MCO UG1 Extraction Plan Amendment Biodiversity Technical Report

Moolarben Coal Operations Pty Ltd

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Abbreviations

Abbreviation	Description
BC Act	*Biodiversity Conservation Act 2016*
CEEC	Critically Endangered Ecological Community
DBH	Diameter at Breast Height
EEC	Endangered Ecological Community
EIA	Ecological Impact Assessment
ELA	Eco Logical Australia
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
LW	Longwall
MCO	Moolarben Coal Operations
MCP	Moolarben Coal Project
OC	Open Cut
PCT	Plant Community Type
TSC Act	*Threatened Species Conservation Act 1995*
TSU	Terrestrial Stratification Unit
UG	Underground

1. Introduction

Moolarben Coal Operations (MCO) is located approximately 40 kilometres north east of Mudgee, within the western coalfield of New South Wales (NSW). Approval to develop Stage 1 and 2 of the Moolarben Coal Project (MCP) was granted under the NSW *Environmental Planning and Assessment Act 1979* on 6 September 2007 (Stage 1) and 30 January 2015 (Stage 2). A modified mine layout for the UG1 Optimisation Modification (Stage 2 Modification 2) was approved in April 2016 (Approved Layout).

Operations at the Moolarben Coal Complex (MCC) include four approved open cut (OC) mines, and three underground (UG) mines. Underground mining activities commenced at MCO in April 2016, with secondary extraction of UG1 commencing during 2017 with mining of longwall (LW) panels 101 to 103 (UG1 LW101-103). This technical report has been developed to support MCO's amendment to the current approved UG1 Extraction Plan to include UG1 LW panels 104 to 105 (UG1 LW104-105) and includes:

- Description of ecological survey work specific to the LW104-105 area (Additional Assessment Area)
- Review of subsidence predictions for LW104-105 (prepared by MSEC) and associated subsidence-related impacts
- Review of data from the biodiversity monitoring program conducted for LW101-103
- Assessment of whether MCO can achieve the Biodiversity Subsidence Impact Performance Measures (as per PA08_0135)
- Review of the suitability of the monitoring and management measures in the UG1 LW101-103 Biodiversity Management Plan (BMP) (MCO 2019a) for application to LW104-105, including consideration of the results from monitoring conducted above LW101-103
- Recommendations for monitoring locations for LW104-105.

1.1 Subsidence performance measures

Schedule 4, Condition 1 of Project Approval 08_0135 provides subsidence performance measures for natural and heritage features within Stage 2 at MCO. The condition requires that "*the project does not cause any exceedance of the performance measures*". Subsidence impact performance measures for biodiversity are presented in **Table 1**.

Table 1: Subsidence impact performance measures - biodiversity

Aspect	Impact performance measure
Threatened species, threatened populations or endangered ecological communities	Negligible subsidence impacts or environmental consequences

1.2 Subsidence predictions

Subsidence predictions and impact assessments for UG1 (LW101 - 105) were developed by MSEC (2015). These predictions were subsequently reviewed for UG1 LW101 - 103 (MSEC 2017) for the current approved UG1 Extraction Plan and for UG1 LW104-105 (MSEC 2020)

These results were used to determine potential impacts to biodiversity within UG1 that may occur as a result of mining activities in the Additional Assessment Area, and to determine the ability of MCO to comply with the subsidence performance measures contained within the Project Approval. An analysis of the predicted subsidence impacts upon biodiversity has been undertaken within **Section 3** of this report. The impact assessment has considered the results of subsidence monitoring conducted during mining of LW101-103.

2. Data Review - Ecological Survey Effort

2.1 Previous survey effort

A review of the ecological survey work specific to the UG1 LW104-105 area is provided in the following sections. The review includes survey work completed for the Stage 1 and 2 Ecological Impact Assessments (EIAs), the UG1 Optimisation Modification and the UG1 LW101-103 vegetation validation.

2.1.1 Stage 1 Ecological Impact Assessment

The Stage 1 EIA (Moolarben Biota 2006) was undertaken in accordance with the Director-General's requirements for assessment of Stage 1 of the Moolarben Coal Project. The EIA focused on assessing the impacts of Stage 1 (including OC1, OC2, OC3, UG4 and all associated infrastructure) and included survey above the UG1 LW104-105 footprint.

The Stage 1 EIA ecological survey consisted of three components, including:

- Mapping of the study area into broad vegetation communities
- Targeted flora surveys
- Targeted fauna surveys.

Broad vegetation communities were mapped across the study area through desktop analysis of aerial photography, and validated through preliminary field investigations, and further field survey using systematic methods (i.e. quadrats) to verify and describe the broad vegetation communities. The results of this field survey provided 'Terrestrial Stratification Units' (TSU's), which formed the basis of the terrestrial survey effort within the study area. The following TSU's were identified above the UG1 LW104-105 footprint:

- Disturbed vegetation
- Sedimentary Ironbark Forests
- Box Woodlands
- Sedimentary Scribbly Gum Woodlands
- Apple Alluvial Forests.

Sedimentary Ironbark Forests and Disturbed vegetation were mapped as the dominant TSU's above the UG1 LW104-105 footprint.

The floristic surveys used both systematic and opportunistic survey methods within each TSU. Systematic surveys collected data that evaluated the main sources of landform/floristic variability such as aspect, slope, soil type/ geology and topographic position along with full floristic survey. Each systematic survey site consisted of a 20 metre (m) x 20m quadrat and a 50m x 8m transect. Opportunistic observations were collected outside the structure of a stratified, randomised and replicated survey regime. These observations generally targeted threatened and/or seasonal species, as well as heterogeneous vegetation such as ecotones and clearings.

