High – due to rock fracture, surface water flow diversions and reduction in pool water levels.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
Mixophyes balbus	Stuttering Frog	E	V	This species is usually associated with mountain streams, wet mountain forests and rainforests (Barker 1995). It rarely wanders very far from the banks of permanent forest streams, although it will forage on nearby forest floors. Eggs are deposited in leaf litter on the banks of streams and are washed into the water during heavy rains (Barker 1995).	Low	Low
Birds						
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 bullrushes (Typha spp.) and spikerushes (Eleoacharis spp.).	Low	Low
Ninox connivens	Barking Owl	V	-	Generally found in open forests, woodlands, swamp woodlands and dense scrub. Can also be found in the foothills and timber along watercourses in otherwise open country (Pizzey 1997).	Moderate	Low
Ixobrychus flavicollis	Black Bittern	V	-	Usually found on coastal plains below 200 m. Often found along timbered watercourses, in wetlands with fringing trees and shrub vegetation. The sites where they occur are characterized by dense waterside vegetation.	Low	Low
Monarcha melanopsis	Black-faced Monarch	-	M	A migratory species found during the breeding season in damp gullies in temperate rainforests. Disperses after breeding into more open woodland (Pizzey 1997).	Moderate	Low
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V	-	Often reported in woodlands and dry open sclerophyll forests, usually dominated by eucalypts, including mallee associations. It has also been recorded in shrublands and heathlands and various modified habitats, including regenerating forests; very occasionally in moist forests or rainforests.	Moderate	Low
Dasyornis brachypterus	Eastern Bristlebird	E	E	Found in coastal woodlands, dense scrub and heathlands, particularly where it borders taller woodlands (Pizzey and Knight 1997).	Low	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
Petroica phoenicea	Flame Robin	V	-	Flame Robins are found in a broad coastal band from southern Queensland to just west of the South Australian border (Australian Museum 2009). The species is also found in Tasmania. The preferred habitat in summer includes eucalyptus forests and woodland, whilst in winter prefers open woodlands and farmlands. It is considered migratory. The Flame Robin breeds from about August to January (Morcombe 2003).	High	Low
Apus pacificus	Fork tailed Swift	-	M	The Fork-tailed Swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher.	Low to moderate - overfly habitat only.	Low
Stictonetta naevosa	Freckled Duck	V	-	The freckled duck breeds in permanent fresh swamps that are heavily vegetated. Found in fresh or salty permanent open lakes, especially during drought. Often seen in groups on fallen trees and sand spits (Simpson, 1996).	Low	Low
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests (Higgins 1999). Also occur in subalpine Snow Gum woodland and occasionally in temperate or regenerating forest (Forshaw 1981). In winter, occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas (Shields 1992). It requires tree hollows in which to breed (Gibbons 1997).	Known	Low
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-	Inhabits forest with low nutrients, characteristically with key Allocasuarina spp. Tends to prefer drier forest types (NPWS 1999) with a middle stratum of Allocasuarina below Eucalyptus or Angophora. Often confined to remnant patches in hills and gullies (Higgins 1999). Breed in hollows stumps or limbs, either living or dead (Higgins and Davies 1996).	Known – crushed cones found within the study area	Low
Hieraaetus morphnoides	Little Eagle	V	-	Most abundant in lightly timbered areas with open areas nearby. Often recorded foraging in grasslands, crops, treeless dune fields, and	High	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
				recently logged areas. May nest in farmland, woodland and forest in tall trees.		
Glossopsitta pusilla	Little Lorikeet	V	-	Distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range in NSW, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri. Mostly occur in dry, open eucalypt forests and woodlands. They feed primarily on nectar and pollen in the tree canopy. Nest hollows are located at heights of between 2 m and 15 m, mostly in living, smooth-barked eucalypts. Most breeding records come from the western slopes.	High	Low
Tyto novaehollandiae	Masked Owl	V	-	Inhabits a diverse range of wooded habitat that provide tall or dense mature trees with hollows suitable for nesting and roosting (Higgins, 1999). Mostly recorded in open forest and woodlands adjacent to cleared lands. Nest in hollows, in trunks and in near vertical spouts or large trees, usually living but sometimes dead (Higgins 1999). Nest hollows are usually located within dense forests or woodlands (Gibbons 1997). Masked owls prey upon hollow-dependent arboreal marsupials, but terrestrial mammals make up the largest proportion of the diet (Gibbons 1997, Higgins 1999).	High	Low
Cuculus optatus, Cuculus saturatus	Oriental Cuckoo	-	M, MA	Mainly inhabits coniferous, deciduous and mixed forests. Breeds in northern hemisphere. Brood parasite, laying eggs in nests of other birds.	Low	Low
Rostratula benghalensis	Painted Snipe (Australian subspecies)	E	-	In NSW, this species has been recorded at the Paroo wetlands, Lake Cowell, Macquarie Marshes and Hexham Swamp. Most common in the Murray-Darling Basin. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.	None	None
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	High	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
				areas. It is most commonly recorded within Red Turpentine in tall open forests and Black She-oak within open forests (Debus 1994a;Debus 1994b). Large mature trees with hollows at least 0.5 m deep are required for nesting (Garnett, 1992). Tree hollows are particularly important for the Powerful Owl because a large proportion of the diet is made up of hollow-dependent arboreal marsupials (Gibbons, 1997). Nest trees for this species are usually emergent with a diameter at breast height of at least 100 cm (Gibbons 1997).		
Anthochaera phrygia	Regent Honeyeater	CE	CE	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. 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.	Moderate	Low
Rhipidura rufifrons	Rufous Fantail	-	M	Migratory species that prefers dense, moist undergrowth of tropical rainforests and scrubs. During migration it can stray into gardens and more open areas (Pizzey 1997).	Low	Low
Myiagra cyanoleuca	Satin Flycatcher	-	M	Migratory species that occurs in coastal forests, woodlands and scrubs during migration. Breeds in heavily vegetated gullies (Pizzey 1997).	High	Low
Petroica boodang	Scarlet Robin	V	-	In NSW Scarlet Robin occur from the coast to the inland slopes. After breeding, some Scarlet Robins disperse to the lower valleys and plains of the tablelands and slopes. Some birds may appear as far west as the eastern edges of the inland plains in autumn and winter.	Known	Low
Tyto tenebricosa	Sooty Owl	V	-	Often found in tall old-growth forests, including temperate and subtropical rainforests. In NSW mostly found on escarpments with a mean altitude <500 m. Nests and roosts in hollows of tall emergent	High	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
				trees, mainly eucalypts (Higgins 1999) often located in gullies (Gibbons and Lindenmayer 1997). Nests have been located in trees 125 to 161 centimetres in diameter (Gibbons and Lindenmayer 1997).		
Monarcha trivirgatus	Spectacled Monarch	-	M	Coastal north-eastern and eastern Australia, including coastal islands, from Cape York, Queensland to Port Stephens, New South Wales. Prefers thick understorey in rainforests, wet gullies and waterside vegetation, as well as mangroves.	Moderate	Low
Lathamus discolor	Swift Parrot	E	CE	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.	High	Low
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 (Higgins and Peter 2002). Usually in areas with rough-barked trees, such as stringybarks or ironbarks, but also in paperbarks or mature Eucalypts with hollows.	High	Low
Haliaeetus leucogaster	White-bellied Sea-Eagle	V	MA	Inhabits coastal and near coastal areas, building large stick nests, and feeding mostly on marine and estuarine fish and aquatic fauna.	Low	Low
Epthianura albifrons	White-fronted Chat	V	-	Low vegetation in salty coastal and inland areas and crops. Runs along ground and is found in local flocks in Winter.	None	None
Hirundapus caudacutus	White-throated Needletail	-	V	An aerial species found in feeding concentrations over cities, hilltops and timbered ranges.	Low-moderate - above canopy airspace only	Low
Motacilla flava	Yellow Wagtail	-	M	Breeds in temperate Europe and Asia. The Yellow Wagtail is a regular wet season visitor to northern Australia. Increasing records in NSW suggest this species is an occasional but regular summer visitor to the Hunter River region. The species is considered a vagrant to Victoria, South Australia and southern Western Australia. Habitat requirements	Low	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
				for the Yellow Wagtail are highly variable, but typically include open grassy flats near water. Habitats include open areas with low vegetation such as grasslands, airstrips, pastures, sports fields; damp open areas such as muddy or grassy edges of wetlands, rivers, irrigated farmland, dams, waterholes; sewage farms, sometimes utilise tidal mudflats and edges of mangroves.		
Invertebrates						
Petalura gigantea	Giant Dragonfly	E	-	The Giant Dragonfly is found along the east coast of NSW from the Victorian border to northern NSW. It is not found west of the Great Dividing Range. There are known occurrences in the Blue Mountains and Southern Highlands, in the Clarence River catchment, and on a few coastal swamps from north of Coffs Harbour to Nadgee in the south (DECCW undated b). Live in permanent swamps and bogs with some free water and open vegetation. Adults emerge from late October and are short-lived, surviving for one summer after emergence.	High	High – not recorded in the present study but numerous records within the locality and habitat present within most of the swamps of the study area.
Mammals						
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 (Eldridge 1995).	Low	Low
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.	Known	Moderate, however limited significance. Maternity caves would not occur within the study area. If roosting occurs it is unlikely to be widespread or significant and minimal impacts from subsidence of features such as cliffs are expected to occur given the