The flora surveys above UG1 LW104-105 footprint consisted of approximately eight flora quadrats, with five located in Sedimentary Ironbark Forests and three located in Box Woodlands. These surveys were undertaken during summer and winter 2005.

Fauna survey undertaken as part of the Stage 1 EIA was conducted over five (5) seasonal survey periods throughout the study area, including summer (December 2004 and January 2005), autumn (April 2005), winter (June/July 2005), early spring (August and September 2005) and late spring (November 2005). Fauna survey design and methodology was determined based upon the TSU's present across the study area.

A range of fauna survey methodologies and effort was undertaken above the UG1 LW104-105 footprint for the Stage 1 EIA and included:

- Quantitative bird surveys – birds were detected visually and aurally through surveys timed for 20 minutes per 4 ha area. If a new species was found within the last 10 minutes of survey then the survey continued, up until a maximum survey time of 1 hour. Seven quantitative bird surveys were conducted above the UG1 LW104-105 footprint
- Call playback – involved 3-5 minutes of call playback for nocturnal fauna, with a brief silence of 3 minutes between calls (including where multiple calls played). Once all calls have been played, this is followed by 10-15 minutes of listening, then at least 10 minutes of spotlighting. Call playback was undertaken across four sites which intersect the LW104-105 footprint, for a combined total of 17 nights. Targeted call playback was also undertaken for Masked Owl at one site intersecting the UG1 LW104-105 footprint for a total of two nights
- Elliott trapping – trapping involved the use of 25 Elliot Type A traps (20 on the ground and five in trees) in a grid pattern over an area of 1 ha and were baited with honey/rolled oats/peanut butter with vanilla. Tree-mounted Elliot Type B traps were also set in trees at respective sites to target arboreal mammals. One Elliot A ground trapping sites and one tree-mounted Elliot Type B trapping site was located above the UG1 LW104-105 footprint
- Hair tubes – hair tubes were set up along 2.3 km transects, with approximately 30 hair tubes per transect at six locations across the study area. The hair tubes consisted of 12 regular tubes baited with honey/rolled oats/peanut butter, 12 regular tubes baited with dry dog food, and 6 flexi glass tubes baited with whole cans of sardines. One hair tube transect was located above the UG1 LW104-105 footprint
- Harp trapping – harp traps were set up opportunistically at sites containing suitable habitat and left in place for a variable number of nights. One harp trapping survey was conducted above the UG1 LW104-105 footprint
- Spotlighting surveys – these surveys were conducted for approximately one hour with two persons and two spotlights at one site above the UG1 LW104-105 footprint
- Scats, tracks and traces searches – dedicated scat searches for a timed period of 15 mins per 1 ha area were undertaken at one site above the UG1 LW104-105 footprint.

The ecological survey undertaken for the Stage 1 EIA identified threatened ecological communities, flora and fauna species across the study area, including above the UG1 LW104-105 footprint.

The endangered ecological community, White Box Yellow Box Blakely's Red Gum Grassy Woodland listed as endangered under the NSW *Biodiversity Conservation Act 2016* (BC Act) (formerly known as the NSW *Threatened Species Conservation Act 1995* (TSC Act)) and critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) was mapped as occurring above the UG1 LW104-105 footprint.

No flora or fauna species being part of any relevant listed endangered population under the BC Act or EPBC Act were found or were known to occur in the Stage 1 EIA study area. The Stage 1 EIA identified the following threated fauna species as being present above the UG1 LW104-105 footprint:

- *Climacteris picumnus victoriae* (Brown Treecreeper [eastern subspecies]) – listed as vulnerable under the BC Act
- *Stagonopleura guttata* (Diamond Firetail) – listed as vulnerable under the BC Act
- *Calyptorhynchus lathami* (Glossy Black Cockatoo) – listed as vulnerable under the BC Act
- *Chthonicola sagittata* (Speckled Warbler) – listed as vulnerable under the BC Act
- *Melithreptus gularis* (Black-chinned Honeyeater) – listed as vulnerable under the BC Act.

2.1.2 Stage 2 Ecological Impact Assessment

The Stage 2 EIA (Eco Vision Consulting 2008) was undertaken in accordance with the Director-General's requirements for Stage 2 of the Moolarben Coal Project. The EIA focused on assessing the impacts of Stage 2 (including UG1, UG2, OC4 and all associated infrastructure) upon terrestrial and aquatic biodiversity within the study area, including threatened flora and fauna species, endangered populations, threatened ecological communities and their associated habitats.

The flora surveys above the UG1 LW104-105 footprint consisted of approximately eight quadrats surveyed for the Stage 2 EIA in spring 2006, spring 2007 and winter 2008. Six quadrats were located within disturbed lands, whilst two quadrats were located in Sedimentary Ironbark Forests. These floristic surveys used the same methods as the surveys undertaken for the Stage 1 EIA.

Fauna survey methodologies undertaken as part of the Stage 2 EIA were consistent with those undertaken for the Stage 1 EIA. The surveys included three quantitative bird surveys, one Anabat survey and three quantitative herpetological surveys. Details of the Anabat and quantitative herpetological survey methodologies area as follows:

- Anabats – two to four Anabat detection devices were used at each site, with one device placed in a stationary location and the remainder used for roaming surveys
- Quantitative herpetological surveys – surveys were conducted for a timed period of 30 minutes per site and involved active searches of micro-habitat.