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
						limited propensity of roosting. No further assessment or offsetting is considered required.
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	-	Inhabit sclerophyll forests, preferring wet habitats where trees are more than 20 m high (Churchill 1998). Two observations have been made of roosts in stem holes of living eucalypts (Phillips 1995). There is debate about whether or not this species moves to lower altitudes during winter, or whether they remain sedentary but enter torpor (Menkhorst 1995). This species also appears to be highly mobile and records showing movements of up to 12 km between roosting and foraging sites (Menkhorst 1995).	High	Low
Micronomous norfolkensis	Eastern Freetail-bat	V	-	Most records are from dry eucalypt forests and woodlands to the east of the Great Dividing Range. Appears to roost in trees, but little is known of this species' habits (Allison 1995, Churchill 1998).	High	Low
Cercartetus nanus	Eastern Pygmy-possum	V	-	Inhabits rainforest through to sclerophyll forest and tree heath. Banksias and myrtaceous shrubs and trees are a favoured food source. Will often nest in tree hollows, but can also construct its own nest (Turner, 1995). Because of its small size it is able to utilise a range of hollow sizes including very small hollows (Gibbons 1997). Individuals will use a number of different hollows and an individual has been recorded using up to 9 nest sites within a 0.5 ha area over a 5 month period (Ward 1990).	High	Low
Kerivoula papuensis	Golden tipped bat	V	-	The Golden-tipped Bat is distributed along the east coast of Australia in scattered locations from Cape York Peninsula in Queensland to south of Eden in southern NSW. Also occurs in New Guinea. Found in rainforest and adjacent wet and dry sclerophyll forest up to 1000 m. Also recorded in tall open forest, Casuarina-dominated riparian forest and coastal Melaleuca forests.	High	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-	Prefer moist gullies in mature coastal forests and rainforests, between the Great Dividing Range and the coast. They are only found at low altitudes below 500 m (Churchill, 1998). In dense environments they utilise natural and human-made opening in the forest for flight paths. Creeks and small rivers are favoured foraging habitat (Hoye 1995). This species roosts in hollow tree trunks and branches (Churchill, 1998).	High	Low
Petauroides volans	Greater Glider	-	V	The Greater Glider is restricted to eastern Australia, occurring from the Windsor Tableland in north Queensland through to central Victoria. It is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows.	Moderate	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 (Tidemann 1995) although some individuals may travel up to 70 km (Augee 1999).	High	Low
Phascolarctos cinereus	Koala	V	-	Inhabits eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall (Reed 1990).	Known	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 (Hoye 1995). Can also be found on the edges of rainforests and in wet sclerophyll forests (Churchill 1998). This species roosts in caves and mines in groups of between 3 and 37 individuals (Churchill 1998).	High	Low
Miniopterus australis	Little bent-wing Bat	V	-	East coast and ranges of Australia from Cape York in Queensland to Wollongong in NSW. Moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub. Generally found in well-timbered areas.	High	Moderate, however limited significance. Maternity caves would not occur within the study area. If roosting occurs it is unlikely to be widespread or significant and minimal