The ecological survey undertaken for the Stage 2 EIA identified no additional threatened ecological communities above the UG1 LW104-105 footprint than those identified for the Stage 1 EIA.

No flora or fauna species being part of any relevant listed endangered population under the BC Act or EPBC Act were found or were known to occur in the Stage 2 EIA study area.

The Stage 2 EIA indicated that *Pomaderris queenslandica* (Scant Pomaderris), occurred in an area above the UG1 LW104-105 footprint. This species is listed as endangered under the NSW BC Act. The ecological survey undertaken for the Stage 2 EIA identified no additional threatened fauna species above the UG1 LW104-105 footprint than those identified for the Stage 1 EIA. *Pomaderris queenslandica* has not been recorded during subsidence monitoring for UG1 LW101-103 (ELA 2019).

2.1.3 UG1 Optimisation Modification

A flora and fauna impact assessment (ELA 2015a) for a Part 3A Modification to UG1 was undertaken in 2015. The flora and fauna impact assessment was undertaken to determine any potential impacts from the proposed modification on threatened ecological communities, flora and fauna within and adjacent to the proposed impact area.

ELA undertook a field survey during June 2014 which consisted of validating BioMetric vegetation types, identifying general floristic structure, targeted threatened flora searches, targeted microbat and diurnal bird surveys, habitat assessment, Koala habitat assessment and opportunistic fauna sightings. Potential habitat for threatened species was also recorded (if present) during the field survey including:

- hollow-bearing trees
- nests
- large woody debris
- rocks and outcrops
- woody understorey plants.

Flora surveys were conducted within the modification study area using rapid vegetation survey plots and the random meander technique (Cropper 1993). Rapid surveys allowed improved understanding of the extent of vegetation communities across the UG1 Optimisation Modification area while the random meander surveys allowed identification of aboveground vascular flora. The random meander technique was used in areas of potential threatened flora habitat.

Within the UG1 Optimisation Modification area, vegetation above the UG1 LW104-105 footprint was mapped into the following seven BioMetric vegetation types:

- HU515: Blakely's Red Gum - Yellow Box grassy open forest or woodland of the New England Tablelands
- HU551: Grey Box - Narrow-leaved Ironbark shrubby woodland on hills of the Hunter Valley, North Coast and Sydney Basin
- HU552: Grey Gum - Narrow-leaved Stringybark - ironbark woodland on ridges of the upper Hunter Valley, Sydney Basin
- HU574: Narrow-leaved Ironbark – Grey gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin
- HU603: Rough-barked Apple - Silvertop Stringybark - Red Stringybark grassy open forest on hills of the upper Hunter Valley, southern North Coast
- HU653: White Box - Narrow-leaved Ironbark shrubby open forest on hills of the central Hunter Valley, Sydney Basin
- HU654: White Box – Yellow Box grassy woodland on basalt slopes in the upper Hunter Valley, Brigalow Belt South.

One endangered ecological community, White Box Yellow Box Blakely's Red Gum Grassy Woodland listed as endangered under the BC Act and critically endangered under the EPBC Act was found within an area above the UG1 Optimisation Modification area.

No flora or fauna species being part of any relevant listed endangered population under the BC Act or EPBC Act were found or were known to occur in the UG1 Optimisation Modification area.

The survey undertaken for the UG1 Optimisation Modification identified one threatened flora species (*Pomaderris queenslandica*) and one threatened fauna species (*Daphoenositta chrysoptera* (Varied Sittella)) above the UG1 LW104-105 footprint. Both species are listed as vulnerable under the BC Act.

2.1.4 UG1 Vegetation Validation

ELA (2020) was engaged to undertake vegetation validation within the area of the UG1 LW104-105 footprint to revise existing vegetation mapping to include detailed extents, and to assign each vegetation community present to a Plant Community Type (PCT) in accordance with the current NSW Vegetation Information Classification System. The survey also specifically targeted any endangered/critically endangered ecological communities (EEC/CEECs) present and identified preliminary locations for the establishment of monitoring sites above both LW104 and LW105.

ELA undertook a desktop review of existing vegetation mapping for the area, including the vegetation communities mapped and described in Eco Vision Consulting (2008) and ELA (2015a; 2015b), and the subsequent mapping of vegetation to Biometric Vegetation Types and EEC/CEECs by ELA (2015c).

Field based vegetation mapping of the UG1 LW104-105 footprint was undertaken over a two-day period during December 2019 and used two complimentary methods to map vegetation present within the survey area, rapid vegetation plots and vegetation community polygons. Rapid vegetation plots were predominantly used across larger, more heterogeneous areas to confirm the vegetation community present, whilst in areas of distinct vegetation communities, the full extent of vegetation community boundaries were traversed and mapped in real time using polygons. For both methods, descriptions of the vegetation encountered was recorded, including dominant flora species in each stratum and relevant abiotic information (e.g. soils, geology and landscape position).

Field data was recorded using both ArcCollector and handheld GPS to maximise spatial coverage of the survey area. The review of existing vegetation mapping allowed for preliminary PCTs to be assigned to each data point / polygon in the field. These 'field assigned' PCTs were then validated as per the process detailed below.

Following the field survey, the preliminary 'field assigned' PCTs were reviewed using the NSW BioNet Vegetation Classification system (OEH 2019). This allowed for each PCT encountered in the field to be analysed with regards to floristic composition and dominant species, landscape position and IBRA bioregion and sub-region classification. Each proposed PCT was also reviewed against the NSW Vegetation Classification and Assessment reports for Brigalow Belt South and South West Slopes bioregions (Benson 2006). These reports are in many cases the source documents for locally occurring PCTs and as such provide detailed descriptions of vegetation communities including structure, occurrence and spatial extent.

Proposed PCTs were also assessed against the relevant listing criteria and policy statements for EECs and/or CEECs listed under both the BC Act and EPBC Act.

The vegetation validation above the UG1 LW104-105 footprint identified ten (10) PCTs which are listed below and displayed in **Figure 1**:

- PCT 76 Western Grey Box tall grassy woodland on alluvial loam and clay soils in the NSW South Western Slopes and Riverina Bioregions
- PCT 266 White Box grassy woodland in the upper slopes sub-region of the NSW South Western Slopes Bioregion
- PCT 281 Rough-barked Apple – red gum – yellow box woodland on alluvial clay to loam soils on valley flats in the northern NSW South Western Slopes Bioregion and Brigalow Belt South

- PCT 420 Red Stringybark – Rough-barked Apple +/- Norton's Box open forest on hillslopes in the Warrumbungle NP – Coolah regions
- PCT 424 Dwyer's Red Gum heathy low open woodland on sandstone ridges in the Pilliga Scrub, Brigalow Belt South Bioregion
- PCT 479 Narrow-leaved Ironbark – Black Cypress Pine – Stringybark +/- Grey Gum +/- Narrow-leaved Wattle shrubby open forest on sandstone hills in the Brigalow Belt South Bioregion and Sydney Basin Bioregion
- PCT 480 Black Cypress Pine – ironbark +/- Narrow-leaved Wattle low open forest mainly on Narrabeen Sandstone in the Upper Hunter region of the Sydney Basin Bioregion
- PCT 1606 White Box - Narrow-leaved Ironbark –Blakely's Red Gum shrubby open forest of the central and upper Hunter North west slopes Dry Sclerophyll Woodland
- PCT 1629 Narrow-leaved Stringybark – Grey Gum shrubby open forest on sandstone ranges of the Sydney Basin
- PCT 1696 Blakely's Red Gum – Rough-barked Apple shrubby woodland of central and upper Hunter.

PCT 1629 was selected as a replacement for PCT 864. PCT 864 has been decommissioned since the vegetation validation assessment for LW101-103 (ELA 2016). This change is reflected in the updated PCT mapping for the whole of the UG1 area presented in **Figure 1**.

The vegetation validation above the UG1 LW104-105 footprint identified the following EECs/CEECs:

- White Box, Yellow Box, Blakely's Red Gum Grassy Woodland and DNG – EPBC Act (DEH 2006) / White Box, Yellow Box, Blakely's Red Gum Woodland – BC Act (NSW Scientific Committee 2002) (EEC/CEEC)
- Central Hunter Valley Eucalypt Forest and Woodland CEEC[1] – EPBC Act (TSSC 2015) / Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions EEC[2] – BC Act (NSW Scientific Committee 2010).

[1] This CEEC was listed in May 2015 and does not apply to the approved Stage 1 and Stage 2 mining operations pursuant to Section 158A of the EPBC Act.

[2] This EEC was listed in 2011 and does not apply to the approved Stage 1 and Stage 2 mining operations pursuant to Section 158A of the EPBC Act.