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
						impacts from subsidence of features such as cliffs are expected to occur given the limited propensity of roosting. No further assessment or offsetting is considered required.
Potorous tridactylus tridactylus	Long-nosed Potoroo	V	V	Inhabits coastal heath and wet and dry sclerophyll forests. Generally found in areas with rainfall greater than 760 mm. Requires relatively thick ground cover where the soil is light and sandy.	Moderate	Low
Pseudomys novaehollandiae	New Holland Mouse	V		Known to inhabit open heathlands, woodlands and forests with a heathland understorey and vegetated sand dunes. It is a social animal, living predominantly in burrows shared with other individuals. Distribution is patchy in time and space, with peaks in abundance during early to mid-stages of vegetation succession typically induced by fire.	Low	Low
Isoodon 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 (Braithwaite 1995). A mosaic of post fire vegetation is important for this species (Maxwell 1996).	High	Low
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.	Moderate	Moderate
Dasyurus maculatus	Spotted-tailed Quoll	V	-	Spotted-tailed Quoll is found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland.	Moderate	Low
Petaurus australis	Yellow-bellied Glider	V	-	Occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Forest type preferences vary with	Low	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
				latitude and elevation; mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south. Found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria.		
Saccolaimus flaviventris	Yellow-bellied sheathtail Bat	V	-	The Yellow-bellied Sheathtail-bat is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range - most of Victoria, south-western NSW and adjacent South Australia - it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes. Roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows.	High	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 1996, Webb 1998).	Moderate	Moderate
Varanus rosenbergi	Rosenberg's Goanna	V	-	This species is a Hawkesbury/Narrabeen sandstone outcrop specialist (Wellington 1985). Occurs in coastal heaths, humid woodlands and both wet and dry sclerophyll forests (Cogger 1992).	High	Moderate
Plants						
Acacia bynoeana	Bynoe's Wattle	V	E1	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. ROTAP: 3VC-	High Previously recorded in DA3C in the Biosis (2007) SIS along Fire Road 6.	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
Allocasuarina glareicola		E	E	Primarily restricted to the Richmond (NW Cumberland Plain) district, but with an outlier population found at Voyager Point, Liverpool. Grows in Castlereagh woodland on lateritic soil. Found in open woodland with Parramatta Red Gum, Broad-leaved Ironbark, Narrow-leaved Apple, Scribbly Gum and Paperbarks.	Low	Low
Caladenia tessellata	Tessellated Spider Orchid	V	E1	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. ROTAP: 3V	Low	Low
Cryptostylis hunteriana	Leafless Tongue Orchid	V	V	Grows in swamp-heath on sandy soils, chiefly in coastal districts, south from the Gibraltar Range. ROTAP: 3VC-	High	Moderate
Cynanchum elegans	White-flowered Wax Plant	E	E	Recorded from rainforest gullies scrub and steep slopes from the Gloucester district to the Wollongong area and inland to Mt Dangar. ROTAP: 3ECi	Low	Low
Epacris purpurascens var. purpurascens		-	V	Grows in sclerophyll forest, scrubs and swamps on sandstone from Gosford and Sydney districts. ROTAP: 2KC-	High	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	Low
Grevillea parviflora ssp. parviflora	Small-flower Grevillea	V	V	Grows in heathy associations or shrubby woodland, in sandy or light clay soils usually over shale substrates. Occurs west and south of Sydney from west of Prospect (where now almost certainly extinct), Kemps Creek and lower Georges River south to Camden, Appin and	High	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
				Cordeaux Dam, with disjunct northern populations south of Putty and near Cessnock and Cooranbong, possibly also south of Moss Vale.		
Grevillea raybrownii		V		It occurs in Eucalyptus open forest and woodland with a shrubby understorey on sandy, gravelly loam soils derived from sandstone that are low in nutrients. Generally occurs on ridgetops and, less often, slopes and benches of Hawkesbury Sandstone and Mittagong Formation. restricted to an area bounded by Dapto, Robertson and Berrima, possibly also Bungonia.	High	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	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. ROTAP: 2VC-	High	Moderate
Melaleuca biconvexa	Biconvex Paperbark	V	V	Biconvex Paperbark generally grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects. Scattered and dispersed populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north.	Low	Low
Melaleuca deanei	Dean's Low Melaleuca	V	V	Grows in wet heath on sandstone in coastal districts from Berowra to Nowra. ROTAP: 3RC-	Moderate	Low
Persicaria elatior	Tall Knotweed	V	V	This species normally grows in damp places, especially beside streams and lakes. Occasionally in swamp forest or associated with disturbance.	Low. No records within 10km of study area.	Low
Persoonia acerosa	Mossy Geebung	V	V	Occurs in heath or dry sclerophyll forest on sandstone, from central Blue Mountains south to Hill Top. ROTAP: 2VC-	High	Low
Persoonia hirsuta		E	E	The Hairy Geebung is found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone.	Moderate	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
Pomaderris brunnea	Rufous Pomaderris	V	V	Brown Pomaderris grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines in association with *Eucalyptus amplifolia*, *Angophora floribunda*, *Acacia parramattensis, Bursaria spinosa* and *Kunzea ambigua*. ROTAP: 2VC-	Low	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.	Low	Low
Pultenaea aristata	Prickly Bush-pea	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. ROTAP: 2V	High. Previously recorded in Biosis (2007) SIS in DA3 (but not DA3A)	Moderate
Pultenaea glabra	Smooth Bush-Pea	V	V	Grows in swamp margins, hillslopes, gullies and creekbanks and occurs within dry sclerophyll forest and tall damp heath on sandstone. Restricted to the higher Blue Mountains.	Low	Low
Rhodamnia rubescens	Scrub Turpentine			Occurs in coastal districts north from Batemans Bay in New South Wales, approximately 280 km south of Sydney, to areas inland of Bundaberg in Queensland. Populations of R. rubescens typically occur in coastal regions and occasionally extend inland onto escarpments up to 600 m a.s.l. in areas with rainfall of 1,000-1,600 mm. Found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils.	Low	Low
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	Low