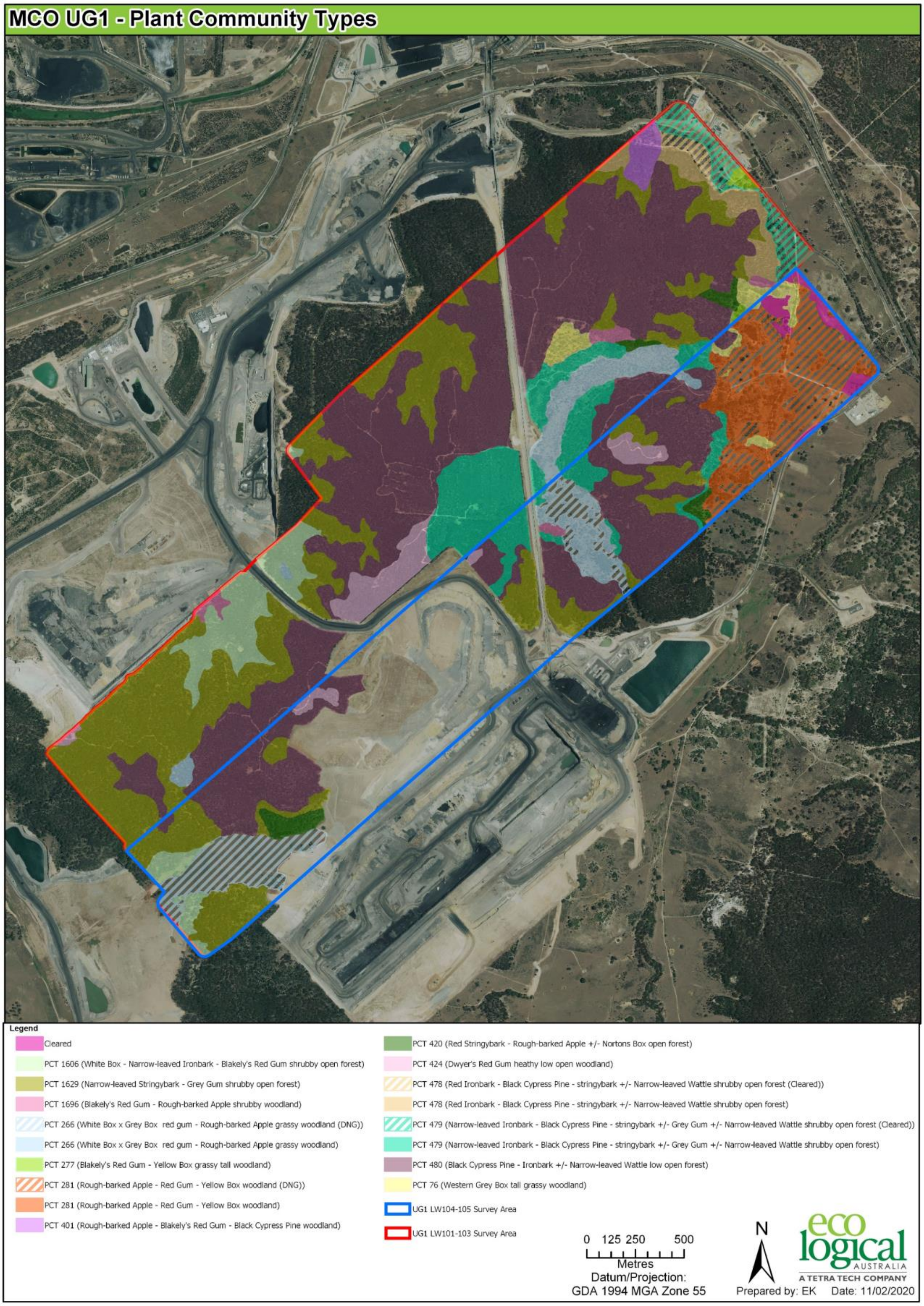

Figure 1: PCTs associated with UG1 LW101-105 (LW104-105 assessment area in blue outline)

3. Subsidence Impacts

Subsidence predictions and impact assessments were developed for the Approved Layout by MSEC (2015). These predictions were reviewed for the UG1 –LW104-105 Extraction Plan (MSEC 2020) and were consistent with the predictions for the Approved Layout.

The subsidence impacts recorded following mining of LW101-103 to date have been consistent with predictions. This, together with the outcomes of the biodiversity impact monitoring, provides a sound technical basis for the predicted biodiversity impact associated with the proposed mining of LW104-105.

3.1 Overall predicted subsidence

The predicted conventional subsidence parameters for UG1 LW104 – 105 were made by MSEC (2020) using the Incremental Profile Method (IPM). The method is an empirical model based on a large database of observed monitoring data from previously mined areas within the coalfields of NSW. It is likely non-conventional ground movements will occur within the UG1 due to near surface geological conditions and steep topography. These non-conventional movements are often accompanied by elevated tilts and curvatures which are likely to exceed the conventional predictions.

The maximum predicted total conventional subsidence due to the extraction of UG1 LW101-105 is 2,400 millimetres (mm). Based on the predicted subsidence contours presented in Appendix E of MSEC (2020), the greatest total subsidence within the Additional Assessment Area would be expected to be between 2,300mm and 2,400mm. The maximum predicted conventional subsidence for areas of EECs is 2,350mm.

The maximum predicted total conventional tilt over the UG1 LW104–105 footprint is >100 millimetres/metre (mm/m), equivalent to an overall change in grade of greater than 1 in 10. Subsidence will result in reduced grades and increased grades depending on the position in the subsidence bowl. These changes in grade may result in ponding of surface water runoff where existing natural grades are relatively shallow, such as over parts of UG1 LW104-105.

The maximum predicted for both total conventional tensile and compressive strains resulting from the extraction of the longwalls is expected to be greater than 30mm/m.

The maximum predicted conventional subsidence, tilt and curvature for areas of EECs, based on the Extraction Plan Layout, are the same as the maxima based on the Approved Layout (MSEC 2020).

Based on the maximum predicted tilts and strains, fracturing of sandstone may occur as a result of the extraction of the longwalls and, hence, could result in small rockfalls. It is expected that occasional rockfalls or fracturing would not impact more than 5% of the total face area of rock ledges and overhangs within the UG1 impact footprint (MSEC 2020).

3.2 Predicted subsidence effects

The overall predicted conventional subsidence effects and impacts upon biodiversity above UG1 LW104-105 are summarised below in **Table 2**. Given the magnitude and nature of predicted subsidence impacts for LW104-105 are similar to those predicted for LW101-103, the potential impacts are consistent with those described in ELA (2017). Additional residual subsidence within mined LW102 and LW103 is predicted due to the extraction of LW104-105 in addition to that which has already occurred. These additional impacts are anticipated to be minimal and MSEC does not expect the subsidence predictions to be any greater overall than those provided in MSEC (2015) prepared for the Approved Layout.

The assessment of potential biodiversity impacts is also supported by monitoring data collected from areas affected by LW101-103 (ELA 2018 & 2019). Non-conventional subsidence may cause localised impacts on vegetation and fauna habitat.

The outcomes of the UG1 biodiversity monitoring program are summarised below:

- Subsidence cracking occurs above UG1 and was present in 4 out of 5 of the LW101-103 post-mining transects monitored. However, where it does occur, no corresponding impact on vegetation health has been observed. A comparison of pre-mining canopy health condition against post-mining conditions shows no significant change.
- No loss of structural layers attributable to subsidence impacts or significant weed incursions were observed during the monitoring undertaken in spring 2019.
- The monitoring data to date indicates that the subsidence impact performance measure within the MCO *UG1 Longwalls 101 to 103 Biodiversity Management Plan* (MCO 2019a) 'negligible subsidence impacts or environmental consequences' for threatened species, threatened populations or EECs has been achieved as predicted in the assessment conducted in ELA (2017).

Table 2: Subsidence predictions (based on subsidence predictions in MSEC 2020)

Aspect	Description	Subsidence prediction	Impact Assessment
Threatened, Protected Species or Critical habitats	Known EEC/CEEC occurs within the UG1 LW104-105 footprint including: • White Box, Yellow Box, Blakely's Red Gum Grassy Woodland and DNG – EPBC Act (DEH 2006) / White Box, Yellow Box, Blakely's Red Gum Woodland – BC Act (NSW Scientific Committee 2002) (EEC/CEEC) • Central Hunter Valley Eucalypt Forest and Woodland CEEC – EPBC Act (TSSC 2015)[3] / Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions EEC – BC Act (NSW Scientific Committee 2010) [4]. Known habitat exists within the UG1 LW104-105 footprint for multiple threatened flora and fauna species.	The maximum predicted conventional subsidence at the vegetation communities is 2,350mm. The maximum predicted conventional tilt at the vegetation communities, at any time during or after the extraction of the longwalls, is >100mm/m (i.e. >10 %), or a change in grade of greater than 1 in 10. Subsidence will result in reduced grades and increased grades depending on the position in the subsidence bowl. These changes in grade may result in ponding of surface water runoff where existing natural grades are relatively shallow, such as over parts of UG1 LW104-105. Based on the maximum predicted tilts and strains, fracturing of sandstone may occur as a result of the extraction of the longwalls and	Subsidence within the underground mining area is not expected to result in the loss of vegetation cover or community structure. This conclusion is supported by previous local studies and monitoring at UG1 that have been unable to detect significant impacts from subsidence on local vegetation communities. Fauna habitat (including that identified as Koala habitat) will not be substantially impacted by the occurrence of subsidence. Direct mortality of a small number of plants and animals may occur as a result of subsidence-induced rock fall or collapse; however, the impact from such events is expected to be short-term, localised and not significant. The potential subsidence of steep slope and rock ledge habitats due to the underground mining may impact upon cave roosting bats (such as *Chalinolobus dwyeri* (Large-eared Pied Bat), *Miniopterus orianae oceanensis* (Large Bent-winged Bat) and *Vespadelus troughtoni* (Eastern Cave Bat) which are known to occur in the proposed mining area or surrounds). The nature and extent of habitat for cave roosting bats is not likely to be significantly altered

[3] This CEEC was listed in May 2015 and does not apply to the approved Stage 1 and Stage 2 mining operations pursuant to Section 158A of the EPBC Act.

[4] This EEC was listed in 2011 and does not apply to the approved Stage 1 and Stage 2 mining operations pursuant to Section 158A of the EPBC Act.

Aspect	Description	Subsidence prediction	Impact Assessment
Natural Vegetation	The Additional Assessment Area generally consists of remnant native vegetation on the sandstone slopes and ridges and cleared and regenerating vegetation in the valley flats and basalt slopes. The vegetation validation conducted above the UG1 LW104-105 area resulted in the identification of 10 different PCTs.	could result in small rockfalls. It is expected that occasional rockfalls or fracturing would not impact more than 5% of the total face area of rock ledges and overhangs within the UG1 Study Area.	as a result of the proposed extraction in a way that would jeopardise these species in the locality. Furthermore, extensive potential habitat for these species is provided within the Stage 2 biodiversity offset areas. The Large-eared Pied Bat, Large Bent-winged Bat and Eastern Cave Bat have been recorded during annual monitoring at nearby MCO biodiversity offset areas (Old Bobadeen, Onsite Offsets and Ulan 18). In summary, the effect of subsidence is expected to cause negligible subsidence impacts or environmental consequences for threatened species, threatened populations or EECs.

4. Discussion & Recommendations

4.1 Subsidence predictions

Given subsidence impacts for UG1 LW104-105 are expected to be consistent with those for the Approved Layout and LW's 101-103, it is considered that mining of UG1 LW104-105 would satisfy the condition set out in Schedule 4, Condition 1 of Project Approval 08_0135, requiring that "*the project does not cause any exceedance of the performance measures*" and more specifically has negligible subsidence impacts or environmental consequences for threatened species, threatened populations or threatened ecological communities.

Furthermore, the monitoring program and management measures recommended below will identify where potential impacts upon ecological values occur and mitigation measures should they occur.

4.2 Recommendations for monitoring

4.2.1 Monitoring program outline

The current approved UG1 Extraction Plan BMP has been prepared to manage the potential environmental consequences of subsidence on aquatic and terrestrial flora and fauna (MCO 2019a). A subsidence monitoring program was developed and has been implemented for UG1 LW101-103 (MCO 2019b) considering the recommendations in ELA (2017). The program focusses on monitoring potential impacts of subsidence so that the project does not exceed the performance measures as set out in Schedule 4, Condition 1 of Project Approval 08_0135.

These documents have been reviewed and the results of monitoring conducted to date under the LW101-103 BMP (MCO 2019a) have been considered in providing the recommendations for monitoring of subsidence impacts on biodiversity associated with LWs 104-105. Key components of the recommended monitoring program are summarised in **Table 3** and details of the methods are provided in the following sections.

The proposed monitoring program for LW's 104-105 recommends conducting baseline monitoring prior to mining and monitoring post-mining for two years following completion of longwall mining beneath the monitoring locations.