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for Impact
Thelymitra kangaloonica	Kangaloon Sun-orchid	CE	CE	Recorded from shallow black peaty soil in coastal heath on sandstone. *Thelymitra sp. Kangaloon* is a terrestrial orchid endemic to New South Wales, and is known from three locations near Robertson in the Southern Highlands.	Low	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	Low
Xerochrysum palustre	Swamp Everlasting	-	V	Found in Kosciuszko National Park and the eastern escarpment south of Badja. Also found in eastern Victoria. Grows in swamps and bogs which are often dominated by heaths. Also grows at the edges of bog margins on peaty soils with a cover of shrubs or grasses.	Low	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.

Appendix 2: Fauna recorded from targeted survey

Table 16 Fauna recorded

Group	Scientific Name	Common Name	NSW Status	EPBC Status	Number of individuals
Aves	***Calyptorhynchus lathami***	**Glossy Black-Cockatoo**	**V**	**-**	**1**
Aves	*Acanthiza pusilla*	Brown Thornbill	-	-	1
Aves	*Acanthorhynchus tenuirostris*	Eastern Spinebill	-	-	1
Aves	*Anthochaera carunculata*	Red Wattlebird	-	-	1
Aves	*Calyptorhynchus funereus*	Yellow-tailed Black-Cockatoo	-	-	1
Aves	*Cormobates leucophaea*	White-throated Treecreeper	-	-	1
Amphibia	*Crinia signifera*	Common Eastern Froglet	-	-	2
Aves	*Eopsaltria australis*	Eastern Yellow Robin	-	-	3
Amphibia	***Litoria littlejohni***	**Littlejohn's Tree Frog**	**V**	**V**	**20**
Aves	*Malurus cyaneus*	Superb Fairy-wren	-	-	1
Aves	*Menura novaehollandiae*	Superb Lyrebird	-	-	2
Aves	*Phylidonyris niger*	White-cheeked Honeyeater	-	-	1
Aves	*Phylidonyris novaehollandiae*	New Holland Honeyeater	-	-	1
Aves	*Rhipidura albiscapa*	Grey Fantail	-	-	2
Aves	*Sericornis frontalis*	White-browed Scrubwren	-	-	2