Table 3: Recommended LW104-105 monitoring program

Data source	Type	Description	Monitoring parameters
Longwall traverses	Transects	Baseline condition and post-mining (for two years after mining), above each longwall during spring, along five permanent transects positioned to intersect with identified EEC/CEEC within the area above LW 104-105 and to provide spatial coverage across each longwall.	Evidence of surface cracking or ponding. Deterioration in tree health that correlates to presence of subsidence cracks or ponding. Areas of weed incursion and/or infestations. Evidence of impacts/disturbance to flora or fauna habitat. Evidence of impacts to threatened flora or fauna species attributable to subsidence impacts.
Floristic monitoring sites	Floristic plots on permanent transects	Baseline condition and post-mining (for two years after mining), above each longwall during spring, at one location within each transect (five plots in total) positioned to coincide with identified EEC/CEEC intersected by the transect.	Canopy health and defoliation. Vegetation structure and species composition. Nature and extent of any impacts on flora and fauna habitats. Evidence of any impacts on terrestrial fauna. Photographic records.
Targeted cliff line survey	Visual inspection	Baseline survey of features that provide potential microbat roosting sites above LW 104-105 (e.g. cliffs, overhangs). Post mining inspections of sites identified potential bat roosting sites between October and February after completion of longwall extraction.	Prior to commencement of longwall extraction beneath potential roosting sites for Large-eared Pied Bat, Large Bent-winged Bat and Eastern Cave Bat. Post-mining: evidence of subsidence impacts to identified features that provide potential roosting sites for Large-eared Pied Bat, Large Bent-winged Bat and Eastern Cave Bat, compared to baseline conditions (e.g. rockfalls, displacement of or dislodgement of boulders or slabs, or fracturing).

4.2.2 Monitoring methods

4.2.2.1 Longwall panel traverses

Five permanent transects should be established across the width of the longwall panel in the area potentially impacted by LW104-105[5] prior to mining (**Figure 2** provides recommended locations). monitoring should be undertaken in spring along these transects to record the baseline state of the landscape and vegetation to allow future comparisons of conditions after secondary extraction. Monitoring should occur for two years during spring, following mining beneath each monitoring location.

Each transect should be traversed on foot and observations recorded at 50 m intervals, with incidental observations recorded in between. The following data should be recorded for all transects:

- Areas of surface cracking or ponding
- Deterioration in tree health that correlated to presence of subsidence cracks or ponding
- Areas of weed incursion and/or infestations
- Mortality of more than a small number of threatened flora or fauna species attributable to subsidence impacts
- Nature and extent of impact to flora or fauna habitat.

[5] Note one transect was established above LW104 in spring 2019 (ELA 2019a).

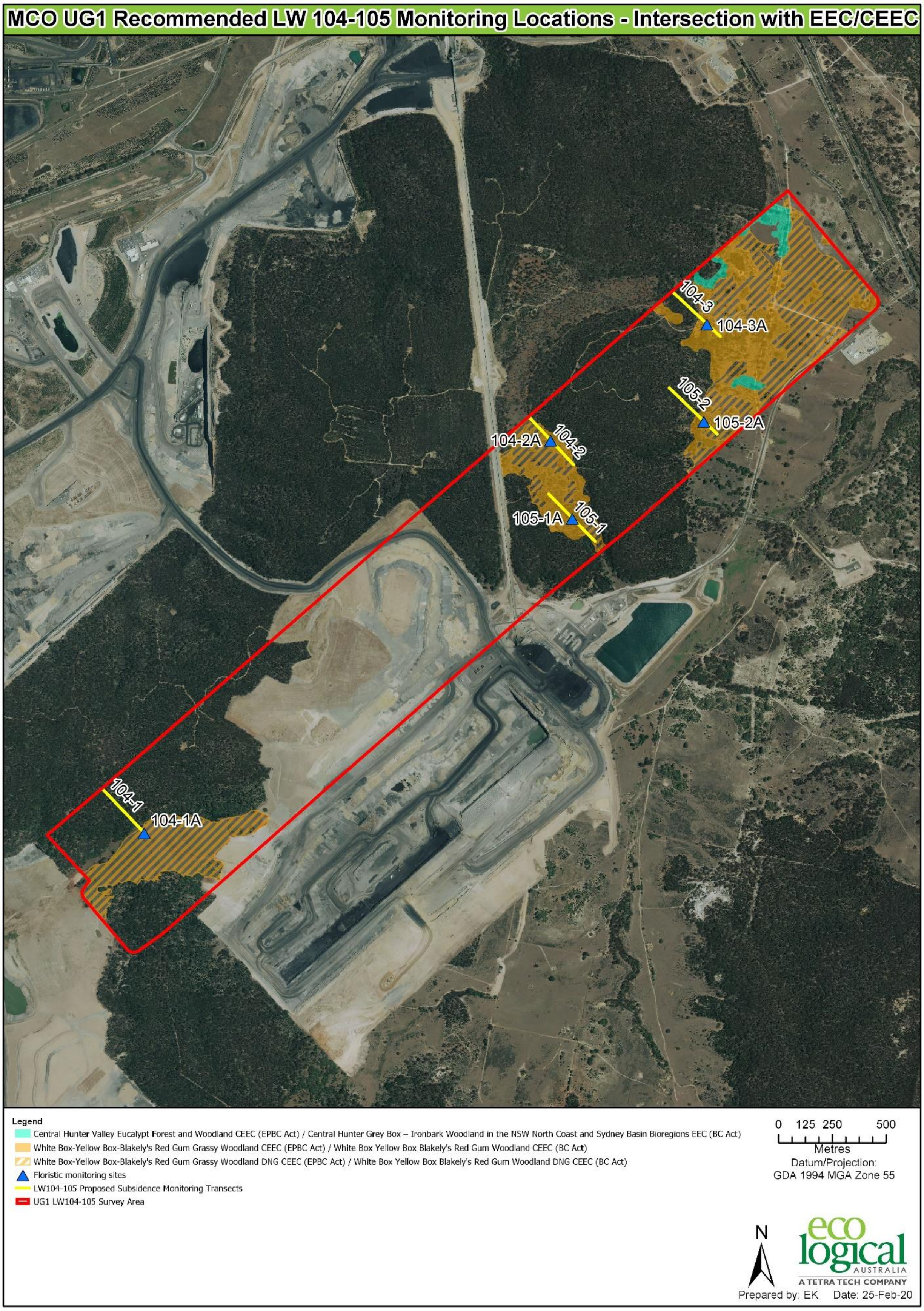

Figure 2: Recommended LW104-105 monitoring locations and intersection with EEC/CEEC

4.2.2.2 Floristic monitoring sites

Five permanent floristic monitoring plots should be established along the longwall transects (one plot per transect). Locations should be positioned randomly within a section of the transect that coincides with identified EEC/CEEC intersected by the transect (**Figure 2** provides recommended locations).

Floristic monitoring sites of 20m x 20m in dimension should be marked out using a star pickets to ensure that the site can be relocated for future monitoring.

The following data should be recorded for each plot:

Plot vegetation:

- Projected foliage cover (PFC – 1-5% then 5% increments) of native grass/ground cover; native shrubs <1 m height; native shrubs/small tress >1 m height)
- PFC (5% increments) of upper canopy (assessed at each quadrat corner and averaged)
- Dominant species at the upper, mid and ground strata, and PFC of each species.

Vegetation structure:

- Exotic species
- Number of stags, estimated time since death
- Lower, estimated median and upper height of canopy (m)
- Lower, estimated median and upper diameter at breast height (DBH) over bark of canopy stems (cm)
- Abundance of each canopy species (identified to species level); calculated total number stems in the transect.

Canopy health and defoliation (all in 5% increments):

- Percentage of epicormic foliage in relation to total tree foliage
- Proportion of primary branches within canopy that have died back
- Percentage of current canopy foliage as a proportion of the estimated canopy foliage volume/potential canopy
- Percentage of canopy foliage discoloured.

Photographs should be taken of the canopy at each corner of each floristic plot (placing the camera on the star picket) and a general photograph taken from the plot along each transect. Additional notes about landscape position and habitat features immediately surrounding the site that might assist with data interpretations should also be recorded.

In addition to annual spring monitoring, where possible, opportunistic inspections of the surface environment above the longwalls should be undertaken by MCO personnel. This will enable prompt identification of matters that warrant further investigation or management intervention.

4.3 Recommendations for management of impacts

If routine monitoring indicates impacts greater than predicted that can be attributed to subsidence are occurring, additional investigation may be required to understand the nature of the impact and identify the most appropriate management measures that should be applied.

Key triggers to investigate the implementation of additional monitoring and appropriate management measures and should include:

- areas of cracking or ponding that exceed predicted subsidence impact
- declining trend in canopy health or vegetation structure correlated to presence of subsidence cracks or ponding or inconsistent with seasonal trends[6]
- deterioration in tree health outside natural variations[3]
- areas of weed incursion and/or infestation
- mortality of more than a small number of threatened flora or fauna species attributed to subsidence impacts.

As appropriate, management measures should be implemented, to comply with the relevant statutory requirements and the subsidence impact performance measures. Based upon the predicted subsidence effects and consequences upon biodiversity values within the UG1 LW104-105 footprint, management measures for have been prescribed below for:

- vegetation management
- terrestrial fauna and habitat
- weed management
- additional monitoring.

4.3.1 Vegetation

Potential management measures for impacts on vegetation include planting preservation of stags (dead trees) and planting of endemic plant species. The vegetation species selected for planting should be representative of the vegetation community in the affected area. Rehabilitation of disturbed areas should be undertaken in accordance with the methods identified in the approved complex-wide Rehabilitation Management Plan (MCO 2019c).

Any vegetation clearance required for subsidence remediation activities must be conducted in accordance with the vegetation clearance protocol as described in the approved complex-wide BMP (MCO 2019d).

4.3.2 Terrestrial fauna and habitat

Potential management measures for impacts on threatened fauna species includes additional monitoring (see **Section 4.3.4**), or investigation may be required to better understand the nature and scale of impact.

The selection and implementation of management measures should be considered with regard to the specific circumstances of the subsidence impact (e.g. the location, nature and extent of the impact) and environmental consequence occurring as a result.

[6] Additional monitoring at analogue sites or data available from spring Biodiversity Offset Area monitoring may be required to assess whether condition changes are due to seasonal environmental effects such as drought.

4.3.3 Weed management

Potential weed management measures for impacts due to a new priority weed incursion or a general priority or environmental weed burden that has the potential to impact on habitat quality, vegetation structure or the integrity of a threatened ecological community, weed management measures should implemented in accordance with the approved complex-wide BMP (MCO 2019d).

4.3.4 Additional monitoring

Where a predicted subsidence impact has been exceeded, it may be appropriate to conduct additional monitoring (e.g. increase the frequency of monitoring or the parameters monitored) or conduct additional targeted survey work. For example, if the routine monitoring indicates impact from ponding or dieback, more frequent monitoring of recently mined areas may be appropriate to allow for more timely implementation of mitigation measures.

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