Appendix 3: Weather data from the survey period

Table 17 Weather data from the survey period (Bellambi AWS [station 068228], BoM 2022)

Date	Maximum daily temperature (degrees celcius)	Minimum daily temperature (degrees celcius)	Average daily temperature (degrees celcius)	Rain (mm)	Wind direction	Maximum windspeed (km/h)
16/06/2022	10.7	21.2	15.95	0	W	48
17/06/2022	11.9	18	14.95	0	SSW	41
18/06/2022	12.1	17.5	14.8	0	S	44
19/06/2022	11.7	17.5	14.6	0	S	39
20/06/2022	11.9	16	13.95	4.6	SSW	31
21/06/2022	11.4	19.7	15.55	0.4	NNW	35
22/06/2022	10	16.9	13.45	0.4	WSW	35
23/06/2022	11.4	18.9	15.15	0	WNW	39
24/06/2022	12.8	18.1	15.45	0	NW	57
25/06/2022	12.5	20.1	16.3	0	NW	37
26/06/2022	10.3	19.3	14.8	0	WSW	30
27/06/2022	10.8	14.7	12.75	0	SSW	61
28/06/2022	9.2	15	12.1	0	SSW	43
29/06/2022	10.1	18	14.05	0	NNW	35
30/06/2022	11.3	17.4	14.35	0	S	31
1/07/2022	10.7	15.7	13.2	0.6	SW	31
2/07/2022	11.2	16.8	14	97.4	SSE	83
3/07/2022	13.8	17.2	15.5	183.4	SE	81
4/07/2022	13.7	15.7	14.7	30.2	S	94
5/07/2022	11.9	16.8	14.35	94	S	76
6/07/2022	11.9	17.3	14.6	3.4	SE	54
7/07/2022	12.9	17.1	15	7.4	S	44
8/07/2022	9	14.9	11.95	0	WNW	74
9/07/2022	9.8	16.4	13.1	0	W	48
10/07/2022	10	16.5	13.25	19	SSE	72
11/07/2022	10	16.2	13.1	25.4	SSW	35
12/07/2022	9.1	17.5	13.3	0	NW	19
13/07/2022	9.3	14.9	12.1	0	SSW	57
14/07/2022	10.4	14.9	12.65	0.4	SW	63
15/07/2022	8.6	16.1	12.35	0	SW	30
16/07/2022	7.4	16.8	12.1	0	WNW	37
17/07/2022	10.5	21.2	15.85	0	NW	59
18/07/2022	10.1	15.1	12.6	0	WSW	56
19/07/2022	7.5	13.5	10.5	0	S	57
20/07/2022	9.1	14	11.55	13.2	SSW	41
21/07/2022	10.7	17.3	14	6.8	E	52

Date	Maximum daily temperature (degrees celcius)	Minimum daily temperature (degrees celcius)	Average daily temperature (degrees celcius)	Rain (mm)	Wind direction	Maximum windspeed (km/h)
22/07/2022	12.7	17	14.85	6.4	ESE	50
23/07/2022	12.3	16.5	14.4	2.6	ESE	35
24/07/2022	10	17.7	13.85	2	ESE	15
25/07/2022	10.6	19	14.8	0	NE	33
26/07/2022	12.7	18.9	15.8	3.8	W	61
27/07/2022	9.7	17.7	13.7	0	W	56
28/07/2022	11	20	15.5	0	WNW	41
29/07/2022	8.8	14.9	11.85	0	SSW	43
30/07/2022	7.4	15.7	11.55	0	N	44
31/07/2022	9.6	17.3	13.45	0	N	41
1/08/2022	11.7	19.6	15.65	0	W	46
2/08/2022	9.9	19.2	14.55	0	W	43
3/08/2022	13.2	21.7	17.45	0	NE	46
4/08/2022	14.9	20.3	17.6	0	NNW	100
5/08/2022	13.7	22.9	18.3	0	NW	67
6/08/2022	11.6	19.5	15.55	0	SW	46
7/08/2022	10.6	16.2	13.4	0	SSW	44
8/08/2022	10.1	15.7	12.9	0	S	46

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Offset brokerage
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